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(54) Ballastic laminated armour

(57) A structure useful to reduce the ballistic capacity of projectiles shot towards protected targets, which comprises a panel (10) including an elastically deformable laminate matrix (11), which supports a plurality of rigid elements (12) located in the front part of said panel, said elements constituting means for absorbing the energy of the incident projectiles and for unstabilizing them in response to the impact of said projectiles on said elements and the elastic deformation of said matrix.

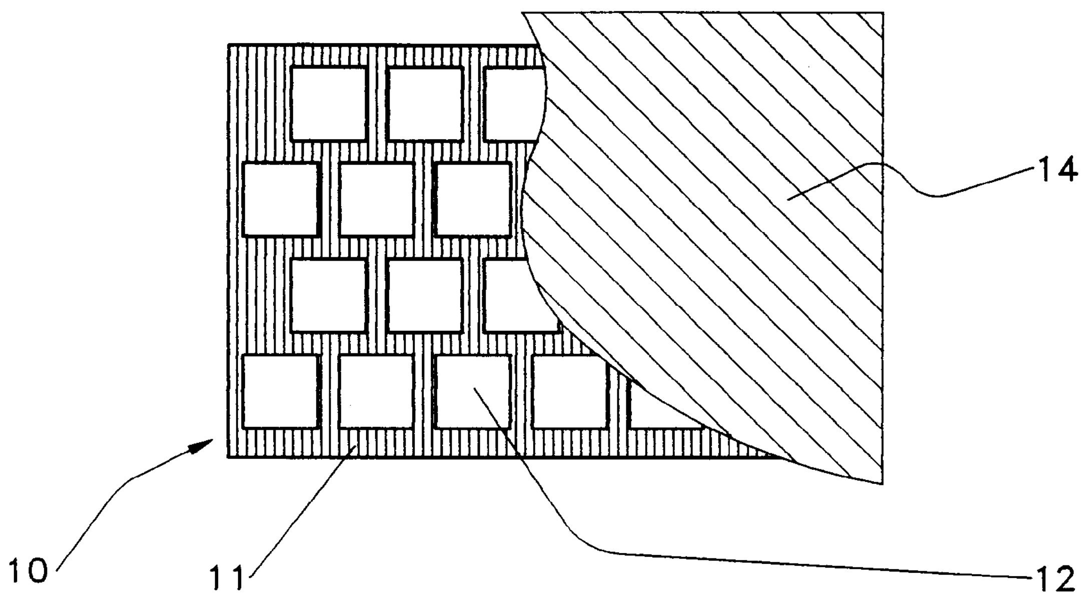

Fig.1

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Description

The parallel development of ballistic theory and practice has led to the technological improvement of antiballistic defenses intended to protect possible targets by weakening or destroying the ballistic capacity of projectiles. This improvement is essentially based on the development and application of structures devised according to certain characteristics of the materials used to form such defenses, such as density, hardness, traction resistance, etc. and also to the thickness of the structures. These factors have led to the application of increasingly heavier and obviously more expensive armors, screens, shields, etc., as it is the case of defenses disclosed in Argentine Patents Nos. 208,008 (1976) and 108,007 (1976).

The incorporation of polyamides and in particular of aramides, such as Kevlar^R, patent Twaron^R --U.S. Patent No. 4,850,050-- has partly solved the above mentioned problems, as materials reinforced with these kinds of fibers are considerably lighter than traditional materials, which were limited up to then to costly metallic alloys and associated to ceramics and special vitreous materials.

Conventional anti-bullet defenses are based on common principles, essentially on the destruction, reduction or restriction of the ballistic capacity of projectiles, preventing, reducing or weakening their penetration in the defense and the access to the targets according to the above mentioned mechanic characteristics of the defenses (hardness, density, friction, etc.) of the materials used (in general, alloys, as the case might be, in combination with elastomers).

Such is the case of the defenses disclosed in Argentine patents Nos. 208,878 (1976) and 208,007 (1976), in which metallic plates combine with cement layers that are inserted, and also German patent 2,759,193 (1979) and European patent application 0,041,271.

German patent No. 2,759,193 corresponds to a multilayer defense or antiballistic packet, which differs from the prior art in the combination of at least one layer formed of a plurality of small units made up of thin sheets of glass, ceramics and/or sintered hard metals, included in a matrix of nylon, synthetic resins, steel, etc. In this case, said layer (s) is(are) combined with layers made of other materials, for example elastomers, or which include hollow tubular or round bodies made of sintered steel or ceramics.

Further, EP 0,041,271 discloses armored defenses formed of panels, each of which is formed of a layer of impact-resistant parallel rods, separated among them, made of a ceramic material. The volume which is not occupied by the rods is filled with an elastomer material in which the sound propagation speed is much lower than in the material of the rods.

The antiballistic defenses disclosed in these patents and in the above mentioned Argentine patents (vide supra) are heavy, rigid and especially passive, since the defense they provide depends on the resistance to the impact of each structure of their capacity to absorb and reduce the propagation of the impact energy.

The incorporation of polyamides and polyester fibers and in particular of aramid fibers (Kevlar^R, Twaron^R, etc.) have partly resolved the problems relating to the weight and cost of passive (or static) structures in general, since said fibers permit the use of reinforced materials and antiballistic structures considerably lighter, personal, fixed or movable, having a remarkable incidence on manufacturing costs, replacement costs, etc.

An important innovation in the technology of antiballistic defenses was the disclosure of structures capable of acting on fired projectiles before they hit armors by perturbing their path and reducing at least partially, their kinetic energy. These refer to structures acting as screens, which have elements with slanting surfaces, having many sides or curved faces, so that with the impact, the projectile bounces, deviates itself and its path is made unstable. The result of this kind of shots is that the projectile does not reach the target, and if it does reach it, it has lost a great part of its ballistic capacity, in view of the loss of velocity and the ballistic unstabilization.

Different documents have disclosed antiballistic structures of this type, which intercept projectiles and protect movable units and fixed installations and form part of a light external armor combined with a conventional internal armor. Such is the case with documents DE 2,332,464 (1939); 682,180 (1939) and 2,815,582 (1980).

The first of these documents discloses ballistic protection systems which comprise a cover of plates articulated among them, having a many-sided front surface. Each of these plates is firmly fixed and secured by an internal armor structure. In particular, it refers to plates having a pyramidal form (i.e. with no parallel faces among them) so that the projectiles always reach oblique surfaces. This system is completed with an elastomeric underlying structure applied to an inner wall or armor.

Document 682,810 corresponds to a similar system, which comprises a cover of round caps, mounted and fixed on a reticulate support structure, formed of layers and intercrossing steel cables fixed to an internal structure or armor. In this system, the impact of each projectile would determine the oscillation of the affected cap(s) and the unstabilization of the projectile, increased by the vibrating movement caused by the impact and transmitted to the whole system.

Furthermore, the structure disclosed in the other document (DE 2,815,582) even if it follows the same principle, it avoids the frontal impact by offering oblique surfaces to the flight of the projectile. It is much simpler, since it refers to a structure formed of an elastomeric matrix including pieces made of ceramics, glass or sintered metals, which have planar surfaces directed obliquely with relation to the direction of the projectiles.

In actual practice, said structures have not been useful, a priori it has been discovered that they are heavy, complicated to build and their effectiveness has not been verified.

It has now been found that it is possible to have definitely light ballistic structures, having tested effectiveness, which structures are easy to build and are remarkably advantageous from an economic point of view. They also refer to the reduction of the ballistic capacity of projectiles so that when they hit the target, they encounter a movable target in the impact point which modifies the projectile's kinetics and dynamics, as its velocity is reduced and its progress becomes erratic, so that it loses its orientation and reaches the deep areas of the structure, in an unfavorable position and without the necessary energy to produce the effects that are characteristic of its caliber and sometimes they fall apart.

It is an object of this invention to provide a structure useful to reduce the ballistic capacity of projectiles shot towards targets protected by antiballistic packets covered by said structures, which structure comprises a panel including an elastically deformable laminar matrix which supports a plurality of rigid elements located on the front face of said panel, said elements being means for absorbing the energy and unstabilizing the incidental projectiles in response to the impact of the projectiles on said elements and the elastic deformation of the matrix.

It is another object of this invention to provide a structure useful to reduce the ballistic capacity of projectiles shot towards targets protected by antiballistic packets covered by said structure, which comprises a panel including an elastically deformable matrix which has a plurality of rigid elements inserted in it, emerging from at least the front face of such panel; each of said rigid elements being an energy absorbing unit and a projectile deviation path unit in response to the impact of the projectiles and the elastic deformation of the matrix.

It is still another object of this invention to provide a structure useful to improve the antiballistic capacity and resistance of antiballistic packets in armored vehicles in general, which structure comprises:

- a plurality of cells open on the front face of the panel and closed on the opposite end on the bottom of the panel;
- each of said cells defines a cavity where there is a rigid ball, said panel being covered by a non rigid sheet extending from the borders of the panel and covering the cell openings;
- and the distance to each other of said rigid balls is less than a caliber of the expected incidental projectiles.

It is another object of this invention an improved antiballistic packet including a structure according to this invention in combination with an armor or an antiballistic defense.

It is still another object of this invention an antiballistic packet of improved antiballistic capacity, which comprises a combination of:

a) at least one non rigid panel, provided with a plurality of cells extending from the front face of said panel and closed on the opposite end, on the bottom of the panel; each of said cells defines a cavity where a rigid ball is located, said panel being covered by a non rigid sheet, extending from the borders of the panel and covering the openings of said cells and the distance of the rigid balls among themselves is less than a predetermined caliber of incidental projectiles; and

b) an armor linked and covered by at least one of the above mentioned panels;

It is still another object of this invention to provide an antiballistic packet having improved antiballistic capacity, in which said armor comprises at least one elastomeric layer put on top of and linked to an armor or armored shield

These and other objects, characteristics and advantages of this invention shall be clearly understood by means of the following detailed description, which shall make reference to the drawings attached hereto for illustrative purposes only.

Figure 1 is a schematic front view of the anti-ballistic structure of one of the preferred embodiments of the present invention.

Figure 2 is a schematic side view of the structure shown in the previous Figure 1.

For illustrative purposes, Figure 3 shows different alternatives forms of the energy absorbing element or unit, which perturbs the path of the projectile and shown as an example in Figure 1.

Figures 4 to 8 are illustrations of other preferred forms of the structure of this invention, in which:

Figure 4 is a partially cut detailed upper view of said structure;

Figure 5 and 5' are partially cut away views of an antiballistic packet in accordance with the present invention;

Figures 6, 7 and 8 are other partial cross-section views of the packet illustrated in figures 5 and 5'.

Even if in the text that follows express reference to antiballistic packets and structures is made, it should be understood that the principles that support this invention, their teachings and advantages are applicable to any other system exposed to the penetration, breaking or deformation by ballistic or mechanical strike.

In figures 1 and 2, reference 10 corresponds to a panel or screen which constitutes one of the preferred embodiments of the antiballistic structure of this invention, which includes an elastically deformable matrix 11 and a plurality of rigid elements 12 inserted into said matrix 11. In Figure 2, reference 13 corresponds to the panel illustrated in Figure 1, which has been completed with a frame or support of the assembly.

The distribution of the rigid elements 12 does not follow a specific plan. The distribution is compatible with the objectives of this invention; as the case might be, it is possible to resort to the orthogonal distribution of elements 12 and even to a distribution having circular symmetry, organizing such elements in concentric arcs or circumferences or in combination with the lineal distributions mentioned above.

The rigid elements 12, in combination with the elastic characteristics of the matrix 11, have a fundamental role in the perturbation of the ballistic capacity of the projectiles directed towards targets protected with defenses which include structures as the one illustrated in figures 1 to 3.

The perturbing effects of the ballistic capacity which characterize the system of this invention correspond mainly to:

- the deviation of the path of projectiles which get into contact with elements 12. If the impact is frontal, the elastic deformation of the matrix in the impact zone will occur and same is elastically transmitted to the whole structure. Depending on the elastomeric characteristics of the matrix and the ballistic capacity of the incidental projectile, the breaking and destruction of the matrix in the impact zone may occur.

If the projectile is obliquely directed and it reaches the target obliquely, a bounce effect similar to the one observed when a stone is originally thrown in descending direction on a water surface may additionally occur. The stone bounces against the surface of the water surface and is shot in ascending direction, in an angle which varies according to the initial velocity and the angle which forms the entry path of the stone in relation to the water surface.

A similar phenomenon occurs when a projectile with an oblique path reaches the surface of an element 12, from where it is shot in this direction, going away from the target. The slantwise strike of the projectile involves a drag which partially consumes the kinetic energy of the projectile and reduces its speed, leading to the obvious reduction of the reach of the projectile and of all the ballistic effects which depend on its kinetic energy (velocity). The energy taken away from the projectile in the impact zone elastically extends to the whole panel structure.

It is understood that the above mentioned effects depend on the geometry of elements 12, since the probability that the above slantwise strike might occur shall depend on the number of faces of the exposed surface to each element 12. The greater the faces the surface has, the greater the probability that the slantwise strike and the deviation of the projectile shall occur. Thus, if "n" is the number of facets of such surface, maximum efficiency is obtained when "n" tends to infinite; i.e. for curved, spherical, ellipsoidal, cylindrical surfaces, and others.

Figure 3 shows different possible forms of the energy absorbing elements. The antiballistic effectiveness of the preferred structure according to figures 1 to 3 obviously depends on the mechanic characteristics of units 12 and the elastic characteristics of matrix 11.

The optimum number of elements 12 is conditioned by the size of said elements. Said elements shall be distributed leaving a certain margin between each other, sufficient to permit the flexion of the mass of matrix 11 located between one element and its neighbors.

It is clear that the separation between each element and its neighbors is in turn conditioned by the caliber of the projectiles. In other words, the separation between elements 12 should be enough to secure the elastic movements of the matrix but also sufficiently reduced to obstruct the pass of projectiles which strike between one and other element.

This alternative of this invention does not depend on one elastomer in particular. It refers especially to elastomers resistant to atmospheric agents and having sufficient elasticity to permit the elastic movements of elements 12 which have been stricken. Silicone butadiene-estiren elastomers, etc. have proved to be highly useful.

It has already been said that elements 12 are units sufficiently rigid and resistant to undergo the slantwise strike and the frontal strike of projectiles. The materials which have proved to be particularly suitable are ceramic, tempered glass or metal materials, particularly ferrous alloys used in the construction of conventional armors and hardened vitrified materials.

The systems or structures according to this alternative of the invention have, for example, the form of panels or screens spatially distributed to protect fixed installations or vehicle components when they refer to movable units, including vessels or airplanes.

The structure according to this embodiment of the invention may be further used in association with other conventional armored structures, for example, in armored vehicles, security boxes, defense walls, and even in combination with mobile or fixed antiballistic packets.

Another of the preferred embodiments of this invention is partially illustrated in figures 4 to 8, which forms part of an antiballistic packet also schematically and partially illustrated in the above mentioned figures and identified under reference 101. Said packet 101 combines another of the preferred embodiments of the antiballistic structure of this invention with reference 102 associated with a band or block 103 (hereinafter simply called "separator") juxtaposed to an armored structure or armor B schematically shown in Figures 4 to 8 (for example, a conventional shield or armor of ballistic laminated steel, such as laminated Krupp HFX 220 steel and/or aramid laminates reinforced with glass or carbon fibers).

This preferred embodiment of the antiballistic packet 101 of the present invention does not essentially depends on the nature and structure of the conventional armor B. For the purposes of this invention, it is useful any antiballistic packet or armor capable of handling unstabilized and partially stopped projectiles, emerging from the bottom of structure 102 on their way to the target.

The novel component of the antiballistic packet illustrated under reference 101 in Figures 4 to 8 is structure 102, which has a fundamental role in the accompaniment and initial unstabilization of the incidental projectiles 15 (Figure 7) in view of the elastic strike or impact of the projectiles with the rigid balls 104.

The antiballistic structure 102 comprises a cellular panel 106 formed of a plurality of cells 107 having a regular distribution; for example according to a honeycomb model (quincunxes), as illustrated as an example in figures 4 and 5, or also in an orthogonal distribution or under the form of concentric circles (circumferential symmetry). In figures 4 to 8, the cells 107 have a circular section. However, in the practice it is possible to use cells having a polygonal section; such as, for example, square, hexagonal and octagonal sections indistinctly, even combining in the same panel cells having a different section.

A rigid little ball 104, either hollow or solid, is housed in each cell 107. An important element for the purposes of this invention is the rigid nature thereof, (i.e. non deformable or elastically deformable as a result of the impact of the projectiles 15). For illustrative purposes only, it might be said that the materials which are suitable for the balls 104 are ceramics, tempered glass, including sintered metals (steel) or polymers, especially aramides reinforced with carbon or glass fibers.

The antiballistic effects of structure 102 may be increased by imparting to the balls 104 a stable electric load of the same sign as the (positive) load which acquires the projectile in a ballistic flight through the atmosphere.

Each little ball 104 is freely confined in its cell 107. For the purposes of this invention, when it is said that every ball 104 is confined, this means that each ball 12 is enclosed but loose in its cell 107, or given the case, detachably immobilized in response to an impact of a certain extent. This means that each ball 104 can be loose or compressed within its cell walls so that even if its movements may be severely restricted by the walls, each ball may oscillate or vibrate in its cell and to a certain extent move itself as much as the resiliency of the cellular structure of panel 106 might permit.

The immobility of balls 104 located in each cell 107 in passive situations is deeply disturbed when the projectile 15 strikes, and this perturbation affects the balls located in the impact zone and especially those which receive the direct impact of the projectile and propagates itself to the whole panel 102.

The principal foundation of this invention refers to the immediate dissipation, and with the greatest spatial dispersion possible, of the energy received in the impact zone and subtracted from the incidental projectile 15 and elastically transmitted to the whole structure 102. Practice has shown that those results depend essentially on the mass, diameter, rigidity, distribution and elastic strike of the balls among themselves and the phase synchronism of their acoustic waves (harmonic resonance).

The rigidity condition imposed to the balls 104 is essential for the purposes of this invention to achieve the elastic strike conditions required for a quick dissipation of the energy of the impact received by the structure 102. The elastic strike condition mentioned above involves the conservation of the kinetic moment in the strike of the projectile 15 against the balls 104 in the impact point and in the succession of elastic strikes in chain from the impact zone, to the extent and in all the directions subject to the mass and distribution of the balls 104.

Practice has shown that if the balls 104 are too heavy in relation to the mass of the projectile 15, the dissipation of the energy of the impact measured in relation to the extent of the disturbed zone of the antiballistic structure 101 is lower.

On the contrary, if the balls 104 are very light in relation to the mass of the projectile 15, the extent of the disturbed zone is greater (the lighter balls are shot at a greater speed), the panel 102 is destroyed and the unstabilization of the projectile 15 is lower or does not occur at all.

The analysis of the above mentioned factors, mass, distribution (or density of balls/m^2) and diameter of the rigid balls has led in practice to the convenience of using balls having the same mass as the projectiles. For example, for an M1 projectile (7.62 AP NATO) which has a mass of 3.56, the mass of the balls shall be of 3.2-3.5 and for an M2 projectile of 5.0 g, the distribution shall be a quincunx distribution.

Similar approaches can be made in relation to the diameter of the balls. In practice, for the 7.62 projectile mentioned in the previous paragraph, balls made of ceramics, tempered glass and also steel, with a diameter in the range of 10 mm, have been acceptable.

In the analysis, review and selection of the parameters for the diameter, the mass and quality of the material of the balls 104, the separator 103 and the conventional armor (B), the "try and error" method has been used, starting with the evaluation of the ballistic danger (caliber, velocity, etc.) and calculating the kinetic energy of the projectile. Once these parameters are known, a technical evaluation is made, the materials for the balls 104 are compared and plans are made for a test program using balls having a determined combination of diameter and mass in a prototype ballistic packet (such as the ones illustrated in Figures 1 to 8).

The first orientation tests in the shooting stand generally lead to the reformulation of the parameters, the preparation of new prototypes and the conducting of further tests until the desired antiballistic values are obtained.

In practice, the panel 106 is a polygonal sheet, preferably of square or rectangular section, including the cells 107, as illustrated in the drawings. There are other constructive possibilities which have not been illustrated. For example, the panel 106 can be a base sheet acting as a tray, from which tubular projections equivalent to cells 107 project vertically. Said tray is surrounded by a perimetral border. In the drawings, the above mentioned cells 107 are closed by a non-rigid cover 105 working as a lid, extending from one end to another end of the panel 106. This cover 105 and the panel 106 may be of identical or different --obviously non rigid-- materials. This characteristic of non rigidity is important to reduce to the minimum the bouncing of the projectile 15, since according to the principles disclosed herein, this invention refers to the provision of a relatively weak target from the antiballistic point of view to the incidental projectile 15 on the impact point, the projectile having a penetrations which shall affect a reduced area surrounding the impact point and which shall deeply affect a limited number of balls with the breaking of 2 to 4 balls (figures 6 to 8). So starts a chain of elastic strikes from the balls 104 which surround the impact zone and there commences the propagation of the strike wave in the core of panel 106, to an extent proportionate to the energy subtracted from the striking projectile 15 by the balls 104 affected by the direct impact and transmitted by the elastic strike thereof to the immediately neighboring balls 104. The direct impact of each projectile 15 (figure 6), subject to its energy, shall cause the fracture and/or the movement of a certain number of balls, starting the propagation of the energy subtracted from the projectile discounting the energy consumed in practice by the fracture of a certain number of balls in the impact point in response to the elastic strike of each perturbed ball with the balls in the neighboring cells. This proves the importance of the non rigid nature of the material which forms panel 106 and the sheets of the frontal cover 105, to achieve the maximum dispersion and dissipation possible of the energy subtracted from the projectile. Materials appropriate to form panel 106 and the sheet 105 are the polymeric resins which adapt themselves to produce the above mentioned undulating effect, which, added to the elastic strike, are the basis of this invention. Such resins are, for example, polypropylene resins, polyurethane resins, silicone elastomer, synthetic rubber, polysobuthane, estirene butadiene rubber, etc. Cellular structures of this kind which have proved to be useful for the purposes of this invention are obtained by the stamping or inlay of sheet of the materials mentioned above, having a suitable thickness (0.5 - 1.0 mm). Alternatively, the panel can be reinforced included a knitted cloth or felt-like fabric, extending, for example, on the bottom of the panel 106 below the cells (not illustrated).

The function of the antiballistic structure 101 is to deprive every incidental projectile from as much of its kinetic energy as possible and to perturb its dynamic equilibrium. In this last respect, it should be remembered that gravity, air resistance and the impulse that the projectile receives when it is fired are balanced in the ballistic flight of a projectile. The projectile moves from this balance towards the target while it rotates around its axis, originating a precession movement and a nutation movement from the gravity center.

The projectile is unstabilized when it strikes a target, it loses its velocity, changes its orientation and given the case, it deforms itself to a variable extent, depending on whether the strike with the target is elastic or non elastic. If it is a non elastic strike, the energy of the projectile is consumed as a result of the deformation and perforation of the target in the impact area, as it occurs with conventional armors and structures which offer a passive resistance to the impact based on the thickness, the type of material and the resistance to the ballistic penetration (Brinell hardness) of armors.

When the strike is elastic as proposed and disclosed in this invention, the projectile 15 is also unstabilized and loses its orientation when it elastically strikes the ball(s) 104. The strike is elastic because the head of the projectile is rigid and the balls are also rigid and in addition, because the set of balls confined in their cells 107 form a plurality of movable targets: some receive the direct impact of the projectile (figures 6 and 7) and are generally broken. A part of the energy subtracted from the projectile 15 is lost in the fracture of the balls and the rest of the energy is transmitted to the surrounding balls by means of elastic strikes, which in turn elastically strike others in their environment, starting a chain of elastic strikes which dissipate the kinetic energy subtracted from the projectile not wasted in the fracture of the little balls which have received direct impact.

Experiences has shown that the projectile loses its direction (figure 5) and encounters the subadjacent armor B in a slanting way, in a less favorable position from the ballistic point of view, losing every time more velocity as it penetrates the support layer 103, its path becoming every time more flatten and ending the way in a non working position (figure 8).

These perturbations of the kinetic energy and of the path of the incidental projectile 15 permit the devise of lighter ballistic packets in view of the reduction of the support layer 103 and the armor B.

The following examples, which are disclosed for illustrative purposes only, provide a summary of the tests and shot experiences which verify the characteristics of the structure of this invention, hereinafter indistinctly called "Energy Absorbing System" (E.A.S.)

EXAMPLE 1 (HPWLI 6605-01C)

Ballistic Limit, Protection (V50B1[P]) Testing of one (1) combination laminated Spectra panel and Energy Absorbing System test sample.

Testing was conducted in accordance with the procedures of MIL-STD-662E, dated 22 January 1987 using caliber 7.62mm, 150.0 grain, M61, AP ammunition. The test sample was mounted on an indoor range 45.0 feet from the muzzle of a test barrel to produce zero (0) degree obliquity impacts. Lumiline screens were positioned at 10.0 and 35.0 feet which, in conjunction with an elapsed time counter (chronograph), were used to compute bullet velocities 25.0 feet from the muzzle. Standard drag coefficient tables for bulleted ammunition were used to calculate striking velocities. Penetrations were determined by visual examination of a 0.020 inch thick sheet of 2024T3 aluminum witness panel positioned 6.0 inches behind, and parallel to, the test sample. Table I is a summary of the registration of data obtained, enclosed herewith

TABLE I: SUMMARY OF RESULTS

Test Sample			Ballistic Threat		Ballistic Limit (fps)		
Number	Thickness (inc) (a)	Weight (lbs)	Caliber	Shots	V50 BL(P)	High Partial	Low Complete
2	2.602	9.35	7.62mm, AP	3	(b)	na	2644

(a) Average of four corner thicknesses.
(b) Incalculable. All shots completed penetrations.

EXAMPLE 2 (HPWLI 6605-01A)

Ballistic Limit, Protection (V50BL[P]) Testing of one (1) high hard steel armor plate and the same high hard steel armor plate with an Energy Absorbing System added.

Testing was conducted in accordance with the procedures of MIL-STD-662E, dated 22 January 1987 using caliber 7.62 mm, 150.0 grain, M61, AP ammunition. The purpose of this test is to establish the change in the V50 Value of a stand alone steel armor plate and that same armor plate when tested in conjunction with the Energy Absorbing System. The test samples were mounted on an indoor range 45.0 feet from the muzzle of a test barrel to produce zero (0) degree obliquity impacts. Lumiline screens were positioned at 15.0 and 35.0 feet which, in conjunction with an elapsed time counter (chronograph), were used to compute bullet velocities 25.0 feet from the muzzle. Standard drag coefficient tables for bulleted ammunition were used to calculate striking velocities. Penetrations were determined by visual examination of a 0.020 inch thick sheet of 2024T3 aluminum witness panel positioned 6.0 inches behind, and parallel to, the test samples. Table II is a summary of the data obtained.

TABLE II: SUMMARY OF RESULTS

Test Sample			Ballistic Threat		Ballistic Limit (fps)		
Number	Thickness (in) (a)	Weight (lbs)	Caliber	Shots	V50 BL (P)	Partial High	Complete Low
1(b)	0.323	38.21	7.62mm, AP	4	2144	2140	2130
1A(c)	1.723(d)	43.40	7.62mm, AP	4	2790	2791	2777

(a) Average of four corner thicknesses.
(b) Stand alone high hard steel armor plate.
(c) Steel armor plate with Energy Absorbing System added.
(d) Steel armor plate (0.323 inch), Energy Absorbing System (1.40 inch).

Based on the dated presented in Table II, the addition of the Energy Absorbing System INCREASED the armor's V50 value by 30%. Although limited, the results of the test demonstrate the potential of the Energy Absorbing System and warrants further testing.

EXAMPLE 3

Ballistic Limit, Protection (V50BL[P]) Testing of two (2) panels of MIL-A-46100 steel armor.

Testing was conducted in accordance with the procedures of MIL-STD-662E, dated 22 January 1987 using caliber 0.30-06, 166.0 grain, M2, AP ammunition. The basic armor panel was mounted on an indoor range 45.0 feet from the muzzle of a test barrel to produce zero (0) degree obliquity impacts. Comparative tests were conducted with panels of Energy Absorbing System material positioned 2-5/8 inch in front of and parallel to, the basic armor. The gap was established with a foam material supplied by a representative that identified it as Semi-Rigid Polyurethane. Lumiline screens were positioned at 15.0 and 35.0 feet which, in conjunction with an elapsed time counter (chronograph), were used to compute bullet velocities 25.0 feet from the muzzle. Standard pierce coefficient tables for bulleted ammunition were used to calculate bullet velocities. Penetrations were determined by visual examination of a 0.020 inch thick sheet of 2024T3 aluminum witness panel positioned 6.0 inches behind, and parallel to, the test samples. Table III is a summary of the enclosed data records.

TABLE III: SUMMARY OF RESULTS

Armor			EAS Applique (12"x12")			Threat		Ballistic Limit	
Type	Thickness (inch) (a)	Obliquity (degrees)	Thickness (inch) (a)	Weight (lbs)	Air-Gap (inch) (b)	Caliber	Shots	V50	Increase (+) Decrease (-)
MIL-A-46100(c)	0.251	0	NA	NA	NA	0.30 AP	6	1638	
			0.628	4.76	2.625	0.30 AP	4	2503	+965(59%)
MIL-A-46100(d)	0.394	0	NA	NA	NA	0.30 AP	6	2115	
			0.615	4.86	2.625	0.30 AP	6	3039	+924(44%)

(a) Average of four corner thicknesses.
(b) Semi-Rigid Polyurethane Foam.
(c) Plate Number 4138 (HPWLI 6469-06).
(d) Plate Number 836A (HPWLI 6469-06).

EXAMPLE 4

Ballistic Limit, Protection (V50BL[P]) Testing of two (2) panels of MIL-A-46100 steel armor.

Testing was conducted in accordance with the procedures of MIL-STD-662E, dated 22 January 1987 using caliber 0.30-06, 166.0 grain, M2, AP ammunition. The basic armor panel was mounted on an indoor range 45.0 feet from the muzzle of a test barrel to produce thirty (30) degree obliquity impacts. Comparative tests were conducted with panels of Energy Absorbing System material positioned in front of and parallel to, the basic armor creating a gap between the basic armor and the EAS material. The gap was established with a foam material provided by its representative that identified it as Semi-Rigid Polyurethane. Lumiline screens were positioned at 15.0 and 35.0 feet which, in conjunction with an elapsed time counter (chronograph), were used to compute bullet velocities 25.0 feet from the muzzle. Standard piercing coefficient tables for bulleted ammunition were used to calculate bullet velocities. Penetrations were determined by visual examination of a 0.020 inch thick sheet of 2024T3 aluminum witness panel positioned 6.0 inches behind, and parallel to, the test samples. Table IV is a summary of the enclosed data records.

TABLE IV: SUMMARY OF RESULTS

Armor			EAS Applique (12"x12")			Threat		Ballistic Limit	
Type	Thickness (inch) (a)	Obliquity (degrees)	Thickness (inch)(a)	Weight (lbs)	Gap-Air (inch)(b)	Caliber	Shots	V50	Increase (+) Decrease (-)
MIL-A-46100(c)	0.239	30	------------NA-------------			0.30 AP	6	2381	
			0.627	4.76	1.000	0.30 AP	2	2427	+46(1,9%)
MIL-A-46100(d)	0.251	30	------------NA-------------			0.30 AP	6	2474	
			0.615	4.95	2.625	0.30 AP	6	2667	+193(7,8%)

(a) Average of four corner thicknesses.
(b) Semi-Rigid Polyurethane Foam.
(c) Plate Number 4G0062 (HPWLI 6450-01)
(d) Plate Number 4138 (HPWLI 6469-06)

EXAMPLE 5

Ballistic Limit, Protection (V50BL[P]) Testing of two (2) panels of MIL-A-12560 steel armor.

Testing was conducted in accordance with the procedures of MIL-STD-662E, dated 22 January 1987 using caliber 0.50, 708.0 grain, M2, AP and caliber 14.5mm, 950.0 grain, B-32 ammunition. The basic armor panel was mounted on an indoor range 45.0 feet from the muzzle of a test barrel to produce zero (0) degree obliquity impacts. Comparative tests were conducted with panels of Energy Absorbing Systems material positioned in front of and parallel to, the basic armor to create a gap between the basic armor and the EAS material. The gap was established with a foam material provide by its representative that identified it as Semi-Rigid Polyurethane. Lumiline screens were positioned at 15.0 and 35.0 feet which, in conjunction with an elapsed time counter (chronograph), were used to compute bullet velocities 25.0 feet from the muzzle. Standard piercing coefficient tables for bulleted ammunition were used to calculate striking velocities. Penetrations were determined by visual examination of a 0.020 inch thick sheet of 2024T3 aluminum witness panel positioned 6.0 inches behind, and parallel to, the test samples. Table V is a summary of the enclosed data records.

TABLE V: SUMMARY OF RESULTS

Armor			EAS Applique (12"x12")			Threat		Ballistic Limit	
Type	Thickness (inch) (a)	Obliquity (degrees)	Thickness (inch) (a)	Weight (lbs)	Gap-Air (inch)(b)	Caliber	Shots	V50	Increase (+) Decrease (-)
MIL-A-12560(c)	0.468	0	------------NA-------------			0.50 AP	6	1756	
			1.366	7.06	2.375	0.50 AP	2	2334	+578(33%)
MIL-A-12560(d)	0.801	0	------------NA-------------			14.5mm	6	2181	
			1.355	12.70(e)	3.125	14.5mm	4	2641	+460(21%)
			1.278	12.49(e)	5.375(f)	14.5mm	2	2858	+677(31%)

(a) Average of four corner thicknesses.
(b) Semi-Rigid Polyurethane Foam.
(c) Plate Number R9810-4AB (HPWLI 6188-10)
(d) Plate Number R9178-2FB (HPWLI 6188-06E)
(e) 16" x 16"
(f) 5/8" foam + 4-3/4" air.

EXAMPLE 6

Ballistic Limit, Protection (V50BL[P]) Testing of a panel of MIL-A-46100 steel armor with Energy Absorbing Systems appliques.

Testing was conducted in accordance with the procedures of MIL-STD-662E, dated 22 January 1987 using caliber 0.30, 166.0 grain, M2, AP ammunition. The basic armor panel was mounted on an indoor range 45.0 feet from the muzzle of a test barrel to produce zero (0) degree obliquity impacts. Comparative tests were conducted with panels of Energy Absorbing Systems material positioned in front of and parallel to, the basic armor to create a gap between the armor and the EAS material. The gap was established with a foam material provide by its representative that identified it as Semi-Rigid Polyurethane. Lumiline screens were positioned at 15.0 and 35.0 feet which, in conjunction with an elapsed time counter (chronograph), were used to compute bullet velocities 25.0 feet from the muzzle. Standard drag coefficient tables for bulleted ammunition were used to calculate striking velocities. Penetrations were determined by visual examination of a 0.020 inch thick sheet of 2024T3 aluminum witness panel positioned 6.0 inches behind, and parallel to, the test samples. Table VI is a summary of the enclosed data records.

TABLE VI: SUMMARY OF RESULTS

Armor			EAS Applique (12"x12")			Threat		Ballistic Limit
Type	Thickness (inch) (a)	Obliquity (degrees)	Thickness (inch) (a)	Weight (lbs)	Gap-Air (inch)(b)	Caliber	Shots	V50
MIL-A-46100(c)	0.258	0	0.618	5.14	1.250	0.30 AP	6	2408
	0.258(d)	0	0.599	4.77	3.625	0.30 AP	6	2502

(a) Average of four corner thicknesses.
(b) Semi-Rigid Polyurethane Foam.
(c) Plate Number 160A (HPWLI 6469-05)
(d) 5/8" foam is added to impact face of basic armor.

EXAMPLE 7

BALLISTIC LIMIT

Testing was conducted in accordance with the procedures of MIL-STD-662E, dated 22 January 1987 using caliber 7.62 mm, 150.0 grain, M61, AP ammunition. The testing sample was mounted on an indoor range 45.0 feet from the muzzle of a test barrel to produce ten (10) degree obliquity impacts. Lumiline screens were positioned at 15.0 and 35.0 feet which, in conjunction with an elapsed time counter (chronograph), were used to compute bullet velocities 25.0 feet from the muzzle. Standard piercing coefficient tables for bulleted ammunition were used to calculate bullet velocities. Penetrations were determined by visual examination of a 0.020 inch thick sheet of 2024T3 aluminum witness panel positioned 6.0 inches behind, and parallel to, the test samples. Table VII is a summary of the enclosed data records.

TABLE VII: SUMMARY OF RESULTS

Test Sample			Ballistic Threat		Ballistic Limit (fps)			
Number	Thickness	Weight	Caliber	Shots	V50	Partial	Complete	(inch)(a)
(lbs)			BL(P)	Low	High			
1B	1.874	42.52	7.62mm, AP	2	2967	2958	2976	

(a) Average of four corner thicknesses.

Claims

1. A structure useful to reduce the ballistic capacity of projectiles shot towards protected targets, which comprises a panel including an elastically deformable laminate matrix, which supports a plurality of rigid elements located in the front part of said panel, said elements constituting means for absorbing the energy of the incident projectiles and for unstabilizing them in response to the impact of said projectiles on said elements and the elastic deformation of said matrix.

2. A structure useful to reduce the ballistic capacity of projectiles directed towards protected targets by antiballistic packets covered by said structure, which comprises a panel including an elastically deformable matrix, in which a plurality of rigid elements are inserted and emerge from at least the front face of said panel; each of said rigid elements constitutes a unit for the absorption of energy and deviation of the path of projectiles in response to the impact of the projectiles and the elastic deformation of the matrix.

3. A structure according to claim 2, in which said elements emerge from both faces of the panel.

4. A structure according to claim 2, in which said elements are bodies having multiple faces.

5. A structure according to claim 2, in which the bodies having multiple faces are regular polyhedron.

6. A structure according to claim 2, in which said elements are cylindrical bars or bars having multiple faces.

7. A structure according to claim 2, in which said elements have an elliptical or circular section.

8. A structure according to claim 2, in which said matrix is made of an elastomeric material, such as silicone rubber or butadiene estirene rubber.

9. A structure according to claims 3 to 7, in which said rigid elements are made of vitreous materials, ceramic materials or of a metallic nature, such as iron or ferrous alloys.

10. A structure according to any of claims 3 to 7 and 9, in which said elements or units for absorbing energy and deviating the path of the projectiles are distributed in said matrix symmetrically, in a concentric circular, orthogonal or quincunx distribution

11. A structure useful to improve the antiballistic capacity of ballistic packets and the resistance to impact of installations and vehicles in general, according to claim which comprises:

   - a panel which comprises a non rigid panel provided with a plurality of open cells on the front face of said panel, and closed on the opposite end on the bottom of the panel;

   - each of said cells defines a cavity in which said panel is housed, a non rigid sheet, extending from the borders of the panel and covering the cells, being the distance between the rigid balls less than the caliber of expected incidental projectiles.

12. A structure according to claim 11, in which said cells have a square section.

13. A structure according to claim 11, in which said cells have a circular section.

14. A structure according to claim 11, in which the rigid balls are hollow.

15. A structure according to claim 11, in which the rigid balls are solid.

16. A structure according to claim 15, in which the rigid balls are of tempered glass or ceramics.

17. A structure according to claim 15, in which the rigid balls are hollow and of reinforced aramid or epoxy resins.

18. A structure according to claim 15, in which the rigid balls have an electric charge of a sign opposite to the electric charge attributed to the incidental projectiles.

19. A structure according to claim 11, in which the panel and the sheet that covers it are made of the same material.

20. A structure according to claim 19, in which said material is a synthetic rubber or elastic polyurethane.

21. A structure according to claim 1, which further comprises a reinforcing fabric extending on the back of the panel and below the cells.

22. An improved antiballistic packet, which comprises a conventional armor in combination with the structure of claim 1.

23. An antiballistic packet of improved antiballistic capacity which comprises the combination of:

a) at least one panel formed of a non rigid panel, provided with a plurality of open cells on the frontal face of said panel and closed on the opposite end, on the bottom of the tray; each of said cells defining a cavity where a rigid ball is confined; said panel being covered by a non rigid sheet extending from the borders of the tray and covering the openings of said cells; the distance between the rigid balls among them being minor than the caliber of the expected incident projectiles, in accordance with claim 11;

b) a conventional antiballistic defense connected and covered by at least one panel, in accordance with claim 1.

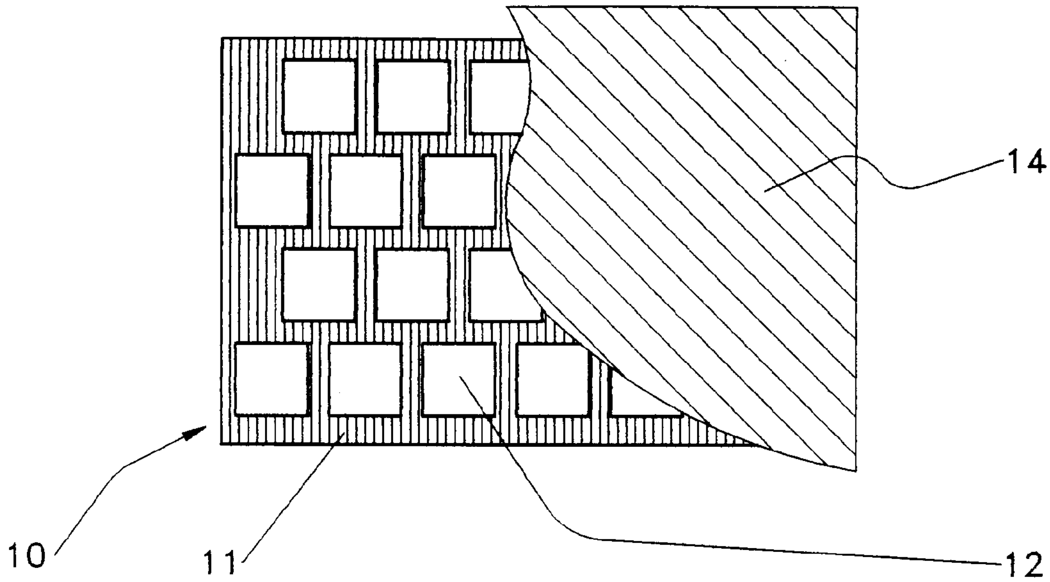

Fig.1

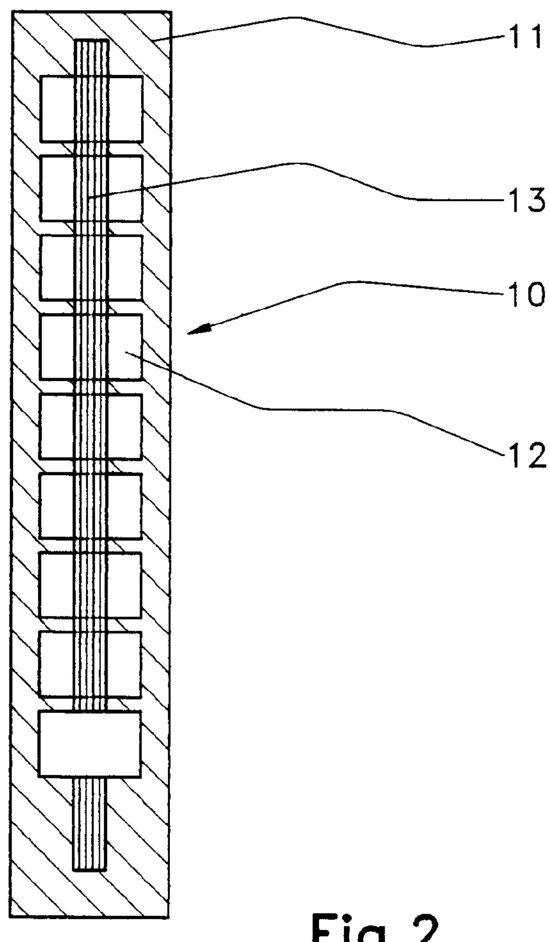

Fig.2

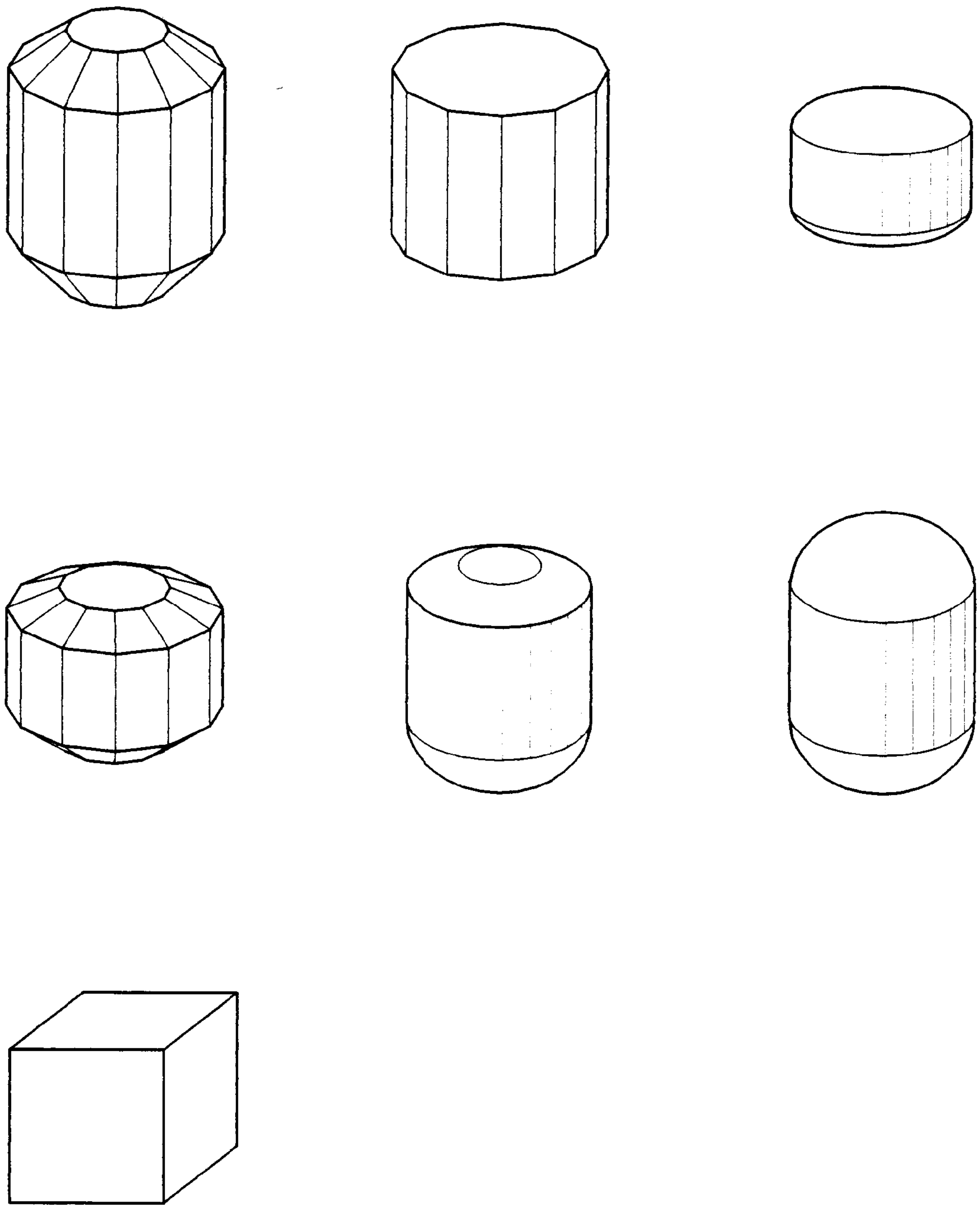

Fig.3

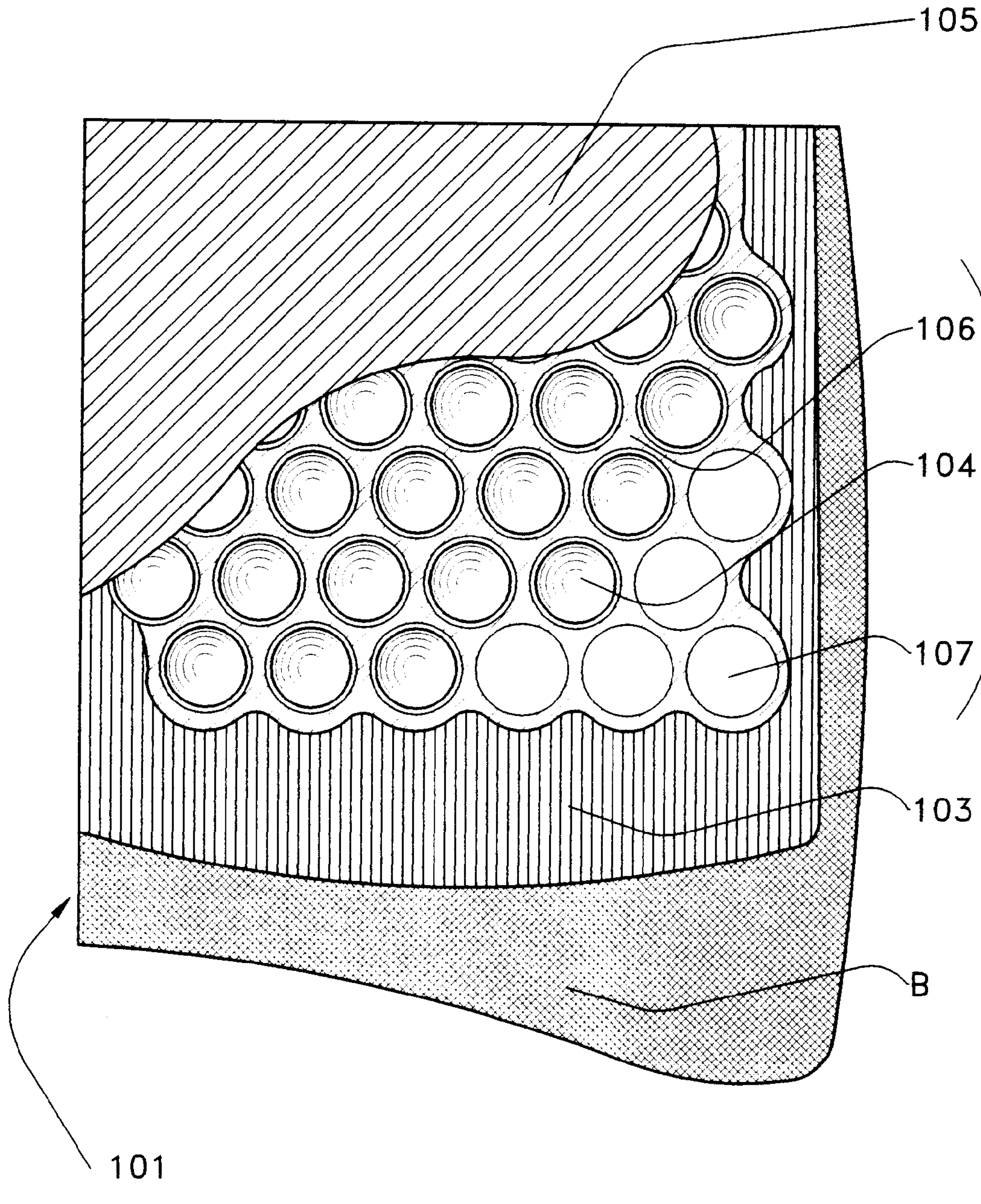

Fig.4

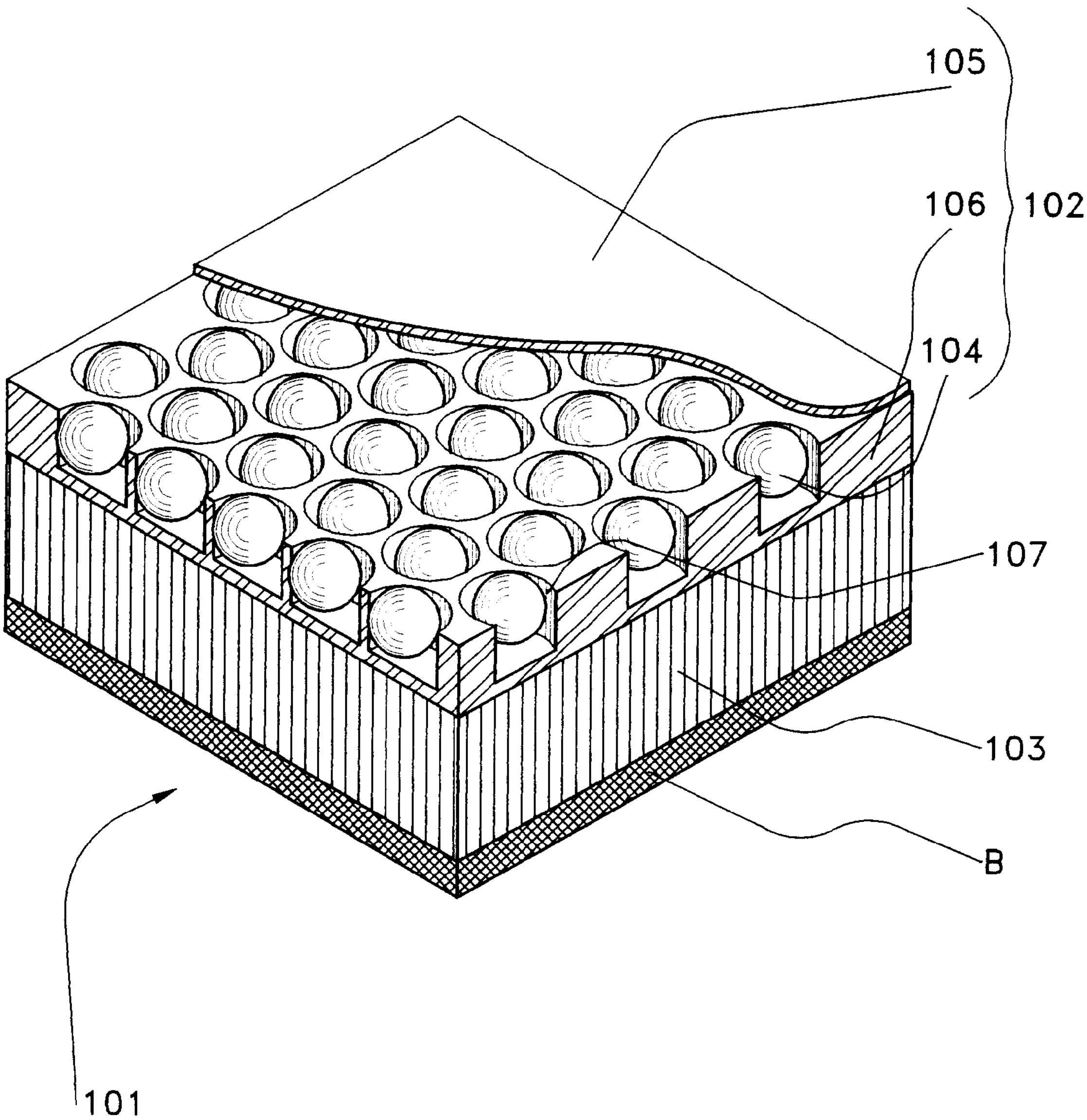

Fig.5

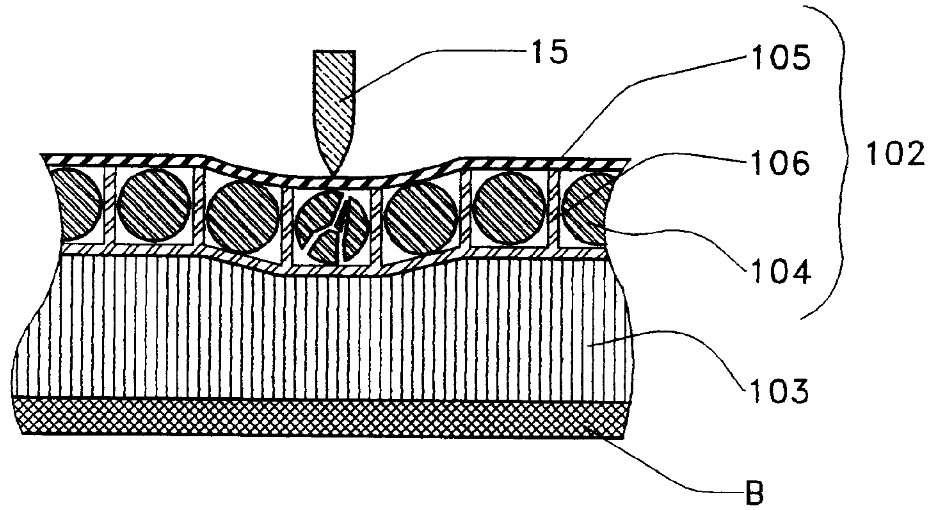

Fig.6

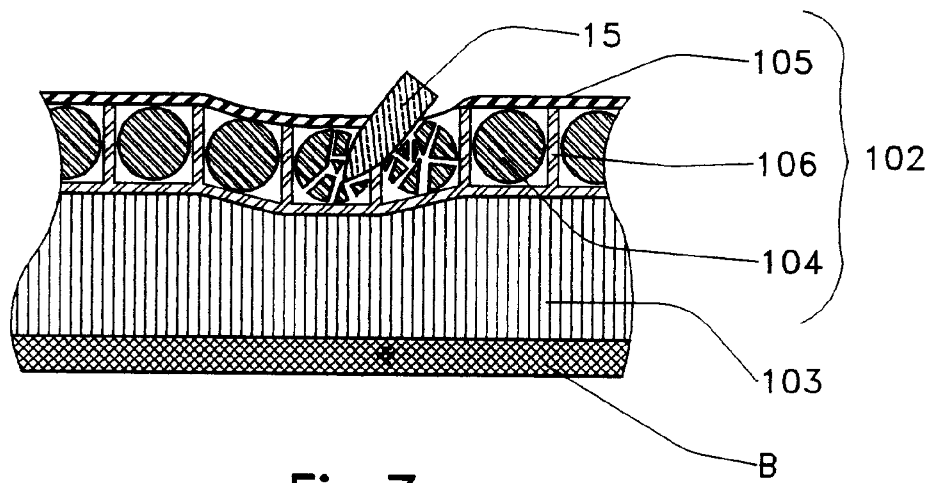

Fig.7

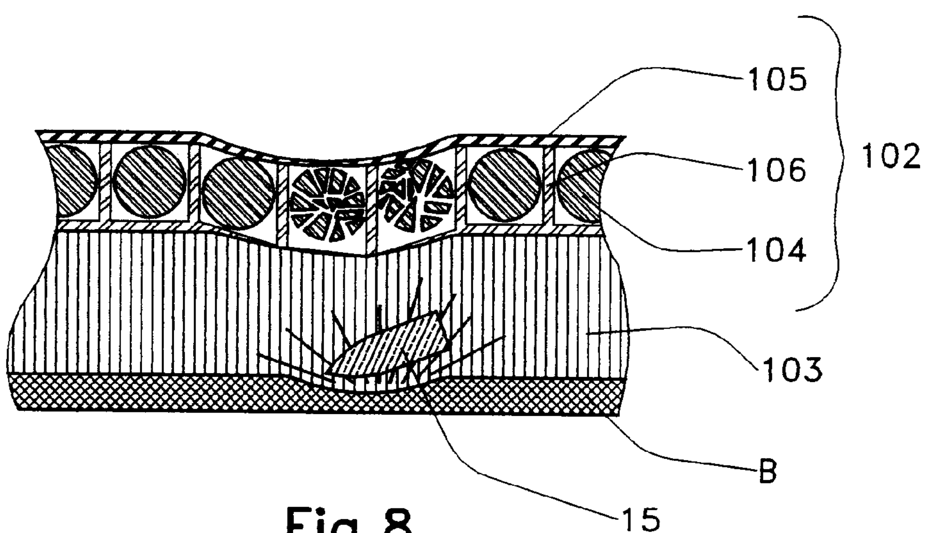

Fig.8