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(54) **ARTICLES, MANUFACTURES, AND ASSEMBLIES UTILIZING CONFIGURED AND SIZED PLATES COMPRISED OF PENETRATION-PROOF LAMINATED CONSTRUCTS FORMED OF ASYMMETRIC COMPOSITE MATERIALS**

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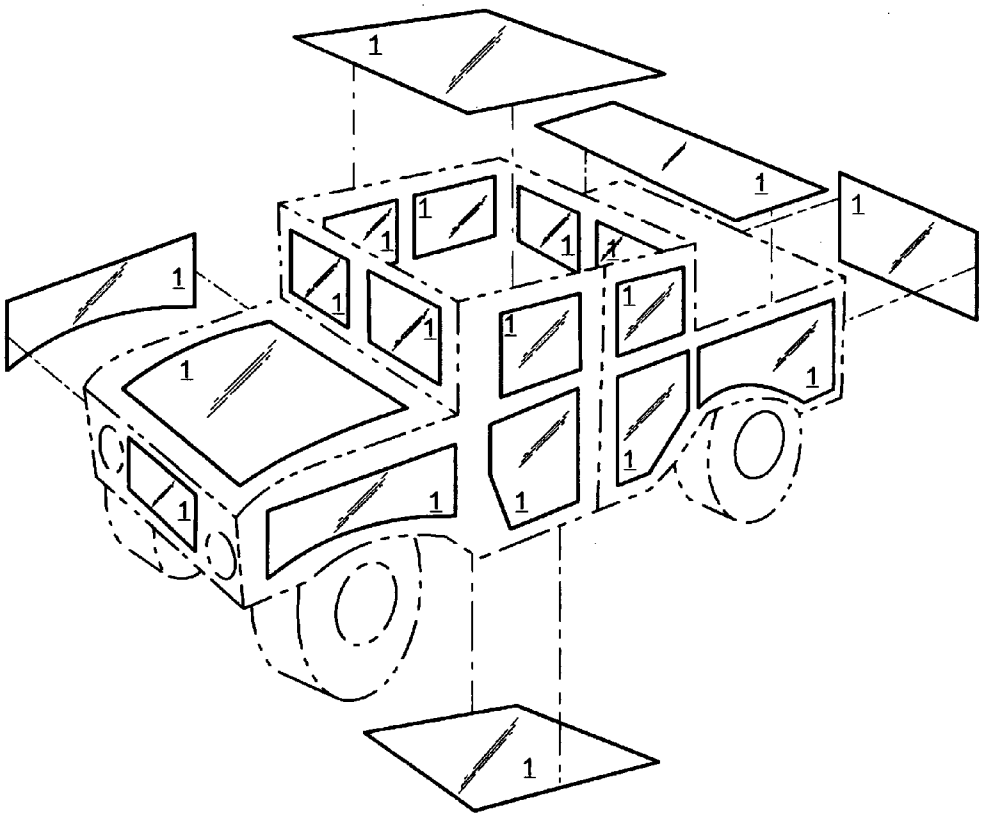
(57) **ABSTRACT**

The present invention is directed to structures, constructions and assemblies able and functional to protect living subjects from a range and variety of moving objects differing in size, volume, and overall shape; from projectiles traveling at many different rates of speed, and from the effects of exploding and/or advancing solid fragments moving at high velocity. More specifically, the present invention relates to protecting living human and animal subjects through the use of three-dimensional designed structures and assemblies which employ configured and dimensioned penetration-resistant plates prepared from laminated constructs comprising multiple individual layers composed of asymmetric composite materials. These penetration-resistant plates will protect living subjects from high velocity projectiles and fragments in both civilian and combat situations.

More specifically, the invention relates to protecting subjects through the use of penetration-resistant prepared plates for use in a wide range and variety of erections, constructions and assemblies. As typical examples, the penetration-resistant plates can be used to great advantage as in the making of shatter-proof windows, doors, curtain wails, face masks, vests, flooring, helmets, tires, computer screens, television screens, housing, aircraft shelters/bunkers, boats, security vehicles, buildings, automotive, sport arenas, guard shields.



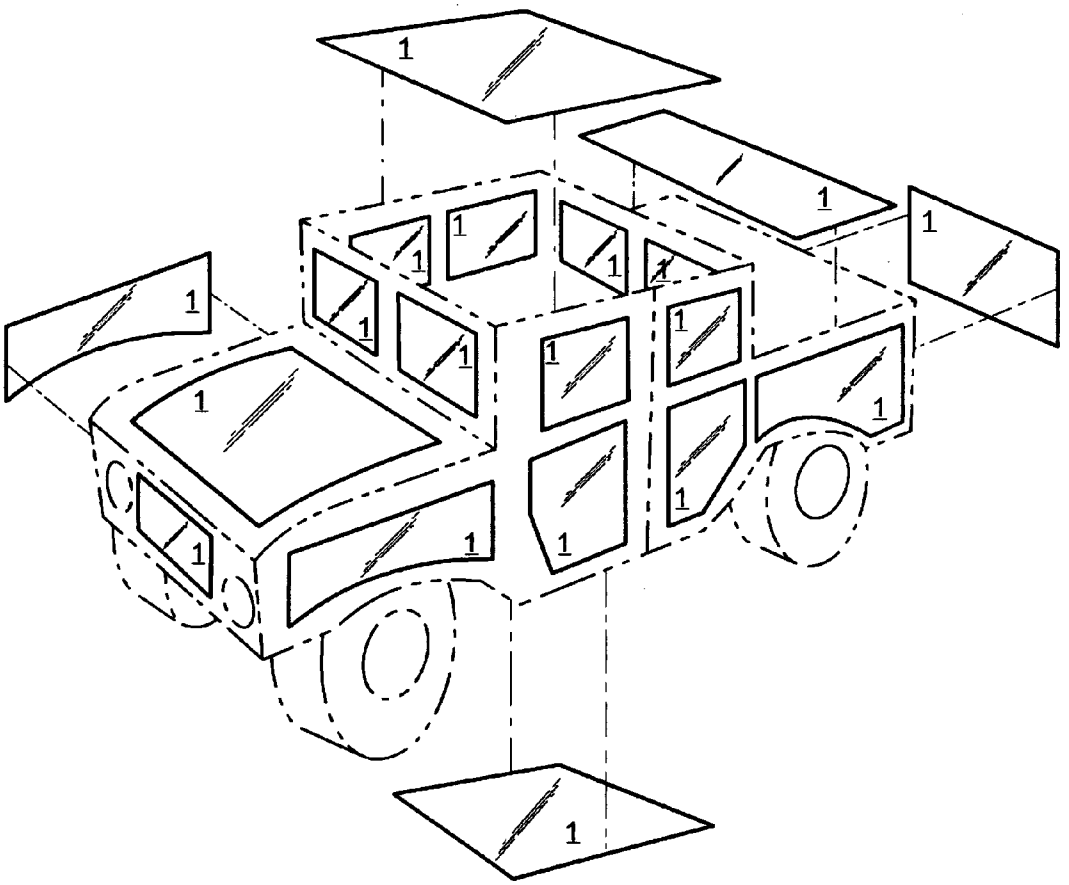


Fig. 1

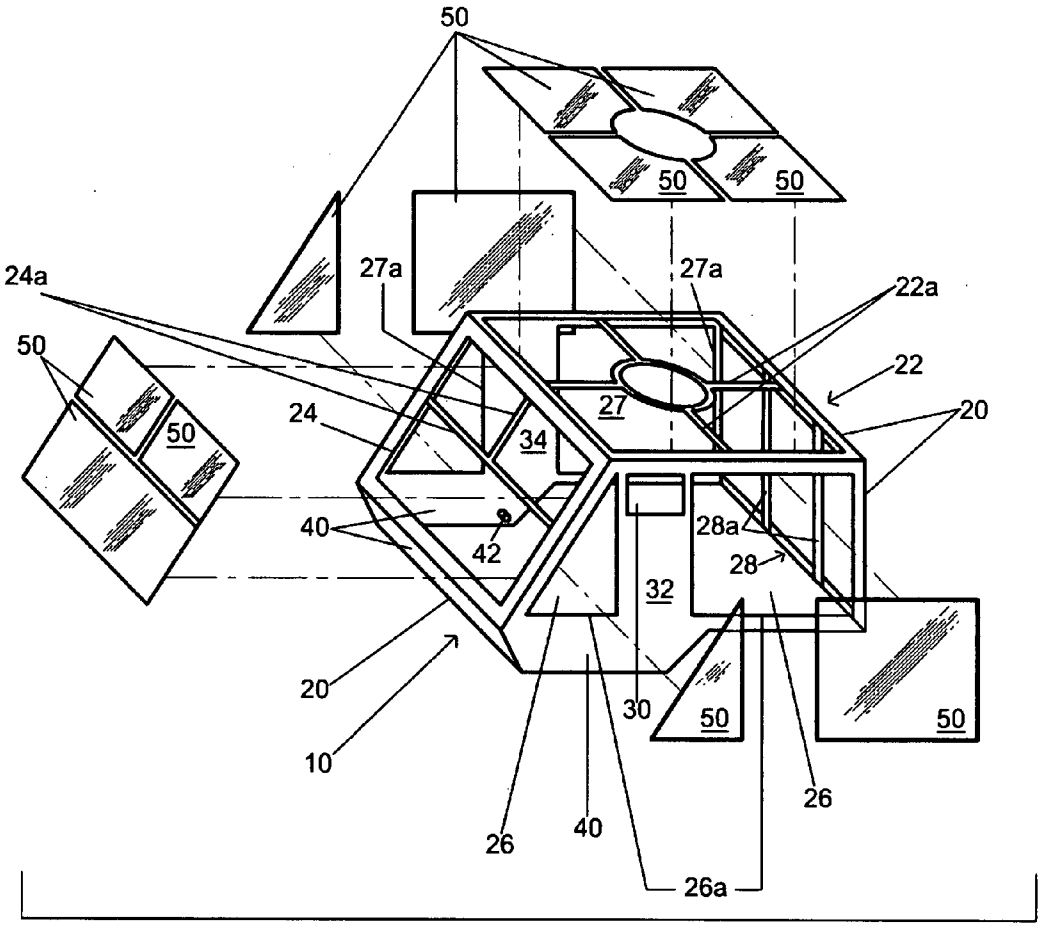

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Fig. 2

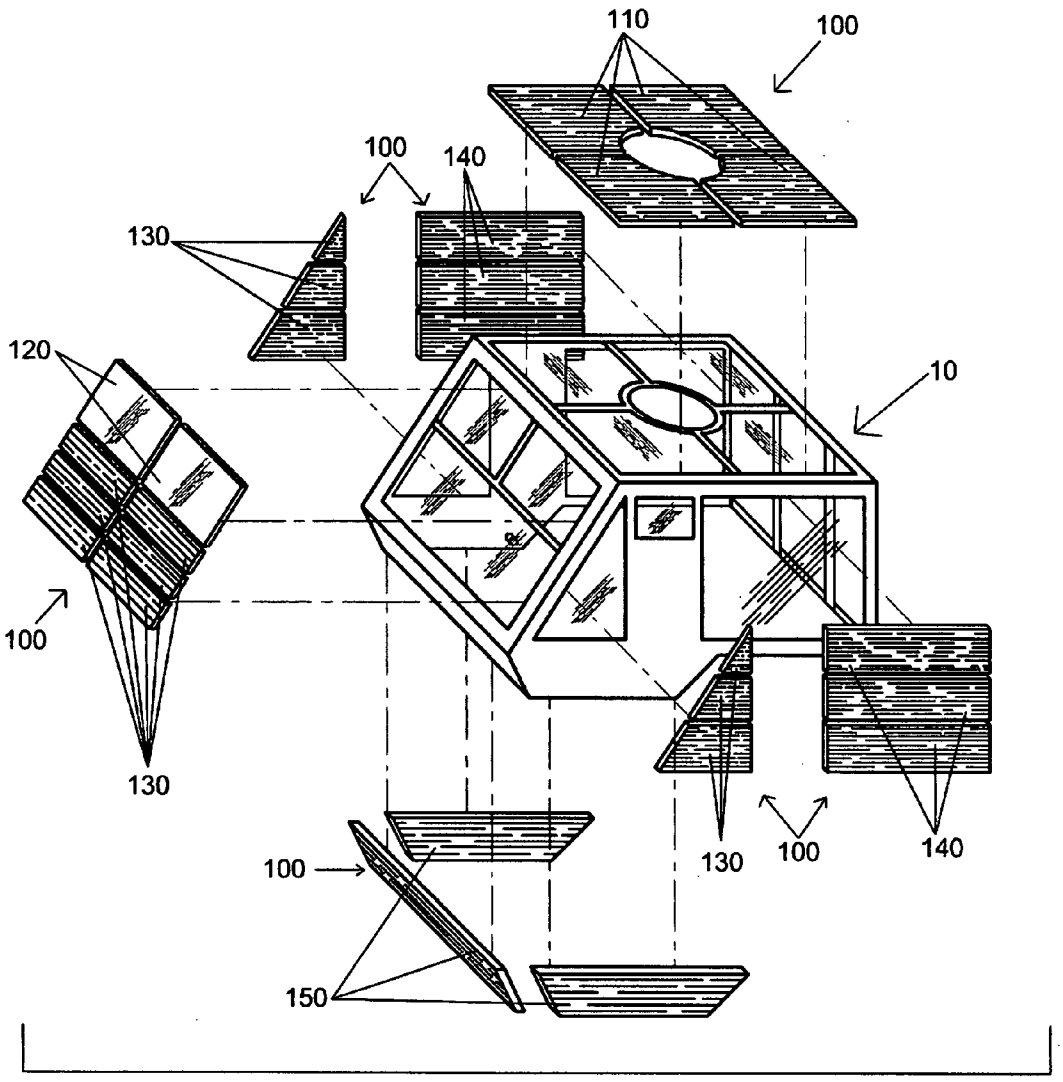

Fig. 3

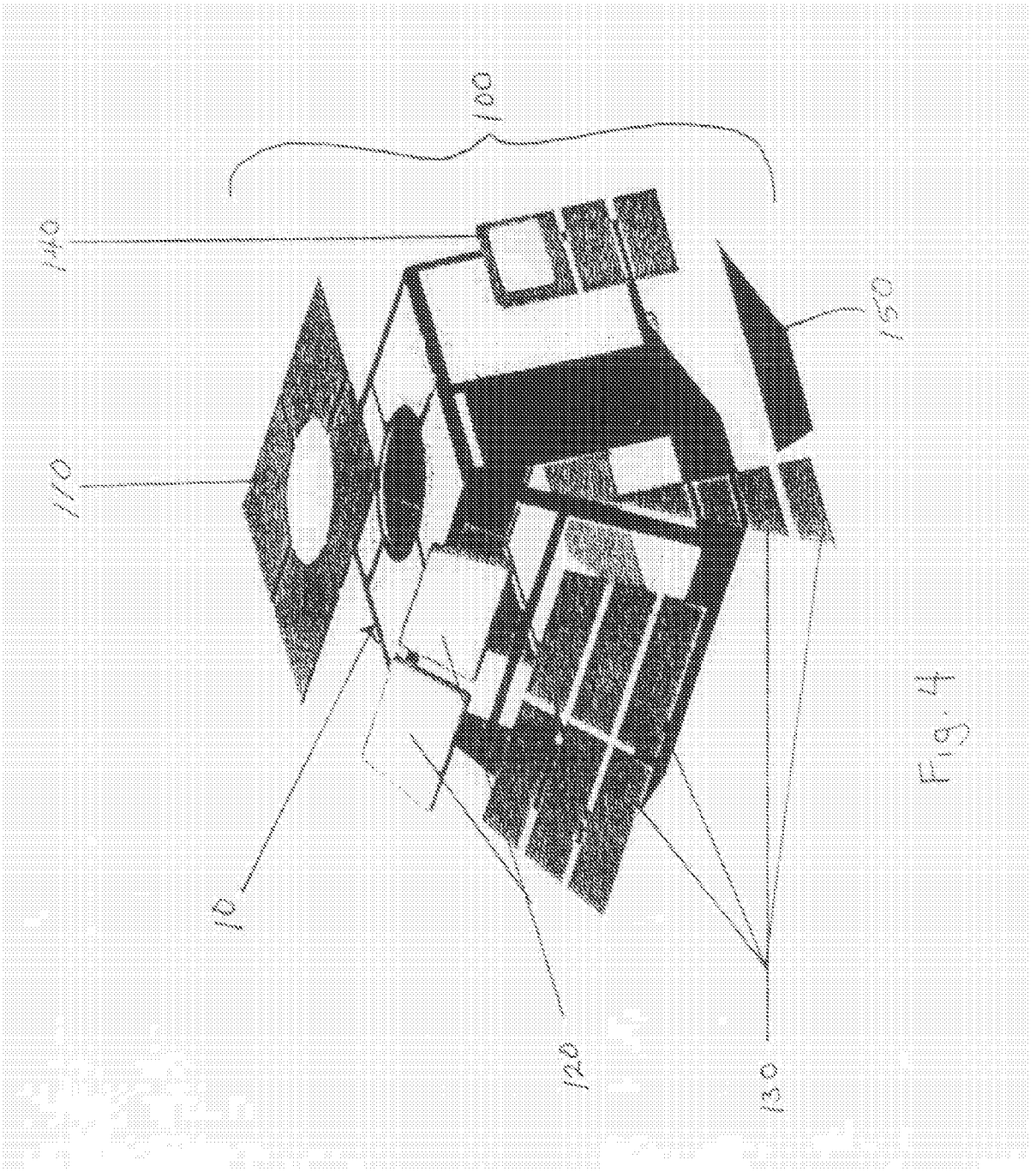

Fig. 4

ARTICLES, MANUFACTURES, AND ASSEMBLIES UTILIZING CONFIGURED AND SIZED PLATES COMPRISED OF PENETRATION-PROOF LAMINATED CONSTRUCTS FORMED OF ASYMMETRIC COMPOSITE MATERIALS

CROSS-REFERENCE

[0001] The present invention is a Continuation-In-Part of U.S. patent application Ser. No. 10/978,880 filed Jun. 29, 2004, now pending; which is a Continuation of International Patent Application No. PCT/US2004/043513 filed 22 Dec. 2004, now pending. The legal benefit and priority of these previously filed applications is expressly claimed.

FIELD OF THE INVENTION

[0002] The present invention is concerned generally with penetration-proof fabrications and constructions useful for the protection of living human and animal subjects from high velocity projectiles and explosion fragments in both civilian and military combat situations; and is directed particularly to articles, manufactures, and assemblies, constituted of configured and dimensioned plates which have been previously prepared as penetration-proof laminated constructs composed of asymmetric composite materials, and which are able to protect and defend living subjects from traumatic injury and/or death

BACKGROUND OF THE INVENTION

[0003] it is an unfortunate and undisputed fact today that, over the course and duration of even an average human lifetime, one encounters many threatening situations and perilous circumstances which are potentially injurious, if not actually life endangering. Exemplifying some of these precarious incidents are: (i) the many hazardous episodes and potentially injurious events typically occurring in nature such as squalls and storms, high wind gales and tornadoes, and the often massive hurricane winds and typhoons capable of destroying homes, offices, and other buildings in our towns and cities; (it) the serious risks and jeopardy to one's person commonly caused by chance accidents and uncontrolled collisions of rapidly moving autos, buses, and trucks as well as the ill fated encounters between water vessels such as pleasure boats, ocean liners and marine freighters; (iii) the perilous and frequently tragic danger to human life and limb caused by the exploding charges, bombs and other detonated devices of terrorist attacks; and (iv) the always-present dangers and often imminent vulnerabilities to the bodies and lives of soldiers, sailors, and airmen caused by modern weaponry and ordinance during training exercises or in actual combat situations.

[0004] Clearly however, the degree of jeopardy to the body and life of a living human or animal subject will vary in severity and degree with each of these commonly occurring circumstances and risk categories. Also, the precise nature of the threat that one faces and the time duration for the risk of injury that one encounters within each of these different situations is disparate and markedly diverse.

[0005] Nevertheless, what is uniformly shared among all these unpredictable conditions and uncertain predicaments is the very real danger to life and limb caused by the penetration and subsequent shattering of solid objects and/or the direct physical impact of flying items or high velocity projectiles, regardless of how they came to be moving entities traveling at speed. Thus, there is a mutually shared need for living beings to avoid the risk of injury and death in all of these hazardous situations and/or high risk occurrences, as well as a commonly held desire to protect one's person and well-being against the potentially serious injurious effects caused by physical contact with solid objects, shattered fragments, and moving projectiles traveling at even moderate speeds.

SUMMARY OF THE INVENTION

[0006] The present invention has multiple aspects, formats, and applications.

[0007] A first aspect of the invention provides a prepared kit for the substitution and replacement of penetrable glass objects with impervious light-transmitting articles, said kit comprising:

[0008] at least one penetration-resistant and light-transmitting plate prepared as a laminated construct comprising not less than 3 individual layers of asymmetric composite materials joined together in series as at least one discrete stack, said penetration-resistant plate having a determinable configuration and fixed dimensions and presenting demonstrable penetration resistance-properties against a moving object having a determinable size, mass and velocity.

[0009] A second aspect of the invention is a prepared kit for the protection of penetrable glass objects with an impervious light-transmitting overlay assembly, said kit comprising:

[0010] at least one framework of pre-designed shape and size able to support and align at least one penetration-resistant plate in position over a penetrable glass object as a protective safety barrier overlay;

[0011] fastening means for holding said framework plate at a chosen location over and adjacent to a penetrable glass object; and

[0012] at least one penetration-resistant and light-transmitting plate prepared as a laminated construct comprising not less than 3 individual layers of asymmetric composite materials which are joined together in series to form at least one discrete stack, said plate having a determinable configuration and fixed dimensions and presenting demonstrable penetration-resistance properties against a moving object having a determinable size, mass and velocity.

[0013] A third aspect of the invention includes a standard vehicle production cab assembly for inclusion within a newly manufactured vehicle, said assembly comprising:

[0014] an overview support structure comprising a predesigned three-dimensional cab framework having distinct sections and viewing zones which serves as an observation dome and viewing compartment for a newly manufactured vehicle;

[0015] mounting provisions for integrally joining said overview support structure to the lower body of a newly manufactured vehicle; and a plurality of differently configured and dimensioned penetration-resistant plates prepared as laminated constructs comprising not less than 3 individual layers of asymmetric composite materials joined together in series as at least one discrete stack, each of said plates having a determinable configuration and fixed dimensions and presenting demonstrable penetration resistance properties against a moving object having a determinable size, mass and velocity.

[0016] A fourth aspect of the invention presents an attachable and detachable on-demand armor array comprising:

[0017] an organized arrangement of discrete armor plates which can be attached on-demand to a pre-existing vehicular cab assembly as a planned disposition of armor plating and be subsequently removed at will repeatedly, wherein each armor plate of said arrangement is

[0018] (i) a prepared plate of predetermined shape, size, and mass which presents enhanced penetration resistance properties against a moving object having a determinable size, mass and velocity; and

[0019] (ii) a laminated composite comprising not less than 3 individual layers of asymmetric composite materials joined together in series as at least one discrete stack.

BRIEF DESCRIPTION OF THE DRAWING

[0020] The present invention may be more readily appreciated and more easily understood when taken in conjunction with the accompanying Drawing, in which:

[0021] FIG. **1** is an illustration of typical engineer schematic drawings of elements of a Medium Tactical Replacement Vehicle (or "MTRV"), with associated installation areas of doors and windshield for the composite materials, with cross section drawings of the composite material, in frame, in a standard installation configuration;

[0022] FIG. **2** is an illustration of a High Mobility Multipurpose Wheeled Vehicle (or "HMMWV") and associated composite panels according to a preferred embodiment of the invention;

[0023] FIG. **3** is an illustration of a standard vehicle production cab assembly of the present invention; and

[0024] FIG. **4** is an illustration of an organized arrangement of discrete armor plates which can be attached on-demand to a pre-existing vehicular cab assembly as a planned disposition of armor plating and then be subsequently removed at will, repeatedly in cycles.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

I. Overall Scope of the Present Invention

[0025] The present invention is directed to structures, constructions, assemblies and arrays capable of protecting living subjects from a range and variety of moving objects which typically differ in size, shape and mass; can travel at moderate to very high rates of speed; and cause serious injury or death as a consequence of physical impact with the body of a living subject. More specifically, the present invention relates to protecting living human and animal subjects through the use of three-dimensional designed manufactures, assemblies and arrays which use penetration-resistant plates prepared as laminated constructs having a plurality of layers composed of asymmetric composite materials. These purposefully designed articles, manufactures, and assemblies will protect living subjects from rapidly moving objects, from high velocity projectiles, and from exploding fragments under both civilian circumstances and combat situations.

[0026] More specifically, the present, invention relates to protecting living subjects through the use of purposely formulated laminated composites, each of which comprises multiple layers of asymmetric composite materials joined in overlay series; and which laminated composites are then configured, sized, and optionally contoured to pre-chosen specifications for future use as penetration-resistant plates suitable in a wide range and variety of frameworks, erections, and deployments.

[0027] For example, once prepared, the penetration-resistant plates can be used to great advantage in the making of shatter-proof windows, doors, flooring, curtains, and walls; for fabricating protective facemasks, vests, helmets, guard shields, and other protective apparel; in manufacturing computer screens and television screens; for producing impermeable tires, aircraft bodies, shelters/bunkers, boats, and security vehicles; and for erecting explosion-proof housing, buildings, offices, and sport arenas. It is understood that, these individually listed items are merely exemplary of the range and variety of possible embodiments, and the above-given listing shall not be construed to be exclusive or limiting for the subject mater as a whole comprising the present invention. All of these articles, manufactures, constructions, and assemblies can be advantageously employed in many different settings; in a diverse range of risk circumstances that vary greatly; and with particular modifications and engineering specifications which allow their immediate deployment and use with a minimum of difficulty by any person of ordinarily skill.

[0028] While the present invention is expected and intended to appear in multiple embodiments and in many different formats, some preferred examples and embodiments of the invention will be described in detail hereinafter, albeit with the clear understanding that the particulars of these embodiments are only illustrative and representative of the formats and applicability for the present invention; and that the true breadth of the invention is not limited in form nor restricted in scope to the exemplary embodiments provided herein.

DEFINITIONS, TITLES & TERMINOLOGY

[0029] To provide greater clarity and ease of comprehension, as well as to avoid ambiguities in wording and a confusion of nomenclature, the following titles, terms and definitions are provided. As concerns the description and details of the present invention, the following terms, definitions, and meanings will be employed routinely and consistently.

[0030] Composite and composite material: a formulated composition or prepared substance composed of different chemical constituents which are combined or blended together to form a single synthetic compound having certain physical attributes and/or chemical properties.

[0031] Layer: A planar sheet, film, fabric, or covering of matter formed using only one formulated composition or individual substance.

[0032] Substrate: A single bed, stage or tier of matter formed using two or more distinct layers of matter having differently formulated compositions and different substances in series or sequential sequence.

[0033] Stratum and/or strata: A more general title and common name for any plane, coating or ply of material which exists and can be identified as being either a layer or a substrate.

[0034] Stack, stack of matter, and/or stacked material): A plurality of different layers, or a plurality of different composed substrates, or a plurality of different layers and substrates joined together in combination as a single aggregate.

[0035] Laminate and laminated construct: At least one stack, and usually multiple discrete stacks of matter joined together in sequence, which form a unified entity and single article of manufacture.

[0036] Plate: A flat pane, panel or slab of determinable dimensions, configuration, volume, and mass which is prepared and exists as a laminated construct formed as multiple layers of asymmetric composite materials.

[0037] Asymmetric and asymmetry: A physical property and dimensional attribute of matter which describes the individual thickness (or girth) for either a layer, or a substrate, or a stack of matter which may exist as part of the laminated composite, and where the thickness of one specific material layer, substrate, or stack within the laminate composite varies, is non-uniform, or is different from other individual layers, substrates, or stacks present in the composite as a whole.

[0038] Penetration-resistance (and of being penetration-resistant): The physical property and attribute of a material to withstanding being pierced, split or fragmented and to prevent being penetrated by the impact force of a moving object traveling at a measurable rate of speed.

[0039] High velocity. Projectile rates of speed in the range from approximately 1500 to 9000 (or more) feet per second.

[0040] Explosion fragments: Any type of high velocity projectiles whose speed is generated by an explosion or an explosive force.

[0041] Opaque: a material which is totally absorbent of visible light rays of a specified wavelength and thus fails to allow visibility when viewing through the material from one side to the other.

[0042] Transparent: a material which allows the visible light rays of a specified wavelength to pass without substantial absorption and thus allows visibility when viewing through the material from one side to the other.

[0043] Translucent: a material which is capable of transmitting light, but through which no image or object can be seen.

II. The Nature and Kinds of the Asymmetrical Composite Materials Used in Making the Laminated Constructs

A. The Laminated Constructs as Tangible Workpieces

[0044] It is critical and essential to recognize and appreciate the nature and dimensional requirement, for the asymmetrical composite materials used in the making of the laminated constructs—which are subsequently employed as tangible workpieces and component parts in the making of the articles, manufactures, and assemblies of the present invention. As defined above, the characteristic of "asymmetry" refers to the thickness dimension of a composite material, a size dimension which exists and is part of the laminated construct organization. Asymmetry is an essential physical requirement and unique feature which identifies and describes the individual differences in thickness (or girth) for either a layer or a substrate composed of a particular composite material, wherein the thickness of that composite material in a discrete one stack of the laminate construct varies, or is inconsistent, or is measurably different from the thickness(es) of that same composite material in any other individual stack (s) also then present within and forming a component part of the laminated construct as a single unitary article.

[0045] The use of asymmetric intermediate materials is also expected and envisioned with the use of different substrate materials, with one or more distinct layers situated as a stratum. Examples of such stratum uses are: employing glasses of different types; utilizing a variety of different polycarbonates; using alternative formulations of steel and other metallic alloys; incorporating refractory ceramics of varying formulations; and applying Kevlar, S Glass steel meshes, and other previously manufactured synthetic compositions.

[0046] As a simple illustrative example, if a first layer formed of a particular composite material has a thickness dimension of 1.5 mm, then at least one of the subsequent layers or strata using or applying that same composite material must be quantitatively different in thickness (or girth) from the 1.5 mm thickness dimension employed by the first layer. Thus, layers or strata that are 1.3 mm, 1.4 mm, 1.6 mm, and the like (i.e., not 1.5 mm in size) are acceptable as asymmetric examples. In addition, a single composite material may be employed within a series of different asymmetric stacks; which, in the alternative, may be present as a plurality of only asymmetric layers, or exist as a solid mixture of asymmetric and symmetric layers/strata in combination.

[0047] As a simple illustrative example therefore, if the construct of choice is a laminated solid article that comprises a plurality of separately positioned and distinguishable single layers, all of which are identically composed of the same composite material, then each of the individually positioned layers must be asymmetric, or be different, in its thickness dimension. Thus each distinct and distinguishable layer formed of the same substance constitutes an individual stratum which differs from all the others by its thickness (or girth) dimension. In this manner, each of the individual layers, albeit formed of the same composite material, has a singular thickness which differs from the others; and each layer (or stratum) is positioned one on top of the other as a series of overlays such that the totality of multiple asymmetric layers in combination thereby forms a single unitary stack. Then, by repeating this process and maintaining the asymmetry of thickness requirement for each discrete stack, a plurality of (i.e., two or more) different asymmetrical stacks can be prepared; and each of these individually prepared stacks can then be joined together in sequential series to form a fused and consolidated laminated construct.

[0048] It will be noted that the joining of multiple individual asymmetrical stacks together to achieve a merged and unified laminated construct can be achieved by using one or more of the many commonly available adhesives which can be applied in different ways; or by bonding the prepared stacks together using one or more of the conventionally known bonding techniques that are well known in industry and widely documented in the technical literature. Material bonding or curing procedures that utilize heat, compression, chemical reactions, radiation, and UV light are preferred and commonplace in this technical field [See for example, the laminate manufacturing techniques described within U.S. Pat. No. 5,443,883, the entire text of which is expressly hereby incorporated by reference].

B. The Choice of Composite Materials

[0049] It will be intuitive to those of skill in the art that a wide range of composite materials can be used in the making of discrete layers, substrates and stacks for the manufacture of the laminated construct, each chosen composite material being able and well suited to provide particular properties. For example, a variety of prepared-in-advance composite materials can be employed, which typically include plastics, glass, aluminum silicates, ionomer resins, metals, rubbers, rigid aramid fiber materials, synthetic film, fabric, ceramics, or different combinations of these materials. These prepared-

in-advance composite materials are frequently used in the fabrication of light-transmitting—i.e., opaque, translucent, and transparent—laminated constructs.

[0050] It will be noted in particular that a variety of opaque and clear ceramic materials are available under the trademark TORVEX® from E. I. Du Pont de Nemours & Co.; and that rigid and flexible aramid fibers, such as those sold under the trademark KEVLAR®, are very desirable for use. Furthermore, a range of desirable composite materials identified by the trademarks SENTRYGLAS® and SENTRYGLAS PLUS® are commercially sold; and a frequently used plastic composite material available under the trademark LEXAN®—are all manufactured and sold today by E. I. Du Pont de Nemours & Co. Other prepared light-transmitting composite materials sold under the mark VISTASTEEL™ are also commercially available from American Defense Systems, Long Beach, N.Y.

[0051] In addition, and as merely a second illustrative list of representative choices, an alternative category of suitable composite materials typically includes polybenzoxazole ("PBO"); polybenzothiazole ("PBT") polymers or related copolymers; thermoplastic polymers (such as polyethylene, polycarbonate, etc.); thermosetting polymers (such as vinyl ester, polyvinyl butyral ("PVB"), epoxy resins, polyvinyl urethanes, etc.); and elastomers (such as polybutadiene, natural rubber, etc.).

[0052] For best results, a very preferred listing of prepared-in-advance composite materials typically includes many diverse kinds and types of glass, ionomer resins, polycarbonates, steel, ceramics, KELVAR, and S Glass steel mesh. For example, AR 500 steel (a high hardened steel manufactured by a variety of different specialty steel manufacturers) and ionomer resins (existing as sodium salts or potassium salts) are available under the trademark SURLYN® from E.I. Du Pont de Nemours & Co., or under the trademark PRIMACORE® from the Dow Chemical Company.

[0053] It will be appreciated that the different and diverse listings of suitable composite materials provided herein are merely illustrative and representative of the commercially available choices; and the examples of the above-given listings should not be construed as being exclusive or limiting in any manner. Many other prepared-in-advance composite materials are suitable for use, are commonly known and may be easily obtained from commercial sources, some of which are alternative formulations or species of the aforementioned materials. Accordingly, any given list of such composite materials is deemed to be non-inclusive, incomplete, and unnecessary for practitioners ordinarily skilled in this technical field.

C. The Penetration-Resistance Properties Provided by the Asymmetric Composite Materials

[0054] The property and demonstrable attribute of penetration-resistance to impact or attack by rapidly moving objects is one of the most essential and critical qualities provided by the asymmetric composite materials in the laminated constructs. However, the presence or absence of this crucial property—effective resistance to penetration by the impact, force of a moving object of determinable size, mass, and velocity—for any formulated composition or manufactured substance is neither apparent, nor foreseeable, nor predictable. To the contrary, recognition that the attribute of penetration-resistance actually exists and is provided by any specific composite material, particular chemical compound, or individual composition of matter depends almost entirely upon direct experimental testing and empirical proof. This was previously and remains today the prevailing view of practitioners within this technical field, and the underlying reasons for this position and commonly accepted belief are abundantly clear.

[0055] It will be recognized and appreciated that the overall force generated by a moving object at the time of its impact upon any formulated composition of matter or manufactured substance will largely vary with and depend upon two distinct factors, which are: (a) the object's physical qualities and intrinsic characteristics, such as its dimensions, volume, shape, mass (or weight), malleability, tensile strength, and hardness; and (b) the rate of speed or travel velocity for the moving object at the moment of impact.

[0056] Thus, for example, when evaluating penetration-resistance among similar thicknesses of the same substance, the capability to avoid being penetrated by an impact force will markedly deviate and vary when the moving object is one of the following; (i) a 2000 pound car driven at 45-95 miles per hour by an out-of-control driver; or (ii) a 8 foot length of 2×4 inch lumber moving between 100-125 miles per hour as a result of hurricane force winds; or (iii) a 9 millimeter lead bullet traveling at 2500-9000 feet per second after being fired from a hand gun.

[0057] Also, as an operational guideline, an object having a larger size and mass will typically travel at a relatively slow to moderate rate of speed, and thus will require a lesser degree of resistance property to prevent penetration of the material upon impact. Conversely, an object of small size and mass will often travel at a much greater rate of speed; and thus the material will be required to demonstrate a much greater degree of penetration-resistance to avoid being pierced, punctured, perforated, fragmented, or shattered.

[0058] Accordingly, if the test material undergoing experimental evaluation empirically demonstrates effective penetration-resistance to high-velocity projectiles of small mass and size, then it may be properly believed and expected that that test material will provide more than adequate penetration-resistance properties against the impact force generated by moving objects of larger size and mass.

[0059] Through prolonged empirical testing, it has been empirically determined that the prepared-in-advance composite materials used herein for making a laminated composite are durable and effective in terms of their capabilities to withstand penetration by high velocity, small mass projectiles. To demonstrate this penetration-resistance capacity, and as one exemplary illustration representative of such compositions and formulations generally, the empirical data and details of Table 1 are provided below.

TABLE 1

Composite Materials	Projectiles	Tests	Weight	Thickness
AlfaClass.5.NS-SGP	9 mm FMJ-1400 FPS	Exceeds UL, NIJ, HP White	6.08 lbs	50 inches
AlfaClass75.NS-SGP	357 Mag158 grs lead 1450 FPS	Exceeds UL, NIJ, HP White	6.75 lbs	0.75 inches

TABLE 1-continued

Composite Materials	Projectiles	Tests	Weight	Thickness
AlfaClass.1.01.NS-PC	44 Mag-240gr lead 1470 FPS	Exceeds UL, NIJ, HP White	8.14 lbs	1.01 inches
AlfaClass.1.01.NS-PC	0.454 Casull 300 grs lead 1550 FPS	Never Tested Before - Beyond Tesing Parameters	8.14 lbs	1.01 inches
AlfaClass.1.01.NS-PC	12 Ga. Shotgun Breneke Slugs	Exceeds UL, NIJ, HP White	8.14 lbs	1.01 inches
Bravo Class. 1.243 NS-PC	0.499 Mini 50 cal express round	2 hits, six inches apart at 15'	10.75 lbs	1.2 inches
Bravo Class. 1.403. S-SGP	5.56 NATO Round	5 hits less then 8" apart at 15'	13.85 lbs	1.403 inches
Bravo Class. 1.305. NS-PC	5.56 AP-NATO Round	1 hit a 15 feet	10.65 lbs	1.305 inches
Bravo Class. 1.305. NS-PC	AK 47	3 hits at 15 feet	10.65 lbs	1.305 inches
Bravo Class. 1.5. NS-PC	AK 74	5 hits at 15 feet	11.37 lbs	1.5 inches
Bravo Class. 1.5. S-SGP	7.62 NATO M-80 Ball	3 hits at 15 feet	10.6 lbs	1.5 inches
Bravo Class. 1.7. S-SGP	7.62 NATO M-80 Ball	5 hits at 15 feet	18.52 lbs	1.7 inches
Bravo Class. 1.745. NS-PC	7.62 NATO M-80 Ball & AK47	13 hits 3-4" apart at 15 feet	17.13 lbs	1.745 inches
Delta Class. 1.745. NS-PC	300 Winchester Mag	2 hits 4" apart at 15 feet	17.13 lbs	1.745 inches
Delta Class. 1.745. NS-PC	300 Weatherby Mag	9 hits 6" apart at 15 feet	17.13 lbs	1.745 inches
Delta Class. 1.950. NS-PC	30.06 AP	1 hit at 15 feet	22.31 lbs	1.95 inches
Delta Class. 1.950. NS-PC	7.62 AP	3 hits 8" apart at 15 feet	22.31 lbs	1.95 inches
Delta Class. 1.850. NS-PC	0.30 Cal AP	1 hit at 15 feet	21.42 lbs	1.85 inches
Tango Class. 2.0. NS-PC	0.50 cal NATO Ball FMJ 700 Grs.	1 hit 100' by 36" barrel	20 lbs	2.05 inches
Tango Class. 2.356. NS-SGP	0.50 cal NATO Ball FMJ 700 Grs.	1 hit 100' by 28" barrel	28.23 lbs	2.3 inches
Tango Class. 2.8. NS-PC	0.50 cal API/PPI Athena - FN USA	1 hit 75 yds by 28" barrel	28.88 lbs	2.6 inches
Tango Class. 3.1 NS-PC	0.50 cal API NATO Silver Tip	2 hits 75 yds by 28" barrel	33.16 lbs	3.4 inches
Tango Class. 3.55 NS-PC	0.50 Cal API-LaMas Urban SWAT	3 hits 8" apart 28" Barrel 100'	37.22 lbs	3.55 inches

[0060] Clearly, Table 1 presents the empirical results of multiple performance tests experimentally conducted using a variety of different composite materials of varying thicknesses. The empirical data of Table 1 illustrates that the attribute of effective penetration-resistance does exist in fact as a distinct and demonstrable property for a range of different composite materials, and in particular identifies a variety of diverse substances able to resist penetration after being impacted by high-velocity projectiles.

[0061] In addition, it will be appreciated that while Table 1 displays the penetration-resistance of many effective composite materials, the data provided by this table does not present nor illustrate the other compositions or substances that were empirically tested, but which failed to resist being penetrated by the moving projectiles. Thus, all the composite materials identified within Table 1 either meet or exceed the recognized and accepted testing parameters and guidelines deemed necessary for intended use as impervious compositions and impenetrable substances. Consequently, the embodiments of the laminated composite, which employ such materials as multiple individual layers joined together in overlay series as a unitary article, have set new performance standards for penetration-resistance which were previously held to be unobtainable (See specifically Examples 1 and 2, below).

D. The Organization Structure of and Range of Formats for the Laminated Constructs

[0062] While the range and variety of layer, substrate and stack specifications are well illustrated by the examples described herein, it will be expressly understood that these particulars are presented solely for representative purposes only, as many other embodiments are considered to be within the scope of the invention.

[0063] Organization:

[0064] For example, a laminated construct may comprise any number of layers, substrates, and stacks that are fabricated using many different kinds or types of composite materials, each varying in the thickness dimension; and the laminated construct will, of necessity, be made to meet and satisfy the exact objectives sought.

[0065] Accordingly, it is deemed to be within the scope of the present invention that a laminated construct can be fabricated using various composite materials in structural formats comprising not less than 3 layers and not more then 20 layers joined in overlay series; and in structural formats comprising not less than 1 discrete stack and not more than 24 discrete stacks laminated together in sequential series, in general, a laminated construct may vary from less than 1.5 inches to more than 2 feet in overall thickness.

[0066] In some preferred embodiments of the invention, the resulting laminated constructs will comprise and utilize multiple composite materials in formats comprising from 3 to 10 layers in overlay series, and from 3 to 15 discrete stacks in joined in sequential series, in the most, preferred embodiments of the invention, it is contemplated one or more composite materials would be present as discrete layers or individual substrates in a range of thicknesses varying from about 0.5 inches to about 5.0 inches in size.

[0067] Structural Format Alternatives:

[0068] it will be clear to those of ordinary skill in the art that a host of different materials can be used in fabrication of the laminated constructs to suit the particular goals and desired objectives. For example, one generally useful embodiment of a laminated construct uses a choice of composite materials wherein the layers, substrates and stacks are created from plastics, glass, aluminum silicates, ionomer resins, metals, rubbers, rigid aramid fiber materials, synthetic film, fabric, ceramics or combinations of these materials.

A Minimalist Format

[0069] As an illustration of how to make a generally useful embodiment, one can manufacture a minimal, three layer (single stack), laminated construct comprised of asymmetric composite materials. This minimalist format comprises one sheet of glass, one ionomer resin interlayer, and one polycarbonate sheet—which are collectively superimposed over one another as overlays and are permanently joined together in sequential series to form a laminate sheet. The three individual composite materials can and are easily joined together to form a unified single article using any of the joining methods commonly known in this art.

[0070] Also if desired, one or more other composite materials can be added as additional layers or substrates to the minimalist three layer (single stack) laminate recipe, to meet the purposes and goals of the particular project. Thus, if and when desired, the minimal three-layered (single stack) fabrication can be further bonded to one or more independently manufactured asymmetric stacks in a manner that produces a more durable and more penetration-resistant laminated construct, which further eliminates spall (i.e. small flying glass shards), a frequently seen event when ordinary glass shatters.

[0071] Moreover, in this minimalist three layer (one stack) laminate embodiment, it has been found that all three layers and composite materials can be dimensioned to extend no more then 1.5 inches in overall thickness; and that this minimal laminated construct format is itself capable of withstanding any penetration or piercing from the impact force of 12 shots from a 7.62 mm M80 standard NATO rounds, with the entire grouping of shots being spaced less then 3 inches apart. Also, as concomitant features, the minimal three layer (one stack) laminated construct is transparent and resists spall.

[0072] Furthermore, if the maker chooses to increase the overall thickness (depth) of the minimal three (one stack) laminated construct to 2.0 inches overall, this format of the laminated construct will withstand penetration of a conventional round fired from a 0.50 caliber machine gun; and, furthermore, if the overall thickness (depth) of the minimal three (one stack) laminated construct is increased to 2.5 inches overall, this format of the fabricated laminate article is able and sufficient to stop penetration from a .50 caliber armor-piercing round.

High Velocity Projectile Resistance Formats

[0073] Another generally useful embodiment of the fabricated laminated construct pertains to the use of opaque, translucent, and/or transparent composite materials that are capable of preventing penetration by high velocity projectiles, high velocity explosion fragments, or combinations of these. The term "high velocity" as used herein, is defined as projectile velocities in the range from approximately 1500 to 9000 or more feet per second, velocities typically demonstrated by various explosion fragments. "Explosion fragments", in turn, is defined as any type of high velocity projectiles whose velocity is generated by an explosion (e.g. including explosions caused by heat, pressure, electricity, compressed air, water, etc.). The phrase "high velocity projectiles" therefore includes both ballistic projectiles, such as bullets; and also encompasses shotgun scatter, bomb shrapnel, and metal or other type material fragments caused by large bombs, improvised explosive devices ("IEDs"), blast mines, and those types of hand grenades equivalent in force to an M67 fragmentation grenade detonated at a horizontal distance of 5 meters.

[0074] It is contemplated and expected that high velocity projectiles and explosion fragments can derive from any number of firearms or explosive devices. Two common example are: a 7.62×39×AP (steel core) bullet [manufactured at Plant 71, 1986, and Plant 3, 1989] fired from an AK 47 (Rumania) rifle [number 155 H Comp B M107 No. D544]; and metal shrapnel fragments generated by the detonation blast of a 155 mm artillery shell.

Transparent, Translucent, and Opaque Embodiments and Formats

[0075] Alternative formats of the asymmetric laminated construct contemplate using composite materials that are substantially transparent, or alternatively are substantially opaque. The term "opaque", as defined herein, identifies a material that fails to allow reasonable amounts of visibility when viewing through from one side of the material to the other, in comparison, the term "transparent", defines a substantially clear material that allows for a reasonable amount of visibility when viewing through from one side of the material to the other; while the term "translucent" defines a material capable of transmitting visible light rays, but through which no clear image or object can be seen.

[0076] It is believed that the transparent, translucent, or opaque formats of the laminated constructs will likely be either tinted or colored light-transmitting fabrications. Generally speaking, the formats pertaining to opaque laminate composites will comprise at least one layer of a metal or alloy material; while those embodiments pertaining to transparent and translucent laminate composite typically will not contain any metal material, but will comprise material layers that allow for the passage of visible light rays. These formats allow for the utilization of transparent composites materials in instances where both explosive blast mitigation and visual function are to be maintained, such as in vehicle and boat windshields, windows in homes and office buildings, etc.

III. Some Intended Applications and Uses for the Fabricated Laminated Constructs as Penetration-Resistant Plates

A. Specifically Configured, Dimensioned, and Contoured Plates

[0077] Each laminated construct, often utilizing opaque, translucent, and/or transparent composite materials, is fabricated initially as an unitary flat plate (i.e., a planar pane, panel or slab); which is then capable of being sized, molded, shaped, bent, and/or contoured into a plurality of radically different, three-dimensional configurations and volumetric orientations. The possibilities include: specifications as to length, width and height, density, and mass; use of geometric and non-geometric configurations; availability of concave

and convex orientations; existence of uniform and non-uniform curves and bends; presence of regular and irregular patterns; desirability of sculpted and non-sculpted models; and appearance of template and non-template fashioned forms.

[0078] It is also expected and intended that a range and variety of differently configured, dimensioned and/or contoured plates will be individually prepared in advanced; and that these prepared plates will be able to be arranged, assembled, and/or arrayed as a collective, with or without a supporting framework, to produce penetration-resistant windows, doors, roofs, wind shields, and canopies; impervious awnings, observation domes, vehicular bodies and carriages; and Impenetrable protective plating suitable for use in any structure, erection or building.

[0079] For the benefit of the intended user, several illustrative applications and uses are presented below.

B. Kits Produced in Advance

[0080] It is intended and expected that produced in advance kits (and subsequently to be used by the actual purchaser or intended beneficiary) will be one major commercial format and manner of sale for the fabricated plates prepared from the laminated constructs. Accordingly, every kit will comprise: one or more fabricated laminated constructs comprised of asymmetric composite materials, which have been produced as specifically sized and configured and/or contoured, penetration-resistant plates (or panes, panels, and slabs); and optionally includes a purposefully designed attachment frame or framework which serves as the structural support for holding the individual fabricated plates in their proper respective positions and intended alignments.

[0081] Clearly there are expected and intended to be a wide range and variety of kits produced in advance to meet a variety of different use demands and contingencies; and each type of produced in advance kit will, in turn, be sold and delivered to the actual purchaser or intended user, through conventional sales methods, distribution and warehousing systems, and common transportation carriers to the given mailing address or indicated geographic location (e.g. a home, office, business, town, city, or other site) for installation by the purchaser or a service technician.

C. Some Illustrative Kinds of Kits

[0082] Protective Safety Barrier Kits:

[0083] A protective safety barrier kit will provide a plurality of differently configured and oriented, flat and curved, fabricated plates; and typically will also provide a custom designed framework for the proper positioning and alignment of all the flat and curved protective plates into an assembly.

[0084] The configured, dimensioned, and contoured plates are prepared as individual laminated constructs comprised of asymmetric laminate layers in series which are typically composed of composite materials such as plastics, glass, aluminum silicates, ionomer resins, metals, rubbers, aramid fiber materials, or combinations thereof. The fabricated plates have been individually sized, shaped, and in certain instances contoured or curved (by subjecting them to heat, light, and pressure); and the fabricated plates are prepared in advance as a plurality of different panes, panels and/or slabs to be fitted individually into a designated position or location within a customized or pre-designed frame or support structure using adhesive and bonding materials and methods conventionally known in the art to join and seal the plates to the framework.

[0085] Once assembled, the erected structure will serve as a protective safety barrier that can effectively protect, human and animal subjects from the impact force of moving objects, high velocity projectiles, and/or explosion fragments in both civilian environments and combat situations. The manner and details for erecting the kit parts as an assembly and attaching the protective safety barrier are illustrated by FIG. **1**.

[0086] As merely one useful example, any military vehicle such as the High Mobility Multipurpose Wheeled Vehicle (or "HMMWV") shown by FIG. **2** can use, quickly erect and beneficially deploy the protective safety barrier kit.

[0087] As illustrated by FIGS. **1** and **2**, the assembled protective safety barrier may be installed directly onto a vehicle such as the HMMWV, especially in those Instances where the vehicle has a solid (typically metal) body shell and one or more of its doors have hard outer (usually metal) surfaces. The customized or pre-designed frame is secured to the outer metal surfaces of the doors and/or body shell, using one or more frame fasteners (provided by the kit). It is also most, desirable that the customized or pre-designed framework (or other support structure) be made from at least one substance which is a member of the group consisting of plastics, glass, substantially pure aluminum silicates, ionomer resins, metals, rubbers, rigid aramid fiber materials, glazing or combinations thereof.

Replacement Kits for Original Windows and Windshields Made of Penetrable Glass

[0088] In another intended application and expected usage of kits, the fabricated laminated constructs, configured and curved and/or contoured in advance to meet preset specifications, are as used as penetration-resistant window and windshield replacements in order to provide greater protective safety for an existing motor vehicle.

[0089] In this instance, the kit's components provide a plurality of penetration-resistant plates which are individually configured, dimensioned, and contoured in advance; and are to be direct replacements and complete substitutions for the shatterable original sheet glass windows and windshield then existing in the vehicle. Such direct replacement and complete substitution of all shatterable or penetrable sheet glass will markedly improve and greatly enhance the protection and safety of the vehicle's occupants. Thus, usage of this kit requires removing all the original sheet glass windows, the original sheet glass windshield, and any other original sheet glass existing within the vehicle; and replacing all the penetrable glass objects with the replacement penetration-resistant plates.

[0090] It is expected also that in many instances it might also be desirable to attach a customized or pre-designed reinforcing framework to the different sections and areas of the vehicle where the original sheet glass is to be found. Preferably, the reinforcing framework (which will hold and support the individual replacement plates) is attached to the vehicle by use of a plurality of penetration-resistant fasteners (also provided by the kit). The fasteners themselves are made from any number of materials, which include metal, plastic, rubber, composites, or any combination thereof. The frame fasteners provided by the kit may also include, or can be used in conjunction with, one or more conventional screws, bolts, pins, shims, hinges, rivets, nails, dowels, clamps, sealants,

and gaskets; and the fasteners are joined to the frame using materials and methods well known in the art.

D. Portability of and on-Site Installation of Kits

[0091] Each and every kit envisioned herein, regardless of its expected use or true application, is intended to be both portable and transportable on demand to a particular geographic site or locale whenever and as needed. The means for properly assembling and/or installing all the component parts of each kit in a vehicle regardless of location has been considered and typically has been included as one extra element added to the kit's component parts. Also included within each kit are specific means and articles for installing the components at the ultimate site of need or at a particular assembly location. For these reasons also, any other needed or desirable equipment (e.g. computers, software, telephone, vehicles, and other apparatus), and hardware (e.g. tools, etc.), useful for the proper assembly and installation of the kit components are expected to be readily available and at hand.

[0092] In certain other versions and formats of the kit, the individual component parts constituting the kit as a whole will be based upon and in compliance with specified measurements or particular engineering specifications, and/or exact architectural drawings; and, at least in these instances, the prepared plates and framework support will rely completely upon these previously given specifics and particulars.

[0093] In addition, the produced in-advance kits are envisioned and expected to be warehoused as accumulated inventory and then subsequently delivered upon demand, order, or sale, as well as in accordance with a preset time schedule. In this manner, the proper type and number of kits will routinely be available to meet the needs of the individual buyer or user; and to satisfy the particular nuances of a particular project; and to comply with the requirements defined by communications between parties, private or government contracts, and specific project coordinators. Quality control, including project testing, is also contemplated as necessary to meet the demands or expectations of the prospective purchaser.

E. Other Expected and Intended Applications for Kits

[0094] As is readily apparent from the foregoing, the configured, dimensioned, and/or contoured plates lend themselves to both non-custom and custom uses and implementation, and will meet the specific logistic circumstances and particulars of any given situation. The overall scope of the present invention considers and takes into account the flexible and often changeable nature of these customary and expected use circumstances.

[0095] For example, in another embodiment of the present invention, the penetration-resistant, safety barrier plates and other components of the kit can be installed on any suitable vehicle, in combat or non-combat settings, including one or more seated HMMWV, MTVR, land rovers, jeeps, automobiles, ambulance, pick-up trucks, cranes, fuel tankers, tractor trailer trucks and cargo pulls, in point of fact, any vehicle (regardless of manufacturer and year of production) is a candidate for kit installation and safety upgrade treatment; and the present invention is not to be construed as being limited to any single type or kind of vehicle.

[0096] It will be recognized and appreciated that architectural buildings, edifices, and other housing structures in particular are contemplated as being retrofitted for enhanced safety and protection by the present invention. For example, any building where large numbers of people may work—such as federal and state court houses, police stations, military barracks, government (state and federal) administrative offices, fuel stations housing large storage tanks, and any other obvious targets of terrorists—are suitable and proper for improved safety and upgraded protection treatment using kits of replacement penetration-resistant plates. The only requirement is that the plates and supporting frames be sized and configured in advance to meet and satisfy the particular fitting requirements or building elements sought to be protected.

[0097] For example, for a kit to meet one building's or vehicle's particular requirements, that building's or vehicle's specific measurements and individual component parts must be supplied or have been recorded as a matter of record. Then, based on size, location, objectives, and functions of the need (s), the kit will provide proper penetrations resistant replacements. Among those particular aspects for replacement that are typically considered are: vehicle size and weight, objectives of task, purported or building or vehicle use, structural integrity required, ease of installation, vehicle and barrier performance, transportability, schedule, location of installation, and visibility.

[0098] Thus, some examples of elements that are sized for replacement treatment include: the inside surfaces, outside surfaces, and internal contours; and the windshields, side/rear windows, and doors; and the walls, floor plates, pillars, body plates, blast panels, roof, ceiling, flooring, mats, pans, engine holds, etc.

[0099] Accordingly, this invention is not limited to the individual embodiments disclosed, but is intended to cover all modifications that are within the spirit and scope of the invention as defined by the appended claims. Further, the description of the specific embodiments of the invention fully reveal the general nature of the invention so that others can readily modify and/or adopt for various purposes such specific embodiments without departing from the general concept; and therefore such adaptations and modifications are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. All references and patents referred to are intended to be incorporated herein by reference.

IV. Original Equipment Manufactures

OEMs

[0100] It is a valuable feature and prominent aspect of the present invention that the fabricated penetration-resistant plates can be employed as original equipment manufacture assemblies and as self-supporting, erected structures for almost any type of motored vehicle, movable carriage, or transporting conveyance, in these instances and circumstances, it is clearly understood that the three-dimensional assembly formed of penetration-resistant plates is intended to be part of the original vehicular construction specifications and manufacturing process, and is not a retrofitted improvement or later replacement upgrade of the original equipment parts used in the vehicle's construction.

[0101] As an original equipment manufacture (or "OEM"), each of the fabricated laminated constructs prepared as an unitary fiat plate (i.e., a pane, panel or slab) has been sized, molded, shaped, bent, and/or prepared in advance to meet specific three-dimensional configurations, contours, and volumetric orientations. The engineering specifications will

include: particulars as to length, width and height, density, and mass; and specific choices of geometric and non-geometric configurations, concave and convex orientations, uniform and non-uniform curves and bends, regular and irregular patterns, sculpted and non-sculpted models, and template and non-template fashioned forms.

[0102] Also, as OEM erections and structures, the engineering specifications will require that the configured and dimensioned in advance plates are able to be arranged and assembled as a collective, with or without a supporting framework; and to provide light-transmitting, penetration-resistant windows, windshields, doors, roofs, canopies, observation domes, and compartment bodies for any newly manufactured vehicle, carriage or conveyance.

[0103] In view of our current geopolitical and economic world climates, it is deemed most useful and desirable to provide some illustrative examples of OEM assemblies which have been prepared for safety and designed for protection against injury in military use instances and particularly under live-fire combat circumstances. These two individual assemblies have been designated as the "Standard Vehicle Production Cab" or the "A" model; and the "Enhanced Armored Cab Array" or the "B" model. Each will described individually below.

The Standard Vehicle Production Cab

"A" Model

[0104] This "A" model assembly represents the second generation of penetration-resistant plate constructions and safety barrier structures for tactical wheeled vehicles suitable for general military uses. The A model assembly provides protection for soldiers and other combatants as the mission dictates; may be used in peacetime and wartime circumstances; and represents a marked increase in fuel economy, payload, and component reliability in comparison to earlier choices and systems, in addition, the A model assembly provides a very high degree of ballistic protection for the occupants of the vehicle; and can be quickly and easily up-graded to the enhanced armor "B" model format for use in extremely dangerous combat situations.

[0105] As merely one immediately useful vehicle type suitable for incorporating an OEM assembly comprising the "A" model format, the HMMWV [High Mobility Multipurpose Wheeled Vehicle] illustrated by FIG. **2** serves quite well. However, it will be expressly recognized and understood that many other military vehicles [such as the FMTV, HEMTT, PES, NET, and mobile fuel tankers (typically of 5000-7500 gallon capacity)] are also very suitable for utilizing structured original equipment manufactured cabs and compartmental carriages based upon the A model assembly format.

The Cab Assembly

[0106] A typical "A" model assembly is shown by FIG. **3** and illustrates a standard vehicle production cab **10** comprising an overview support structure **20** and a plurality of differently configured and dimensioned plates **50** comprised of penetration-resistant laminated constructs composed of asymmetric composite materials. The overview support structure **20** is a pre-designed three-dimensional cab framework having distinct sections and transparent viewing zones, which collectively and cumulatively appear as an erected observation dome and protected viewing compartment. The assembled cab **10** provides a discrete observation roof **22**, a viewing front windshield **24**, transparent viewing sidewalls **26**, **27** and rear wall **28**, and transparent viewing windows **30**, and doors **32** and **34**; as well as a floor pan **40** and mounting provisions **42** for joining the totality of the overview support structure **20** to the lower body and remainder of the HMMWV (not shown).

[0107] As shown by FIG. **3**, the roof **22** is formed by five different and individual plates **50**, each of which is sized and shaped differently and which collectively are held in intended position and proper alignment by the framed section **22***a* of the support structure **20**. Similarly, the front windshield **24** is formed of three individually shaped and dimensioned plates which are collectively are held in intended position and proper alignment by the framed section **24***a* of the support structure **20**. Also, the two doors **32** and **34** are part of the sidewalls **26**, **27**, all of which are separately configured and sized as discrete and individual tangible plates, and which are supported in their individual intended positions and proper alignments by the framed sections **26***a* and **27***a* respectively. Finally, the rearwall **28** (not shown in detail by FIG. **3**) is formed using multiple plates **50**, each of which is sized and shaped individually, and which collectively are supported in their intended positions in proper alignment and orientation by the framed section **28***a*.

[0108] It is intended and expected that the standard vehicle production cab comprising an overview support structure and a plurality of differently configured and dimensioned plates comprised of penetration-resistant laminated constructs composed of asymmetric composite materials will be prepared as an original equipment manufacture as individual and separate items; and be prepared as an OEM kit which is then warehoused and stored as kit inventory. Subsequently, at a chosen time, the prepared kit is shipped to the factory or assembly location at which the entire vehicle is to be constructed; and then the component parts in the prepared OEM kit will be assembled as an erected cab structure and Integrally joined into the rest of the vehicular structural body to form a unified and fully constructed vehicle.

The Formulation of the Configured and Dimensioned Plates

[0109] A variety of differently prepared laminated constructs composed of asymmetric composite materials can be employed as individually configured and dimensioned plates within the "A" model assembly.

[0110] As one example of how to make a general use plate, one can utilize the minimalist, three layer (single stack), laminated construct described in detail above. This minimalist format is composed of asymmetric composite materials; comprises one sheet of glass, one ionomer resin inter layer, and one polycarbonate sheet which are overlaid and permanently joined together in sequential series; and the three individual composite materials have been joined together to form a unified single article using any of the methods commonly known in this art.

[0111] As a second and alternative formulation for the plates utilized in the "A" model assembly of FIG. **3**, a more penetration-resistant laminated construct comprised of five distinct asymmetric layers arranged as three stacks joined in sequential series as specified and described later herein by Experimental Example 2 and Table E3 respectively. The laminated constructs can be initially prepared as discrete plates; and then each plate is shaped and sized to meet particular engineering requirements and specifications. This more pro-

tective plate formation is wholly transparent; and has been experimentally tested and empirically evaluated.

The Enhanced Armored Cab Array

"B" Model

[0112] The "B" model assembly represents a second generation of enhanced penetration-resistant armor plate arrays formed of laminated constructs comprised of asymmetrical composite materials. The armor plate assemblies are useful as safety barrier structures for tactical wheeled vehicles; are suitable for general military uses; and are a quickly and easily up-grade from the "A" model format for use in extremely hazardous or dangerous combat situations. In addition, the "8" model assembly provides enhanced penetration resistance protection for soldiers and other combatants; can be used in actual combat situations and severe wartime conditions; and represents a marked improvement in safety protection, human carrying capacity, and armor plating reliability in comparison to earlier choices of armored systems.

The Attachable and Detachable on-Demand Armor Array

[0113] It is intended and required that at least one assembled "A" model standard vehicle production cab or some other erected cab assembly be present as an existing original equipment manufacture compartment and integrated cab portion of a vehicle, such as the HMMWV. The entirety of the detailed description for the "A" model assembly presented above is therefore presumed to be present as the underlying framework for the enhanced armor array of the "B" model. This requirement and presumption is illustrated by FIG. **4**, which shows the intended locations and placement for the array of individual panels, panes and slabs employed in the enhanced armor format as protective overlays.

[0114] As shown by FIG. **4**, the "B" model format is an attachable and detachable on-demand armor array; and provides a planned and organized arrangement comprised of transparent and opaque armor panels, panes, and slabs—each of which has been prepared, sized and shaped as a discrete article of armor plating. The armor array collectively and cumulatively can be attached as an organized and planned disposition of armor plating and then be removed at will repeatedly, when and where needed, by two persons of ordinary skill with a minimum of advance training and present effort.

[0115] The armor array will typically include both transparent and opaque armor panels, panes, and slabs which meet the optical and visibility requirements of combat conditions, in general, the armor plating is HMD compatible, is scratch resistant, is capable of being defrosted, offers UV protection, and creates little or no visual distortion of images.

[0116] As seen in FIG. **4**, the armor array **100** will typically include a roof armor plate **110**, two transparent windshield armor panels **120**, a plurality of opaque side armor panes **130**, door armor slabs **140**, and a series of belly armor overlays **150**. All of the armor plates used in the array have individual configurations and dimensions; and each armor plate is to be attached on-demand to the vehicle using prepared fasteners which are preferably fashioned from the same formulations as those employed in the enhanced penetration-resistant armor plates.

[0117] It is also intended and expected that the attachable and detachable on-demand armor plating array (comprising a plurality of individually configured and dimensioned plates comprised of enhanced penetration-resistant laminated constructs composed of asymmetric composite materials) will be prepared as an original equipment manufacture; and exist as individual and separate items in an OEM kit, which is then warehoused and stored as "B" kit inventory. Subsequently, at a chosen time, the prepared "B" kit will be shipped to a factory or assembly location at which the entire vehicle is to be constructed; and then the component, parts in the prepared "B" kit will be available for assembly as an armor plate array and attached on-demand into the rest of the vehicular structural body to form an integrated and fully armor plated vehicle.

The Formulation of the Enhanced Armor Plates

[0118] A wide variety of differently prepared laminated constructs composed of asymmetric composite materials can be employed as individually configured and dimensioned armor plates within the "B" model assembly and array. As preferred examples, the transparent and opaque formulations of the armor plates utilized in the "6" model assembly of FIG. **4** desirably are those enhanced penetration-resistant plates prepared from laminated constructs comprised of five distinct asymmetric layers arranged as three stacks joined in sequential series—particularly as specified and described hereinafter by Experimental Examples 1 and 2 and by Tables E2 and E3 respectively.

[0119] Each armor plate formulation can be initially prepared as discrete plates; and then each plate is shaped and sized to meet particular engineering requirements and specifications. These formulations are thus either transparent or opaque to the human eye; and have been experimentally tested and empirically evaluated for their enhanced penetration resistance properties and suitability as armor plating.

V. Experiments and Empirical Data

[0120] To demonstrate the merits and value of the present invention, a series of planned experiments and empirical data are presented below. It will be expressly understood, however, that the experiments described and the results provided hereinafter are merely the best evidence of the subject matter as a whole which is the present invention; and that the empirical data, while somewhat limited in content, are only illustrative of the scope of the invention envisioned and claimed.

Experimental Example 1

Opaque Composite Material Blast Testing

[0121] The physical specifications of the opaque composite material being tested are provided by Table E1 below.

TABLE E1

Layers of Composite Material	Layer Thickness	Layer Materials
Number 1	.125 inch	AR 500 Steel (high hardened)
Number 2	.03 inch	Ionomer Resin (Surlyn ®)
Number 3	.125 inch	Opaque Ceramic (98% pure aluminum silicate)
Number 4	.03 inch	Ionomer Resin (Surlyn ®)
Number 5	.375 inch	Aramid Fiber (Rigid Kevlar ®)
Total: 5 layers × 3 stacks	.56 inch, or 14.3 mm for each individual stack	Total weight per square foot: 10.03 lbs.

[0122] In order to test the capability of one embodiment of the present invention to withstand projectile and fragment penetration, a 12"×12" opaque composite material test,

sample having the dimensions described in Table E1 was installed in a metal frame at a height of approximately 5 feet. The sample was then subjected to six consecutive 7.62×39× AP steel core shots from an AK 47 rifle, followed by being further subjected to the metal shrapnel fragments from a detonation blast of a 155 mm shell placed at the distance of approximately 33 feet from the opaque composite material. The composite material remained at a height of approximately 5 feet above the ground, while the 155 mm shell was detonated at a height of approximately 8 feet above the ground.

[0123] Results of the multiple impacts on the opaque composite material tested are provided by Table E2 below.

TABLE E2

	Projectile		
Blast Number	Angle of Projectile	Projectile Velocity	Results
1 (bullet)	0 degree angle of projectile impact	2520 feet per second	No Penetration No spall detected
2 (bullet)	0 degree angle of projectile impact	2520 feet per second	No Penetration No spall detected
3 (bullet)	0 degree angle of projectile impact	2520 feet per second	No Penetration No spall detected
4 (bullet)	30 degree angle of projectile impact	2520 feet per second	No Penetration No spall detected
5 (bullet)	30 degree angle of projectile impact	2520 feet per second	No Penetration No spall detected
6 (bullet)	30 degree angle of projectile impact	2520 feet per second	No Penetration No spall detected
7 (detonated shell)	30 degree angle of projectile impact	8000 feet per second	No Penetration No spall detected

[0124] After impact of the high velocity explosion fragments with the composite material of Table E2, it was determined by visual inspection that the composite material was not penetrated by any of the 7 blasts. The impact of the six ballistic projectiles on the 12"×12" opaque composite material test sample was determined. The impact of the seventh blast, which was a shrapnel bomb blast, was scattered across the surface of the material. But it was determined by post ballistic testing that a 1.5"×0.75" inch explosion fragment was stopped, and did not penetrate the material. Surprisingly, no spall was detected.

Experimental Example 2

Transparent Composite Material Blast Testing

[0125] Physical specifications of transparent composite material tested are provided by Table E3.

TABLE E3

Layers of Composite Material	Layer Thickness	Layer Materials
Number 1	0.5 inch	Annealed glass
Number 2	0.06 inch	SentryGlas Plus ®
Number 3	0.375 inch	Annealed glass
Number 4	0.05 inch	Polyurethane
Number 5	0.375 inch	Polycarbonate
Total: 5 layers × 3 stacks	1.36 inch, or 34.54 mm each for individual stack	Total weight per square foot: 14.33 lbs.

[0126] In order to test the capability of one embodiment of the present invention to withstand projectile and fragment penetration, a 12"×12" opaque composite material test sample having the dimensions described in Table E3 was installed in a metal frame at a height of approximately 5 feet. The sample was then subjected to three consecutive 7.62×39× AP steel core shots from an AK 47 rifle, followed by being further subjected to the metal shrapnel fragments from a detonation blast of a 155 mm shell placed at the distance of approximately 33 feet from the opaque composite material. The composite material remained at a height of approximately 5 feet above the ground, while the 155 mm shell was detonated at a height of approximately 8 feet above the ground.

[0127] Results of the multiple impacts on the transparent composite material tested are provided by Table E4.

TABLE E4

	Projectile		
Blast Number	Angle of Projectile	Projectile Velocity	Results
1 (bullet)	0 degree angle of projectile impact	2520 feet per second	No Penetration No spall detected
2 (bullet)	0 degree angle of projectile impact	2520 feet per second	No Penetration No spall detected
3 (bullet)	0 degree angle of projectile impact	2520 feet per second	No Penetration No spall detected
4 (detonated shell)	0 degree angle of projectile impact	8000 feet per second	No Penetration No spall detected

[0128] After impact of the high velocity explosion fragments with the composite material of Table E4, it was determined by visual inspection that the composite material was not penetrated by any of the 4 blasts. The impact of the six ballistic projectiles on the 12"×12" opaque laminated composite material test sample was determined. The impact of the forth blast, which was a shrapnel bomb blast, was scattered across the surface of the material. But it was determined by post ballistic testing that a 1.5"×0.75" inch explosion fragment was stopped, and did not penetrate the material. Again, no spall was detected.

[0129] The present invention is not to be restricted in form nor limited in scope except by the claims appended hereto.

What I claim is:

1. A prepared kit for the substitution and replacement of penetrable glass objects with impervious light-transmitting articles, said kit comprising:

at least one penetration-resistant and light-transmitting plate prepared as a laminated construct comprising not less than 3 individual layers of asymmetric composite materials joined together in series as at least one discrete stack, said plate having a determinable configuration and fixed dimensions and presenting demonstrable penetration-resistance properties against, a moving object having a determinable size, mass, and velocity.

2. A prepared kit for the protection of penetrable glass objects with an impervious light-transmitting overlay assembly, said kit comprising:

at least one framework of pre-chosen shape and size able to support and align at least one penetration-resistant plate in position over a penetrable glass object as a protective safety barrier overlay;

fastening means for holding said framework plate at a chosen location over and adjacent to a sheet of shatterable sheet glass; and

at least one penetration-resistant and light-transmitting plate prepared as a laminated construct comprising not

less than 3 individual layers of asymmetric composite materials joined together in series as at least one discrete stack, said penetration-resistant plate having a determinable configuration and fixed dimensions, and presenting demonstrable penetration-resistance properties against a moving object having a determinable size, mass, and velocity.

3. The prepared kit as recited in claim **1** or **2** wherein said laminated construct of said penetration-resistant plate further comprises a plurality of asymmetric stacks joined together in sequential series.

4. The prepared kit as recited in claim **1** or **2** wherein said individual layers formed of asymmetric composite materials consist of at least one member of the group selected from plastics, glass, substantially pure aluminum silicates, ionomer resins, metals, rubbers, rigid aramid fiber materials, or any combination of these.

5. The prepared kit as recited in claim **1** or **2** wherein said individual layers formed of asymmetric composite materials consist of at least one member of the group selected from polybenzoxazole, polybenzothiazole polymers or related copolymers, thermoplastic polymers, thermosetting polymers, and elastomers.

6. The prepared kit as recited in claim **1** or **2** wherein said individual layers formed of asymmetric composite materials consist of at least one member of the group selected from polycarbonates, steel, ceramics, Kevlar, and S Glass steel mesh.

7. The prepared kit as recited in claim **1** or **2** wherein said moving object is a high velocity projectile.

8. The prepared kit as recited in claim **1** or **2** wherein said moving object is an explosion fragment.

9. The prepared kit as recited in claim **1** or **2** wherein said penetration-resistant plate is substantially transparent.

10. The prepared kit as recited in claim **1** or **2** wherein said penetration-resistant plate is substantially translucent.

11. The prepared kit as recited in claim **1** or **2** wherein said penetration-resistant plate is substantially opaque.

12. A standard vehicle production cab assembly for inclusion in a newly manufactured vehicle, said cab assembly comprising:

an overview support structure comprising a pre-designed three-dimensional cab framework having distinct sections and viewing zones which serves as an observation dome and viewing compartment for a newly manufactured vehicle;

mounting provisions for integrally joining said overview support structure to the body of a newly manufactured vehicle; and

a plurality of differently configured and dimensioned penetration-resistant plates prepared as laminated constructs comprising not less than 3 individual layers of asymmetric composite materials joined together in series as at least one discrete stack, each of said plates having a determinable configuration and fixed dimensions and presenting demonstrable penetration resistance properties against a moving object having a determinable size, mass and velocity.

13. The standard vehicle production cab assembly as recited in claim **12** wherein said overview support structure further comprises a discrete observation roof, a viewing front windshield, transparent viewing sidewalls and rear wall, and transparent viewing windows and doors.

14. The standard vehicle production cab assembly as recited in claim **12** wherein said overview support structure further comprises a floor pan.

15. A prepared kit for assembling a standard vehicle production cab in a newly manufactured vehicle, said kit comprising:

an overview support structure comprising a pre-designed three-dimensional cab framework having distinct sections and viewing zones which serves as an observation dome and viewing compartment for a newly manufactured vehicle;

mounting provisions for integrally joining said overview support structure to the lower body of a newly manufactured vehicle; and

a plurality of differently configured and dimensioned penetration-resistant plates prepared as laminated constructs comprising not less than 3 individual layers of asymmetric composite materials joined together in series as at least one discrete stack, each of said plates having a determinable configuration and fixed dimensions and presenting demonstrable penetration resistance properties against a moving object having a determinable size, mass and velocity.

16. An attachable and detachable on-demand armor array comprising:

an organized arrangement of discrete armor plates which can be attached on-demand to a pre-existing vehicular cab assembly as a planned disposition of armor plating and be subsequently removed at will, repeatedly, wherein each armor plate of said organized arrangement is

(i) a prepared plate of predetermined shape, size, and mass which presents enhanced penetration-resistance properties against a moving object having a determinable size, mass and velocity; and

(ii) a laminated construct comprising not less than 3 individual layers composed of asymmetric composite materials joined together in series as at least one discrete stack.

17. The attachable and detachable on-demand armor array recited in claim **16** wherein said organized arrangement, of discrete armor plates includes at least one member selected from the group consisting of transparent, translucent, and opaque armor panels, panes, and slabs.

18. The attachable and detachable on-demand armor array recited in claim **16** wherein said organized arrangement of discrete armor plates are NVD compatible, scratch resistant, capable of being defrosted, UV protective, and creates little or no visual distortion of images.

19. The attachable and detachable on-demand armor array recited in claim **16** wherein said organized arrangement of discrete armor plates includes at least one roof armor plate, at least one windshield armor panel, a plurality of side armor panes, at least one door armor slab, and a plurality of belly armor overlays.

20. The attachable and detachable on-demand armor array recited in claim **16** further comprising prepared fasteners to hold and support said organized arrangement of discrete armor plates in proper position upon the pre-existing vehicular cab assembly.

21. A prepared kit for deploying an attachable and detachable on-demand armor array, said kit comprising:

a plurality of discrete armor plates which can be attached on-demand to a pre-existing vehicular cab assembly as

an organized arrangement and planned disposition of armor plating and be subsequently removed at will repeatedly, wherein each armor plate of said organized arrangement is

(i) a prepared plate of predetermined shape, size, and mass which presents enhanced penetration resistance properties against a moving object having a determinable size, mass and velocity;

(ii) a laminated construct comprising not less than 3 individual layers of asymmetric composite materials joined together in series as at least one discrete stack; and

multiple fasteners able to hold and support said organized arrangement of discrete armor plates in a proper and aligned position upon a pre-existing vehicular cab assembly.

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