

BALLISTIC ARMOR PANEL

FIELD OF THE INVENTION

The present invention is generally in the field of ballistic armor panels and in particular it is concerned with a panel for protecting individual, equipment and structures against high energy ballistics, i.e. high speed fire arm projectiles or
5 fragments of explosives. The invention also concerns the bodies deployed within such ballistic armor panels.

BACKGROUND OF THE INVENTION AND PRIOR ART

Ballistic armor panels are utilized for a variety of protective purposes, in particular for reducing hit-risk of individuals, equipment, vehicles, structures, etc.
10 from small-arms projectiles or from fragments of explosive charges. For that purpose, armor panels should be capable of stopping a bullet or a projectile of an explosive charge within an extremely short distance, i.e. the effective thickness of the ballistic armor panel which is used for shielding the individual, vehicle or structure.

15 A variety of armor panels are known and are disclosed for example in U.S. Patents Nos. 3,523,057, 4,179,979, 4,602,385 and 5,361,678, all of which disclose ballistic armor panels comprising one or more layers of material holding a plurality of hard objects either of uniform shape or comprising different shapes and typically made of ceramic material for effectively distributing the impact of a projectile,
20 bullet, etc.



Of particular interest is International Publication Serial No. WO 98/15796 disclosing a ceramic body for deployment in a composite armor panel being substantially cylindrical in shape with at least one convexly curved end face, wherein the ratio D/R between the diameter D of the cylindrical body and the
5 radius R of the curvature of the at least one convexly curved end face is at least 0.64:1. The disclosure of this patent provides a thorough study convincing why it should be preferred to use circular bodies having at least an end face remote from the protected item (i.e. facing the impacting member, namely a bullet or a projectile) with a rounded face with a radius of curvature R as above.

10 A considerable disadvantage of the above-referred to patents is that they are not transparent and are thus not suitable for use where vision is a requirement, e.g. vehicle windows, etc. The case is so even when using components which are essentially transparent but which owing to radius of curvature act as a lens or of prism breaking light passing therethrough in a manner which prevents clear vision
15 therethrough.

Even more so, when considering the construction of the armor panel disclosed in the above WO 98/15796, it will be appreciated that the mechanism by which the bullets or projectiles are stopped is a function of the curvature of the spheric and of the cylindrical bodies, and its efficiency is determined by the
20 parameter of D/R .

It is an object of the present invention to provide a ballistic armor panel of improved ballistic characteristics and substantially reducing or overcoming the drawbacks of the prior art. It is a further object of the present invention to provide a cylindrical body for deployment in such a ballistic armor panel.

25 SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a ballistic armor panel comprising a carrier member and a plurality of cylindrical bodies made of a high density material, each body formed with two flat end faces having a normal coaxial with a longitudinal axis of the cylindrical body; said cylindrical bodies

being of equal diameter and equal length and are attached to the carrier member at their end faces with the longitudinal axis extending normal to the carrier member.

In accordance with one preferred embodiment two neighboring bodies are in contact with one another along their generatrix, i.e. having their longitudinal axes
5 parallel to one another.

In accordance with another preferred embodiment the carrier member is a flat board of material. The carrier member may be made of a composite material comprising fiber material. By one specific embodiment the carrier member is essentially pliable.

10 By one most preferred embodiment the carrier member and the cylindrical bodies are essentially transparent, rendering the armor panel transparency. According to this preferred embodiment, the cylindrical bodies are attached to the carrier member by a transparent bonding material, or by a welding process in which the transparency features remain.

15 In accordance with another specific embodiment of the present invention, intermediate three neighboring bodies there is provided a cylindrical filler body of equal length and made of a high density material, and formed with two flat end faces having a normal coaxial with a longitudinal axis thereof; said filler body being attached to the carrier member at one of its end faces with the longitudinal
20 axis extending normal to the carrier member; said filler body being in contact with the neighboring cylindrical bodies along their generatrix.

The arrangement is such that in use, the carrier member faces the object to be protected by the ballistic armor panel and where a free end of the cylindrical bodies constitutes an impact side thereof, to be encountered by the bullet,
25 projectiles or explosive fragments.

By another specific embodiment, the radii of each cylindrical body is significantly greater than its height or equal thereto, rendering the cylindrical bodies the shape of disks.

For practical means, the carrier member and plurality of cylindrical bodies may be received within a protective case which preferably is made of a transparent polymeric material.

In accordance with one specific arrangement, the cylindrical bodies are
5 arranged in a compact array of parallel rows.

In accordance with another aspect of the present invention there is provided a cylindrical body for use in a ballistic armor panel, said cylindrical body being made of a high density material and formed with two flat end faces having a normal coaxial with a longitudinal axis of the cylindrical body; said cylindrical body being
10 attachable to a carrier member at either of its end faces.

In accordance with a preferred embodiment of the second aspect, the cylindrical bodies are essentially transparent.

By one specific embodiment of the second aspect of the present invention the radii of the cylindrical body is significantly greater than its height, rendering it
15 the shape of a disk.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, a preferred embodiment will now be described, by way of some non-limiting examples only, with reference to the accompanying drawings, in
20 which:

Fig. 1 is a perspective view of a first embodiment of a ballistic armor panel in accordance with the present invention;

Fig. 2A is a side elevation of a body member used in conjunction with the ballistic armor panel of the present invention;

25 Fig. 2B is a modification of the cylindrical body seen in Fig. 2A;

Fig. 3 is a perspective view of a second embodiment of a ballistic armor panel in accordance with the present invention;

Fig. 4 is an isometric view illustrating still another embodiment of a ballistic armor panel in accordance with the present invention;

Fig. 5 illustrates a vehicle fitted with ballistic armor panels in accordance with different embodiment of the present invention; and

Fig. 6 is a personal protective garment fitted with a ballistic armor panel according to the invention.

5 DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Attention is first directed to Fig. 1 of the drawings illustrating a ballistic armor panel in accordance with the present invention generally designated **20** and comprising a carrier member **22** which depending on the application may be made of metal, composite material comprising fibers, e.g. Kevlar™ or Dynem™ etc.

10 In accordance with the specific embodiment, illustrated in Fig. 1, the carrier member **22** is made of a transparent polymeric material.

A plurality of cylindrical bodies **24** (see also Figs. 2) are made of an essentially hard material e.g. alumina, boron carbide, silicon carbide, glass, etc. The cylindrical bodies **24** have two end faces **26** and **28** both of which are parallel to one another and have a normal parallel to a longitudinal axis of the cylinder. The

15 cylindrical bodies **24** are attached to carrier member **22** by a suitable attachment, e.g. bonding, heat welding by use of a suitable polymeric material, etc.

As seen in Fig. 1, the cylindrical bodies **24** are arranged in a compact array wherein two neighboring cylindrical bodies are in contact with one another along their generatrix which is parallel to a longitudinal axis thereof ensuring a most

20 compact structure.

It was found that a structure of a panel as illustrated in Fig. 1 has an improved multiple hit capability i.e. has improved ballistic characteristics which have proved to be superior to prior art ballistic panels, in particular in obstructing

25 several bullets or fragments of an explosive charge hitting the free end **26** of the cylindrical body.

In order to reduce mechanical stress of the cylindrical bodies, at least their free end (referred to at times as an "*impact side*"), namely the end facing the

ballistic threat, are chamfered, as seen in cylindrical member **40** of Fig. 2B wherein its impact side **42** has a chamfer **44**.

The compact structure of the array of cylindrical bodies has an advantage over using polygonal bodies which are in surface contact with neighboring such
5 bodies, since the kinetic energy absorbed at the impact end of the cylindrical bodies is converted into mechanical damage thereof and is not transferred to neighboring bodies, as is the case in using polygonal bodies.

The structure of the armor panel in accordance with the present invention, as illustrated for example in Fig. 1, has a serious advantage in that the cylindrical
10 bodies **24** may be made of a transparent material and owing to the fact that the end faces **26** and **28** are flat and have their normals extending parallel to the longitudinal axes of the cylindric bodies, there is no distortion of light and thus, upon applying the cylindrical body **24** to a transparent carrier member **22**, using a transparent adhesive agent, then an essentially transparent ballistic armor panel is
15 obtained. This is useful in particular where it is required to protect windows of vehicles, etc. where vision is required.

An advantage of the arrangement seen in Fig. 1 is that it is about 10% lighter in weight as compared with armor panels providing similar protection.

Further attention is now directed to Fig. 3 illustrating another embodiment
20 of the invention generally designated **50** wherein the ballistic armor panel comprises a carrier member **52** as in Fig. 1, a plurality of cylindrical bodies **54** arranged in a compact array, the difference residing in that between three adjacent cylindrical bodies **54** there is deployed a cylindrical filler body **56** which is of equal length as of cylindrical bodies **54**, the arrangement being such that each such filler
25 body **56** is in tangential contact with three adjacent cylindrical bodies **54**.

It was found that this arrangement improves the multiple hit capability of the ballistic armor panel to coefficient of 3 bore diameters or more.

In the embodiment seen in Fig. 4, there is provided a ballistic armor panel generally designated **60** and comprising a carrier member **62** onto which are
30 attached a plurality of cylindrical bodies **64** which, distinct from the previous

embodiments are disk-like shaped, i.e. their radii is essentially larger or similar to their length. This arrangement is suitable for using particular with a personal ballistic garment, as it is lighter in weight and slimmer.

Preferably, where the armor panel is not intended for protecting a window,
5 and where transparency is not of importance, then the armor panel is received within a protecting case 56 which is useful on the one hand for improving ballistic resistancy (in case it is made of some reinforced composite material) and, on the other hand, provides some protection from splinters which may be splintered upon impacting of a bullet.

10 The embodiment of Fig. 5 illustrates the use of ballistic armor panels for protecting a VIP's vehicle. However, it will be appreciated that armor panels in accordance with the present invention may be used for protecting vehicles of any nature, namely military vehicles, airborne vehicles, etc.

The vehicle 70 seen in Fig. 5 comprises a plurality of ballistic armor panels
15 of which panels 72 are essentially transparent ballistic armor panels as described hereinabove with reference to Fig. 1. A plurality of armor panels 74 are received within protective cases as explained hereinabove e.g. with reference to Fig. 4 and serve for protecting the body of the vehicle.

In Fig. 6 there is illustrated a personal protective garment designated 80
20 which is typically made of a flexible woven composite material with suitable pockets holding one or more ballistic armor panels 82, in accordance with the invention which are typically of the slimmer design, i.e. as disclosed in Fig. 4 of the drawings. For improving flexibility of the armored garment instead of using a single panel 82 there may be provided two or more such panels attached to the
25 garment or received within suitable pockets.

A skilled person will appreciate that only some preferred embodiments have been shown and described in the specification and drawings. However, it is to be understood that it is not intended thereby to limit the disclosure of the invention, but rather it is intended to cover all modifications and arrangements falling within
30 the scope and spirit of the present invention, *mutatis mutandis*.

CLAIMS:

1. A ballistic armor panel (20) comprising a carrier member (22) and a plurality of cylindrical bodies (24) made of a high density material, each body (24) formed with two flat end faces (26; 28) having a normal coaxial with a longitudinal
5 axis of the cylindrical body (24); said cylindrical bodies (24) being of equal diameter and equal length and are attached to the carrier member (22) at their end faces (28) with the longitudinal axis extending normal to the carrier member (22).
2. A ballistic armor panel (20) according to claim 1, wherein two neighboring bodies (24) are in contact with one another along their generatrix.
- 10 3. A ballistic armor panel (20) according to claim 1, wherein the carrier member (22) is a flat board of material.
4. A ballistic armor panel (20) according to claim 1, wherein the carrier member (24) is essentially transparent.
5. A ballistic armor panel (20) according to claim 1, wherein the carrier
15 member (24) is made of a composite material comprising fiber material.
6. A ballistic armor panel (20) according to claim 1, wherein the carrier member (22) is essentially pliable.
7. A ballistic armor panel (20) according to claim 1, wherein the cylindrical bodies and the carrier member are essentially transparent, rendering the armor
20 panel (22) transparency.
8. A ballistic armor panel (50) according to claim 2, wherein intermediate three neighboring bodies (54) there is provided a cylindrical filler body (56) of equal length and made of a high density material, and formed with two flat end faces having a normal coaxial with a longitudinal axis thereof; said filler body 56
25 being attached to the carrier member 52 at one of its end faces with the longitudinal axis extending normal to the carrier member (52); said filler body (56) being in contact with the neighboring cylindrical bodies (54) along their generatrix.
9. A ballistic armor panel according to claim 1, wherein at use the carrier member (22; 52) faces an object to be protected by the ballistic armor (20; 50) and

where a free end (26; 42) of the cylindrical bodies constitutes an impact side thereof.

10. A ballistic armor panel (60) according to claim 1, wherein the radii of each cylindrical body (64) is significantly greater than its height.

5 11. A ballistic armor panel (60) according to claim 1, wherein the carrier member (62) and plurality of cylindrical bodies (64) are received within a protective case (66).

12. A ballistic armor panel (60) according to claim 11, wherein the protective case (66) is made of an essentially transparent polymeric material.

10 13. A ballistic armor panel (20; 50) according to claim 1, wherein the cylindrical bodies (4; 54) are arranged in a compact array of parallel rows.

14. A cylindrical body (24; 40; 54) or use in a ballistic armor panel, said cylindrical body (24; 40; 54) being made of a high density material and formed with two flat end faces (26; 28; 42) having a normal coaxial with a longitudinal
15 axis of the cylindrical body; said cylindrical body being attachable to a carrier member (22; 52; 62) at either of its end faces.

15. A cylindrical body according to claim 14, being essentially transparent.

16. A cylindrical body (64) according to claim 14, wherein the radii of the cylindrical body is significantly greater than its height.