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(54) Title: TRANSPORTABLE MODULAR SYSTEM PERMITTING ISOLATION OF ASSETS

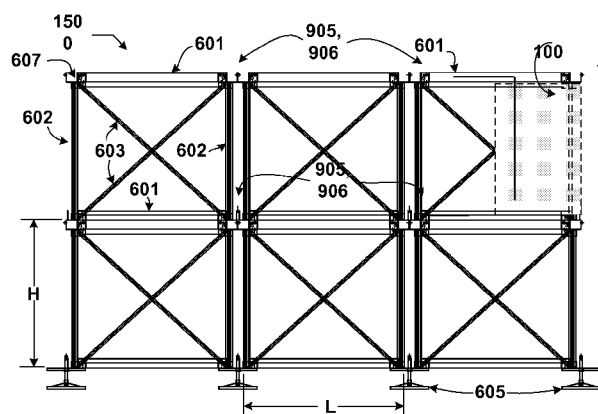


Fig. 15

(57) Abstract: A configuration (600), all components of which are man portable, for holding inexpensive composite panels (100) that protect assets against external force and impacts from airborne projectiles. An open box-like stackable frame module (1400) holds thin panels (100) along a longitudinal axis of the frame (1300). Multiple frames (1400) are connected to construct a protective barrier, such as a wall (1500). The panels (100) may be formulated of a very high strength portland cement-based concrete with one side, both sides, or both sides and all edges, covered with elastic material, the combination of which significantly reduces penetration of projectiles. A panel (100) may be covered with specially formulated elastic material (103) comprising multiple layers, each layer of a different type or thickness of elastic material (103). The elastic material (103) may include reinforcing material such as fabric woven from available COTS high-strength fibers. The panels (100) may be fabricated using basic means available in rural locations. A method of installing is also provided.



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TRANSPORTABLE MODULAR SYSTEM PERMITTING ISOLATION OF ASSETS

RELATED APPLICATIONS

5 Under 35 U.S.C. §119(e)(1), this application claims the benefit of prior co-pending U.S. Provisional Patent Application No. 61/033,061, *Transportable Modular System of Components for Physical Protection*, by Durst et al., filed March 3, 2008, incorporated herein by reference. This application is also related to co-pending U.S. Provisional Patent Application No. 61/033,240, *Method of Manufacturing Cement Based Armor Panels*; U.S. Provisional Patent Application No. 61/033,212, *A Self-Leveling Cementitious Composition with Controlled Rate of Strength Development and Ultra-High Compressive Strength upon Hardening and Articles Made from Same*; U.S. Provisional Patent Application No. 61/033,264, *Cement Based Laminated Armor Panels*; U.S. Provisional Patent Application No. 61/033,258, *Cement Based Armor Panel System* and U.S. Provisional Patent Application No. 61/033,059, *Transportable Modular Frame for Holding Panels for Physical Protection*, by Durst et al., each of the above filed on 03/03/2008 and incorporated herein by reference.

STATEMENT OF GOVERNMENT INTEREST

20 Under paragraph 1(a) of Executive Order 10096, the conditions under which this invention was made entitle the Government of the United States, as represented by the Secretary of the Army, to an undivided interest therein on any patent granted thereon by the United States. Research supporting at least part of the work described herein was accomplished with the United States Gypsum Company under a Cooperative Research and Development Agreement, CRADA-05-GSL-04, dated 20 May 2005. This and related patents are available for licensing to qualified licensees. Please contact Phillip Stewart at 601 634-4113.

BACKGROUND

30 It is important to protect both material and personnel from catastrophe, especially in cases where the probability of occurrence is greater than the norm. Conventionally, both temporary and permanent means may be used for this purpose, depending on the scenario. For example, a permanent military facility may best be protected by a permanent configuration, whereas a mobile field unit would best be served by a temporary, but not

necessarily less effective, configuration. Conventionally, protection against manmade catastrophe, such as occurs in war zones, has been provided with large bulky concrete structures or earthen embankments that require heavy equipment to produce, whether temporary or permanent. Needs for protective structure may include barriers to prevent personnel access, vehicular intrusion, or even line-of-site access in the case of a sniper, as well as protective enclosures for emergency response personnel or revetments for high value assets. Because of constraints such as geography, response time, availability of both material and heavy equipment, and the like, select embodiments of the present invention that provide good protection for both personnel and valued assets are of value for protection of both military and community assets.

To protect personnel and resources, military organizations use a variety of protective materials ranging from soil cover to expensive, high-performance, lightweight ballistic ceramics. A need exists for an inexpensive blast and fragmentation barrier for large-area applications, such as forward facilities, installation and structure perimeters, and both interior and exterior protective upgrades. Certain applications call for panels that may be emplaced on robust platforms, both the modular platform sections and panels being of sufficiently light weight to be man portable.

Select embodiments of the panels of the present invention have excellent energy absorbing capacity against blast and ballistic penetration forces. This capacity is often described as toughness, a term also associated with the tensile strength of concrete. Select embodiments of the panels of the present invention obtain their strength and toughness qualities through engineering of the type and quantity of component materials.

When combined with an elastic outer layer, the core of select embodiments of the panels of the present invention reduces fragment velocities as compared to existing core materials that cost more, weigh more, and require greater thickness to achieve the same kinetic energy reduction. Cost is reduced by employing high performance concrete materials as a core. Use of multi-dimensional, discrete and continuous fibers of various material compositions distributed throughout the core matrix optimizes strength and toughness. Coating or covering the inexpensive core with a tough pliable material provides the necessary "toughness" to dampen or completely eliminate through penetration of fragments and debris from an event such as a hurricane, nearby explosion or even penetration by munitions.

Select embodiments of both the panels and the box-shaped platform modules of the present invention are man portable. Systems, such as walls, employing select embodiments of the present invention are designed to replace existing systems that are heavier, e.g., those that employ thicker panels comprising materials conventionally used for protection from ballistic sources. Because some existing systems are made from exotic materials, such as ceramics, they are also more expensive than embodiments of the present invention.

A need also exists for inexpensive protective cladding with superior resistance to wind damage, including penetration of debris generated by natural forces, such as tornadoes and hurricanes. Although select embodiments of the present invention may be used as ballistic armor, connectors, protective construction, blast-resistant panels, protection against fragmenting munitions, vehicle up-armorings, forced entry resistant structural elements, other applications include strengthening of building components such as walls, floors and ceilings. Because select embodiments of the panels of the present invention have high strength and toughness, they are suitable for use in new construction of residential housing as structural members that are resistant to the natural forces and debris impact of tornadoes and hurricanes and in commercial security situations such as the construction of bank vaults and armor protective enclosures.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a perspective view of components of panels of a first generic embodiment of the panels that may be used with embodiments of the present invention.

FIG. 2 is a perspective view of components of panels of a second generic embodiment of the panels that may be used with embodiments of the present invention.

FIG. 3 is a perspective view of components of panels of a third generic embodiment of the present invention and a perspective view of a resultant generic embodiment of the panels that may be used with embodiments of the present invention.

FIG. 4 is a perspective view of components of panels of a fourth generic embodiment of the panels that may be used with embodiments of the present invention.

FIG. 5A is a perspective view of components of panels of a fifth generic embodiment of the present invention and a perspective view of a resultant generic embodiment of panels as may be used with the present invention comprising these components.

- 5 FIG. 5B is a perspective view of the components of FIG. 5A in an alternate resultant generic embodiment of panels as may be used with the present invention comprising these components.

- 10 FIG. 5C is an end view through a cross section of two alternative geometries of an outer covering of the resultant generic embodiment of panels of the present invention as is represented in FIG.5A.

- FIG. 6 is a longitudinal side elevation view of a single box-shaped platform and single installed panel thereon that may be employed in embodiments of the present invention.

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FIG. 7 is a top plan view of the single box-shaped platform of FIG.6 that may be employed in embodiments of the present invention.

- 20 FIG. 8 is a top plan view of a bottom plate connector, as well as elevation views of the two vertical outer sides of the connector that may be employed in embodiments of the present invention, one of four such bottom plate connectors on each of the box-shaped platform modules of FIG. 6.

- 25 FIG. 9 is a top plan view of a top plate connector, as well as elevation views of the two vertical outer sides of the connector that may be employed in embodiments of the present invention, one of four such top plate connectors on each of the box-shaped platform modules of FIG. 6.

- 30 FIG. 10 illustrates how a corner is formed using box-shaped platforms and panels of embodiments of the present invention.

FIG. 11 shows detail of an adjustment unit that may be used with embodiments of the present invention to adjust height of individual box-shaped platform modules to match modules connected therewith.

- 5 FIG. 12 shows plan and edge views of a "z-bar" employed to hold panels onto individual platform modules that may be used in embodiments of the present invention.

FIG. 13 is a perspective of the basic structure of a box-shaped platform module expanded for installation of panels, to include z-bars, compression and members in tension and top and
10 bottom mounts that may be used with embodiments of the present invention.

FIG. 14 is a perspective of the basic structure of a platform module collapsed for transportation or storage without z-bars and members in tension that may be used with
15 embodiments of the present invention.

FIG. 15 is an elevation view of a longitudinal side of a box-shaped wall comprising three long by two high interconnected box-shaped platform modules that may be employed in
20 embodiments of the present invention, and a single installed panel thereon for illustration purposes only.

FIG. 16 shows plan and elevation views of a strap that may be employed to constrain the z-bars in the box-shaped platform modules of an embodiment of the present invention after
25 installation of the panels in the z-bars.

DETAILED DESCRIPTION

Select embodiments of the present invention comprise transportable components for fortifying an area. Select embodiments of the present invention include opaque blast and projectile resistant panels and rectangular box-shaped platform modules for holding the
30 panels in order to provide a secure perimeter. The panels are resistant to sudden impulses such as may occur with explosions or impact with projectiles and also shield what they are protecting from view of possible adversaries.

In select embodiments of the present invention, a transportable configuration provides protection for assets. Main components of select embodiments of the present invention comprise an open stackable frame of a length greater than or equal to the width, the width in turn less than or equal to the height. A frame comprises four sides, eight corners and an open top and bottom. In select embodiments of the present invention the frame comprises: mounts at each of its eight corners, four of the mounts being of a first type and located at the top of the frame and four of the mounts being of a second type and located at the bottom of the frame such that the first and second types are able to be interlocked via suitable means to permit vertical stacking as well as horizontal connection of the frames one to another; a pair of cross members in compression on each side of the frame, such that each cross member of a pair is pivotally joined at the center to the other cross member of the pair thereby allowing pivoting of the pair of cross members in one plane, and such that each cross member is also pivotally joined to one top mount of a first type and one bottom mount of a second type thereby allowing pivoting of the connected pair of cross members in one plane; and two or more members in tension on each side of the frame, a first member in tension attached to the top mounts of a first type and a second member in tension attached to a bottom mounts of a second type; pairs of z-bars to be affixed, in one embodiment, along a first longitudinal side of the frame, ends of one of the z-bars affixed to the top mounts of a first type and ends of the second z-bar of a pair affixed to two bottom mounts of a second type; tensioning means for securing the ends of the z-bars to the top and bottom mounts; four height adjustable bases, on which rest the bottom mounts of a second type; and panels, preferably quadrilateral, having a length and width either of which is much greater than the depth of a panel, the panels having a pre-specified resistance to blast and penetration by airborne projectiles such that when the panels are mounted in the z-bars on the frame the combination provides physical protection of assets on the side of the configuration away from the origination of any blast and airborne projectiles.

In select embodiments of the present invention, third and fourth z-bars are mounted on the longitudinal side of the frame opposite the longitudinal side on which the first two z-bars are mounted. These z-bars accommodate mounting optional panels on the "back" side (the side away from the origin of external hazards) of the frame.

In select embodiments of the present invention, the cross members are of tubular construction and further comprise means for pivotally connecting each cross member of a

pair of cross members at the respective approximate center of each cross member. For example, the means for pivotally connecting may be a bushed rivet or clevis pin. In select embodiments of the present invention the cross members are metal tubes having a quadrilateral cross section, e.g., a square or rectangular cross section.

5 In select embodiments of the present invention, the members in tension are braided wires affixed to the plates horizontally, e.g., via rivets through holes in the plates and end loops on the braided wire from one top plate to another top plate and from one bottom plate to another bottom plate, all on the same frame module.

10 In select embodiments of the present invention, the z-bars are formed from sheet metal and incorporate means for positioning them on the frame and tensioning means for attaching the z-bars to the appropriate mounts, i.e., to top mounts for bottom z-bars and vice versa.

15 In select embodiments of the present invention, the configuration mounts are formed from sheet metal and further comprise: means for positioning the z-bars to the frame, for example an "external slot," and means for attaching the tensioning means for connecting the z-bars to the mounts, e.g., a strap with hook on one end and a tightening ratchet on the other end; means for connecting to the first and second members in tension, e.g., slots or holes to which a wire may be affixed via a rivet or the like; channels for positioning the cross members at the mounts, e.g., vertical tabs incorporating attachment holes, the tabs affixed by
20 suitable means such as "tack welding" to the base of the mounts; and means for connecting each end of the cross members in the channels, e.g., bushed pins such as clevis pins or the like.

25 In select embodiments of the present invention, the adjustable bases comprise: a first mount for affixing the mounts of a second type, the mount incorporating a first threaded collar approximately centered in the first mount; a threaded rod incorporating means for moving, such as an affixed hex nut, the threaded rod in the first threaded collar to raise and lower the first mount; and a second reinforced mount incorporating a second collar for receiving the threaded rod, so that the threaded rod may be turned via the means for moving to adjust the height of the adjustable base to facilitate interconnecting a frame module to
30 adjoining frame modules.

In select embodiments of the present invention, the quadrilateral panels comprise a core of very high strength concrete having elastic material bonded to at least one side, the

side defined by the length and the width of the quadrilateral panel, the depth or thickness of the panel much less than either the length or width. In select embodiments of the present invention, the quadrilateral panel incorporates elastic material bonded to both its sides. In select embodiments of the present invention, the quadrilateral panels incorporate elastic material bonded to the outside of the quadrilateral panel. In select embodiments of the present invention the elastic material completely encapsulates the panel.

In select embodiments of the present invention, the quadrilateral panels further comprise means for suspending them from the frame, e.g., grommets, tabs and the like.

In select embodiments of the present invention, the frames employ four or more connection pins, such as steel bar stock of circular cross section with both ends chamfered to facilitate insertion of the pins, to affix each bottom mount of a second type to each adjustable base as well as to affix vertically stacked frames to those below.

In select embodiments of the present invention, a method of installing a transportable configuration that provides protection for assets, comprises: providing an open stackable frame having a length greater than or equal to a width that is less than or equal to a height, four sides, and eight corners, the frame comprising: mounts at each of the eight corners of the frame, such that a first four mounts are of a first type located at the top of the frame and a second four mounts are of a second type located at the bottom of the frame, a pair of cross members in compression on each side of the frame, such that each cross member of a pair is pivotally joined at the center to the other cross member of the pair to allow pivoting of the pair of cross members in one plane, and such that each cross member is pivotally joined to one top mount of a first type and one bottom mount of a second type so as to allow pivoting of the pair of cross members in one plane; and two or more members in tension on each side of the frame, tension provided from a member such as a braided wire, a first member in tension attached to the top mounts and a second tension member attached to the bottom mounts. The method further provides z-bars, the z-bars affixed along a longitudinal side of the frame, ends of a first z-bar affixed to two top mounts and ends of a second z-bar affixed to two bottom mounts; providing tensioning means in a vertical plane, such as braided wires adjustable for amount of tension, connectable to each end of the z-bars; providing adjustable bases such that each base supports a bottom mount for one or two frames depending on the position of the frames in a final protective wall; providing four or more connection pins for affixing each frame to the four adjustable bases; and providing quadrilateral panels having a

pre-specified resistance to blast and penetration by airborne projectiles; transporting said configuration to a location having assets requiring physical protection and unloading the configuration from its transporting means, such as a truck. The method further comprises completing the following steps to result in a protective wall for the assets: a) arranging the adjustable bases on the desired substrate, e.g., the ground, to permit placement of the frames thereon and adjusting the bases to be about six turns from bottoming out; b) leveling the adjustable bases with respect to the substrate; c) placing a first frame on four adjustable bases; d) connecting the frame to its adjustable bases with four connection pins; e) further arranging two adjustable bases for holding one side of an initially adjoining frame to the originally placed frame, leveling the two adjustable bases, placing the adjoining frame on the two adjustable bases common to the initially placed frame and the two further arranged adjustable bases; f) connecting the adjoining frame to the adjustable bases on the one side common to the initially placed frame; g) connecting the adjoining frame to the two further arranged adjustable bases; h) leveling the initially placed frame by adjusting the adjustable bases to facilitate joining the initially placed frame and the adjoining frames at the top mounts; i) connecting the initially placed frame and the adjoining frames at adjoining top mounts; j) along the length of the frame, attaching a z-bar at the top of each installed frame and a second z-bar at the bottom of each installed frame; k) employing the tensioning means at the ends of each z-bar, securing the z-bars to the frame; l) inserting the quadrilateral panels between the top and bottom z-bars along the length of each installed frame; and m) repeating steps a) through l) treating each added frame as an initially added frame until a pre-specified length of said protective wall is attained.

In select embodiments of the present invention, the method of installation further comprises installing third and fourth z-bars on the side of the frame opposite that on which the first and second z-bars are installed, installing the third and fourth z-bars in a manner identical to that of installing the first and second z-bars; and inserting quadrilateral panels between the third and fourth z-bars along the length of each installed frame.

In select embodiments of the present invention, the method of installation further comprises: a) stacking a frame module above each frame module of an initially installed protective wall, b) attaching each bottom mount of the added frame module to a corresponding top mount of the initially installed frame module using a connection pin per connection; c) as necessary, further leveling the adjustable bases with respect to the substrate

to facilitate joining each stacked frame module to an adjoining stacked frame module at the respective top mounts; d) connecting the stacked frame modules at adjoining top mounts, e.g., via a rivet and slot arrangement; e) along one side of the length of the stacked frame module, attaching a z-bar at the top of each installed stacked frame module; f) employing the tensioning means at the ends of each newly installed z-bar, securing the newly installed z-bars to the stacked frame module; g) inserting quadrilateral panels between the originally installed top z-bar of the bottom layer of frame modules and the newly installed z-bars of the top layer of frame modules along the length of each installed stacked frame module until the pre-specified length of the protective wall is attained at the increased height resultant from adding the stacked frame modules.

In select embodiments of the present invention, the method of installation further comprises: installing an additional z-bar on the top of the side of the stacked frame module opposite that on which the newly installed top z-bar is installed, installing the additional top z-bars in a manner identical to that of installing the newly installed top z-bars; and inserting quadrilateral panels between the initially installed top and the newly installed top z-bars along the "back" length of each installed stacked frame module.

In select embodiments of the panels of the present invention, inexpensive impact-resistant composite structures incorporate a core of an improved very high strength concrete (VHSC) and an external "skin" of elastic material. The skin may be applied to one or more sides of the structure or completely cover a structure, e.g., a rectangular panel could be covered on both sides and all four edges. Materials that form a composite structure of an embodiment of the present invention may include a core of a cementitious material such as COR-TUF™ (a high-performance VHSC) coupled with reinforced polymer-based facings placed on one or more sides of the VHSC core or completely enveloping the core. Note that VHSC is an accepted descriptor in the profession for high performance concrete. COR-TUF™ and methods for producing it are described in published U.S. patent application, 2007/0228612 A1, Serial No. 11/390,084 (hereafter the '084 application), filed March 28, 2006, incorporated herein by reference. Further, the elastic material for covering the panels may be of the type described in United States patent application serial no. 11/819,340 *Reinforced Elastomeric Configuration Tailored to Meet a User's Requirements for Protecting a Structure and a Structure Comprised Thereof*, filed June 27, 2007 (hereafter the '340

application), incorporated herein by reference. Methods for applying the elastomeric material to a panel are also provided in the '340 application.

Refer to FIG. 1 detailing major components of a panel 100 that may be employed in select embodiments of the present invention. In select embodiments of the present invention, a thin rectangular core 101 of length, L , width, W , and thickness, T , much less than either L or W , comprising a VHSC concrete such as COR-TUF™, has sheets 102, 103 of flexible or elastic (hereafter elastic) material affixed to each side 104 of the core 101. The elastic material may be in the form of sheets 102, 103, thin membranes, laminates and the like or "flowed on" a side 104 of the core 101 by spraying, rolling, brushing, troweling or the like.

Multiple layers, such as thin membranes built up into a laminate, and the like, may be employed as the sheets 102, 103 of elastic material on any side of the core 101, each layer placed in accordance with manufacture's instructions to insure proper adhesion of the resultant sheets 102, 103 of elastic material to the core 101. Multiple layers of fluid elastic material that solidifies upon curing may be applied to build up a veneer (sheet) 102, 103 of elastic material of appropriate thickness upon final cure. Each application coat of fluid material is applied in accordance with manufacture's instructions to insure proper curing and adhesion of the sheets 102, 103 of elastic material to the core 101. For select embodiments of the present invention employing elastic material in the form of sheets 102, 103 of elastic material, to include such as thin membranes alone or thin membranes built into laminates, an adhesive may be applied to either or both the sheets 102, 103 of elastic material and the sides 104 of the core 101 in compliance with the manufacturer's instructions for the elastic material used for the sheets 102, 103 of elastic material and the adhesive. Sheets 102, 103 of elastic material, to include such as thin membranes and laminates thereof may be provided with a "peel and stick" type of adhesive that may permit ready adhesion of sheets 102, 103 of elastic material to a side 104 of the core 101 prepared in accordance with the manufacturer of the "peel and stick" type adhesive. In select embodiments of the present invention, the edges 107 of the core 101 need not be covered by the sheets 102, 103 of elastic material in order to achieve a desired level of performance.

Refer to FIG. 2 depicting the core 101 of FIG. 1. In select embodiments of the present invention only one side of the core 101 has a sheet 102 of elastic material adhered thereto. The type of elastic material used in the sheet 102 and method of application may be any of the types and methods used for the "double-sided" example of FIG. 1. Again, for

select embodiments of the present invention, the edges 107 of the core 101 need not be covered by the single sheet 102 of elastic material in order to achieve a desired level of performance.

Refer to FIG. 3 in which the same core 101 is shown as in FIGS. 1 and 2. In select
5 embodiments of the present invention both sides 104 and all four edges 107 of the core 101 have a sheet 102, 103 of elastic material adhered thereto. The type of elastic material used for the sheets 102, 103 of elastic material and method of application may be any of the types and methods used for the "double-sided" example of FIG. 1. Further, in select embodiments of the present invention, the elastic material incorporated in the sheets 102, 103 of elastic
10 material may be reinforced with one or more "webs" 302, 303 of woven or un-woven reinforcement material. In select embodiments of the present invention, the webs 302, 303 of reinforcement material may comprise fabric incorporating polymer fibers. In select embodiments of the present invention, the webs 302, 303 of reinforcement material may comprise fabric incorporating polymer "strands" arranged in a matrix such that one set of
15 strands runs at a "bias" (i.e., non-parallel) to the length, L , and the intersecting set of strands runs at a bias to the width, W , of the core 101. In select embodiments of the present invention, the finished "encapsulated" panel 306 has edges 307 that are also covered with sheets 102, 103 of elastic material that incorporate webs 302, 303 of reinforcement material.

Refer to FIG. 4 in which the same core 101 is shown as in FIGS. 1-3. In select
20 embodiments of the present invention, the core 101 has one or more reinforcement layers 402, 403 *externally* added to the sheets 102, 103 of elastic material adhered to both sides 104 of the core 101. The type of elastic material in the sheets 102, 103 and method of application may be any of the types and methods used for the "double-sided" example of FIG. 1. In select embodiments of the present invention, the material of the reinforcement layers 402,
25 403 may comprise fabric incorporating polymer "strands" arranged in a matrix such that one set of strands runs parallel to the length, L , and the intersecting set of strands runs parallel to the width, W , of the core 101. Again, for select embodiments of the present invention the edges 107 of the core 101 need not be covered by the sheets 102, 103 of reinforced elastic material in order to achieve a desired level of performance.

Refer to FIG. 5A in which the same core 101 is shown as in FIGS. 1-4. In select
30 embodiments of the present invention both sides 104 of the core 101 have sheets 102, 103 of an elastic material adhered thereto. However, the edges of the sheets 102, 103 of elastic

material are allowed to overlap far enough to be joined together to create a "border" in which grommets 504 may be inserted for ease in hanging the resultant encapsulated panel 501. The type of elastic material in the sheets 102, 103 and method of application may be any of the types and methods used for the "double-sided" example of FIG. 1. Further, in select
5 embodiments of the present invention, the elastic material in the sheets 102, 103 may be reinforced with one or more webs 502, 503 of woven or un-woven reinforcement material similar to that of FIG. 3. In select embodiments of the present invention, the web 502, 503 of reinforcement material may comprise fabric incorporating polymer fibers. In select
10 embodiments of the present invention, the web 502, 503 of reinforcement material may comprise fabric incorporating polymer "strands" arranged in a matrix such that one set of strands runs at a "bias" (i.e., non-parallel) to the length, L , and the intersecting set of strands runs at a bias to the width, W , of the core 101. In select embodiments of the present invention incorporating a border as shown in the encapsulated panel 501, the web 502, 503 of reinforcement material may comprise fabric incorporating polymer "strands" arranged in a
15 matrix that runs as shown in FIG. 4. Refer to FIG. 5B. In select embodiments of the present invention, loops (tabs) 506 may be sewn into the borders of the encapsulated panel 505 as an alternative to grommets 504.

Refer to FIG. 5C in which two configurations of attaching the overlapped edges of the sheets 102, 103 of elastic material of FIG. 5A are shown. On the viewer's left is shown the
20 two sheets 102, 103 of elastic material as reinforced by webs 502, 503 of reinforcement material, being joined at the middle of the depth, d , of the resultant encapsulated panel 501. On the viewer's right is shown two un-reinforced sheets 102, 103 of elastic materials being joined in the same plane as one sheet 103 of elastic materials, i.e., at one side of the resultant panel 501. This latter configuration would facilitate the resultant panel 501 lying flatter
25 against the surface to which it is mounted since the mounting item (e.g., an eyehook) would not need to protrude as far from the mounting surface to engage grommets 504.

In select embodiments of the present invention, sheets 102, 103 of elastic materials used for the "skin" of the composite may comprise a spun para-aramid fiber, e.g., KEVLAR®, ballistic grade E-glass, commercial E-glass, S2-glass, polypropylene
30 thermoplastic sheet, polyurethane/polyurea-blended sheet, polyurethane films (with or without reinforcement), fiberglass, carbon fiber, metal mesh/grid fiber reinforced plastic (FRP), and the like. Where more than one layer of skin is applied as a sheet 102, 103, e.g., as

a laminate, the layers may be of the same material and same thickness, same material different thicknesses, different materials of the same thickness or different materials of different thicknesses. Further, individual layers may be a composite of different material, e.g., a laminate of FRP and carbon fiber. The selection of materials depends on the amount of protection required and may also be subject to a cost/benefit constraint. The core 101 may comprise variants of hard armor material produced from high performance concretes, ceramics, quarried stone, various architectural armors, plastics and the like. To keep costs in line, portland cement-based VHSC's, such as COR-TUF™, are preferred.

In select embodiments of the present invention, a core 101 is prepared to accept one or more outer sheets 102, 103 of an elastic material, such as a polymer, by applying a compatible adhesive, such as an epoxy, to the sides 104 and to the surface of the sheets 102, 103 of elastic material, such as solid sheets of polymer, and mating the surfaces of the sheets 102, 103 to that of the surfaces of the sides 104 in accordance with the instructions of the adhesive manufacturer. In select embodiments of the present invention, the sheets 102, 103 may be attached via applying pressure to the back (top) surface of the sheets 102, 103 of elastic material. In select embodiments of the present invention, if the sheet 102, 103 of elastic material is applied in fluid form prior to curing to a flexible solid, e.g., either sprayed, brushed, trowelled or rolled on, the bonding mechanism is generally the fluid form of the elastic material itself, such as a sprayable polymer, and no adhesive is necessary. In select embodiments of the present invention, a "laid-up" composite panel 306 is then allowed to cure in accordance with the instructions of the manufacturer of the material used to create the flexible solid sheets 102, 103 of elastic material.

In select embodiments of the present invention, the core 101 is a very high-strength, high-toughness cement-based material, e.g., a VHSC, that is very efficient at absorbing or reducing the kinetic energy of any impacting object, such as a fragment projected from a blast or deposited by wind.

In select embodiments of the present invention, one or more sheets 102, 103 of elastic material, such as a polymer sheet, trap impacting objects thereby increasing protection from airborne fragments as compared to the trapping capacity available from use of the core 101 alone. A sheet 102, 103 of elastic material, e.g., a polymer sheet, on the non-impact side (inside) 104 of a panel 306 provides added resistance to punching shear in the core 101.

Additionally, facing a core 101 with a high tensile strength (high "toughness") membrane on the impact side (outside) 104, further enhances the performance of the panel 306.

Select embodiments of the present invention may be employed in building construction products such as roofing tiles, wall panels, floor tiles, hurricane and tornado resistant structural elements, forced entry resistant structural elements and the like.

The ability to choose among many polymer materials for an appropriate sheet 102, 103 of elastic material makes various embodiments of the present invention suitable for use in a variety of military, first responder, commercial, industrial and consumer applications.

EXAMPLE I

Select embodiments of the panel of the present invention include a panel 306 having a core 101 comprising a portland cement-based composite material, such as COR-TUF™, that is completely encapsulated in a sheet 102, 103 of thermoplastic material bonded to the core 101 through application of heat and pressure. Because of the combined properties of the thermoplastic material and the COR-TUF™, select embodiments of the present invention are capable of blunting sharp edges of shrapnel resultant from an explosion. This blunting flattens airborne debris (or shrapnel) as it penetrates the core 101, thereby slowing it while decreasing the depth of penetration. Select embodiments of the present invention provide a composite panel 306 that has the compressive strength of high-performance concrete coupled with the additional capacity (toughness) to trap at least some impacting fragments in the encapsulation layers of the sheet 102, 103 of elastic material applied to both the impact (outside) side 104 and non-impact (inside) side 104 of the panel 306.

In select embodiments of the present invention, using COR-TUF™ as the core 101 of a panel 501 such as that of FIG. 5A, the core 101 is prepared according to any of the methods described in the '084 application and cured. The cured COR-TUF™ core 101 is covered with sheets 102, 103 of thermoplastic (elastic) material, approximately 0.1-0.2 in. (2.5-5 mm) thick, cut so that the sheets 102, 103 overlap the core 101 by approximately three inches on each edge 107.

With the sheets 102, 103 of thermoplastic material placed beneath and over the core 101 the sheets 102, 103 are welded to each other through one of the following processes. While heat is applied to the sheets 102, 103 of thermoplastic material, mechanical pressure such as from weights, applied pressure or other clamping technique, is applied to the top and bottom edges of the sheets 102, 103 to melt the thermoplastic material of the sheets 102, 103

and to fuse the edges of the sheets 102, 103 of thermoplastic material together providing a completely encapsulated core 101 resulting in a panel such as the panel 501 of FIG. 5.

In select embodiments of the present invention a vacuum assist, coupled with the heating of the sheets 102, 103 of elastic material, may be used to withdraw any air from inside the confines of the two facing layers and draw the sheets 102, 103 of elastic material to the core 101 to thermally weld one sheet 102 of thermoplastic material to another sheet 103 of thermoplastic material.

Alternatively, in select embodiments of the present invention, a mechanical mold (not shown separately) may be employed. The mold may consist of top and bottom forms that are three inches larger on all sides than the core 101, and deep enough to surround the core 101 with resin (not shown separately) to a depth of about 0.20 inches. In select embodiments of the present invention, a resin incorporating reinforcing polymer fibers is injected around the core 101 in a manner similar to an injection molding process.

Alternatively, in select embodiments of the present invention, an adhesive may be applied to the internal side of the top and bottom sheets 102, 103 of elastic material and mechanical pressure applied to them to "weld" the sheets 102, 103 of elastic material around the core 101. This process bonds the outer sheets 102, 103 of elastic material to themselves and the core 101 as an alternative to a thermal welding process.

These processes are particularly suitable for making inexpensive thin panels 501 for use as armor. If the sheets 102, 103 of elastic material are impermeable to moisture, the core 101 will not gain any moisture after sealing the elastic material of the sheets 102, 103. This is important in areas where any freezing water in a porous concrete core 101 may cause cracking or if the core 101 is reinforced with steel that may corrode upon introduction of moisture.

In select embodiments of the present invention, panels 306, 501 made from these processes may be produced in size and thickness to accommodate man-portability. These man-portable panels 306, 501 may be configured for attaching to a structural framework to produce a protective system for mitigation of blast and fragmentation effects. Further, resistance to dynamic pressure forces makes these embodiments suitable as a panel to resist collateral damage due to hurricanes and tornadoes.

EXAMPLE II

Select embodiments of the panels of the present invention comprise a core 101 of a high-performance concrete such as COR-TUF™ coupled with an elastomeric "skin" consisting of a blend of polyurethane and polyurea that hardens to a tough, elastic sheet (coating) 102, 103 bonded to the core 101.

5 The polyurethane/polyurea sheet (coating) 102, 103 is applied to the core 101 by suitable means, such as a pressure driven spray gun. The sheet (coating) 102, 103 is applied at ambient temperature by means of multiple passes to build up a sheet thickness of about 1/16 to 1½ inches (1.5 mm – 38 mm). For select embodiments of the present invention, the sheet (coating) 102, 103 dries to the touch within 30 seconds and achieves full strength within
10 24 hours of application.

 The bonding of the sheet (coating) 102, 103 of elastic material to the core 101 reduces or eliminates spalling of debris and strike-face chipping by confining fragments behind the sheet (coating) 102, 103 at the front and back faces of resultant panels 306. The resultant panel 306 reduces or eliminates hazards from shock; fragments, projectiles and debris that
15 may strike the panel 306; and reduces or eliminates injuries associated with flying objects. Equipping the panel 306 with sheets (coatings) 102, 103 of this type also minimizes the tendency towards forward momentum of the panel 306 that would accompany ejection of material on the impact side (outside) 104 of the panel 306. Further, the integrity of a significant thickness (greater than ¾") of a polyurethane/polyurea sheet (coating) 102, 103
20 has been found to be better than that achieved by adhesively laminating multiple thin polymer sheets 102, 103.

EXAMPLE III

 Select embodiments of the present invention comprise a core 101 of a high-performance concrete, such as COR-TUF™, coupled with an applied elastomeric sheet (skin)
25 102, 103 comprising a blend of polyurethane and polyurea material augmented with an aramid reinforcing layer 302, 303 that is embedded into the blend before the mix hardens to a tough, elastic sheet (coating) 102, 103 bonded to the core 101.

 In select embodiments of the present invention, the aramid component comprises strands of the aramid woven into a reinforcing fabric 302, 303. The reinforcing fabric 302,
30 303 may be composed of one type or a combination of types of strands oriented at various angles to the long axis, *L*, of the core 101, e.g. oriented as a matrix of fibers, one set at 90° to another to form a matrix (checkerboard), one axis of the matrix aligned along the length, *L*, of

the core 101. In select embodiments of the present invention, an alternate alignment aligns the same matrix as above and aligns it at a 45° angle (i.e., "on a bias") to the length, *L*, of the core 101. In select embodiments of the present invention, the reinforcing fabric 302, 303 is cut to the desired size to fit one or more sides 104 of the core 101 and affixed to the sides 104 before a spray-on elastomer is applied to cure as an elastic sheet 102, 103. The reinforcing fabric 302, 303 may be affixed to both the front and back sides 104 of the core 101 or cut to completely enclose the core 101 as shown in the encapsulated panel 306.

As in Example II, in select embodiments of the present invention, a polyurethane/polyurea material is applied and cured as a sheet (coating) 102, 103 to an aramid covered core 101 by suitable means, such as a pressure driven spray gun. The polyurethane/polyurea material is applied to the core 101 at ambient temperature and pressure and by means of multiple passes to build up a thickness of about 1/16 to 1-1/2 inches (1.5 mm – 38 mm). The polyurethane/polyurea material dries to the touch within 30 seconds and achieves full strength within 24 hours of application. The polyurethane/polyurea material may be applied to one side 104 of the core 101, both sides 104 of the core 101, or both sides 104 and all four edges 107 of the core 101 to fully encapsulate the core 101 as shown in the panel 306.

In select embodiments of the present invention, the polyurethane/polyurea material saturates the threads of the reinforcement cloth 302, 303, e.g., aramid strands, and penetrates to the sides 104 and edges 307 of the core 101. The bonding of the polyurethane/polyurea material to the reinforcement cloth 302, 303 and the core 101 produces a sheet 102, 103 of elastic material that reduces spalling of debris from the front and back sides 104 of the core 101 as well as the edges 307. An aramid reinforcement cloth 302, 303 provides an increase of tensile strength (toughness) in the resultant composite panel 306.

The use of aramid as the reinforcement cloth 302, 303 adds a level of flexural failure resistance (toughness) to the resultant panel 306 when under load from a blast. Availability of aramid cloth 302, 303 woven at custom orientations allows a user to specify axis-specific material properties that are beneficial to enhancing the structural capacities of the resultant panels 306. The additional expense of the aramid employed in the reinforcement cloth 302, 303 may limit the use of these panels 306 to fragile or high-value targets.

EXAMPLE IV

Select embodiments of the present invention comprise a core 101 of a high-performance concrete such as COR-TUF™ coupled with a facing of a thin elastomeric sheet (membrane) 102, 103 on one or both sides 104 of the core 101. The elastomeric sheet (membrane) 102, 103 may contain embedded reinforcement 302, 303 in a grid or mesh configuration that may be oriented in various geometries (compare FIG. 3 to FIG. 4) to establish desired performance characteristics for specific applications.

In select embodiments of the present invention, the thin-film elastomeric sheets (membranes) 102, 103 may comprise polymer resin systems of the type: polyurethane, polyurea, polyethylene, polypropylene, commercial elastomeric polymers, and combinations thereof. The thickness of the applied elastomeric membrane 102, 103 may be varied between about 20 mils to 0.5 inches (0.5- 12.5 mm). In select embodiments of the present invention, a thin-film sheet (membrane) 102, 103 is affixed to a core 101 by means of an adhesive compatible with both the material of the core 101 and the thin-film sheet (membrane) 102, 103.

In select embodiments of the present invention, the sheet (membrane) 102, 103 may be reinforced. Reinforcement cloth 302, 303 may be provided in grid or mesh configuration and embedded into the sheet (membrane) 102, 103 of elastic material as shown in FIGS. 3, 4 and 5A. In select embodiments of the present invention, the reinforcement cloth 302, 303 may be adhered separately (not shown separately) between the core 101 and the elastomeric sheet (membrane) 102, 103. The reinforcement cloth (matrix) 302, 303 may be of the following types: spun para-aramid fiber (e.g., KEVLAR®), fiberglass, carbon fiber, polypropylene, nylon, polyethylene, commercially available geo-grid materials, commercially available geo-fabric materials, metallic grids, metallic meshes, metallic membranes, combinations thereof, and the like. The reinforcement cloth 302, 303 may be oriented as a matrix (grid or mesh) of fibers, one set of fibers at 90° to another to form a matrix (grid or mesh), one axis of the matrix aligned along the length, L , of the core 101, as shown in FIG. 4. In select embodiments of the present invention, an alternate alignment aligns the same matrix at an angle less than 90° as shown in FIG. 3, e.g., a 45° angle (i.e., "on a bias") to the length, L , of the core 101.

The bonding of the thin film elastomeric sheets (membranes) 102, 103 to the core 101 reduces spalling of debris from the front and back sides 104 and edges 107 of the core 101. The resultant panel 306 reduces or eliminates hazards from shock; fragments, projectiles and

debris that may strike the panel 306; and reduces or eliminates injuries associated with airborne objects that impact the panel 306. Equipping the panel 306 with thin film sheets (membranes) 102, 103 of this type also minimizes the tendency towards forward momentum of the panel 306 that would accompany ejection of material from an impact side 104 of the panel 306.

Further, select embodiments of the present invention employing adhered thin film sheets (membranes) 102, 103 have the potential for manufacture in remote or austere locations using a minimal amount of specialized equipment. This may significantly reduce cost, including transportation, where the panels 306 are to be used near the site of fabrication.

EXAMPLE V

Select embodiments of the present invention comprise a core 101 of a high-performance concrete such as COR-TUF™ backed with layers of reinforced polymer sheets 102, 302, 103, 303 in FIG. 3, for example. In select embodiments of the present invention, the reinforced polymer sheets 102, 302, 103, 303 may employ components comprising at least: spun para-aramid fiber (e.g., KEVLAR®); ballistic grade E-glass; commercial E-glass; S2-glass; polypropylene thermoplastic sheet; polyurethane/polyurea blended sheet; polyurethane films; fiberglass, carbon fiber, metal mesh fiber reinforced plastic (FRP), grid FRP, combinations thereof and the like.

In select embodiments of the present invention, the reinforced polymer sheets 102, 302, 103, 303 may be pre-fabricated sheets or be provided in a package of reinforcement fabric webs 302, 303 and a polymer in fluid form for local application, such as brush-on, trowel-on or spray-on formulations. In select embodiments of the present invention, the reinforcement cloth 302, 303 may be either a self-contained layer of woven material that may be sandwiched between layers of polymer sheets 102, 103 or a woven mesh that is embedded in a thermoplastic polymer (resin) system that is sprayed, brushed or troweled over the mesh, thus encapsulating the strands of the mesh. The reinforcement cloth 302, 303 may be oriented as a matrix (grid or mesh) of fibers, one fiber set at 90° to another to form a matrix (grid or mesh), one axis of the matrix aligned along the length, L , of the core 101. In select embodiments of the present invention, an alternate alignment aligns the same matrix on a bias to the length, L , of the core 101 as discussed above.

In select embodiments of the present invention, polymer sheets 102, 103 are bonded to the back (non-impact) side 104 of the core 101 to provide toughness and spall protection.

In select embodiments of the present invention, both the back and front sides 104 of the core 101 may incorporate polymer sheets 102, 103. The same type and thickness of polymer sheet 102, 103 need not be used on the front side 104 as the back side 104 and either or both sides 104 may incorporate reinforcement cloth 302, 303 in the polymer sheets 102, 103 as the user's application dictates. Select embodiments of the present invention provide a modular panel 306 that allows tailoring protection levels to user needs and flexibility in applied configurations and geometry.

Further, select embodiments of the present invention employing adhered, brushed, sprayed-on, or troweled-on polymer coatings (sheets) 102, 103 have the potential for manufacture in remote or austere locations using a minimal amount of specialized equipment. This may significantly reduce cost, including transportation, for panels 306 to be used in the vicinity of their fabrication.

EXAMPLE VI

Select embodiments of the present invention comprise a core 101 of a high-performance armor material, e.g., COR-TUF™, coupled with reinforcement of *rigid, yet elastic*, polymer sheets 102, 103 on one or both sides 104 of the core 101. The polymer sheets 102, 103 may be any *rigid, yet elastic*, composite comprising a suitable binder/hardener and material of the type comprising: spun para-aramid fibers (e.g., KEVLAR®); ballistic grade E-glass; commercial E-glass; S2-glass; polypropylene thermoplastic sheet; polyurethane/polyurea blended sheet; polyurethane films (with or without reinforcement); fiberglass, carbon fiber reinforced plastic (FRP), metal mesh FRP, combinations thereof, and the like. The component materials used in these embodiments of the present invention obtain strength and toughness qualities by appropriate choice of the type and quantity of component materials, balancing cost with the required performance in each application.

In select embodiments of the present invention, the core 101 may comprise any of various hard armor materials such as that produced from high performance concretes including VHSCs, ceramics, quarried stone or various architectural armors. In select embodiments of the present invention, once fabricated, the sides 104 of the core 101 are prepared to accept a sheet 102, 103 comprising a rigid, yet elastic, outer layer of polymer material by applying a compatible adhesive to the applicable sides 104 of the core 101 that will be bonded to the sheets 102, 103 of rigid, yet elastic, polymer material. In select

embodiments of the present invention, adhesive is also applied to the inner surface (not shown separately) of the sheets 102, 103 of rigid, yet elastic, polymer material. Following the adhesive manufacturer's recommended procedures, the core 101 and the sheets 102, 103 of rigid, yet elastic, polymer material are mated and pressure applied to the outer surface of the sheets 102, 103 of rigid, yet elastic, polymer material as provided for in the adhesive manufacturer's instructions for use.

In select embodiments of the present invention, the multi-part rigid, yet elastic, sheets 102, 103 allow a user to tailor configurations for specific applications while optimizing a cost/performance ratio. These embodiments have excellent toughness to resist blast and ballistic penetration forces.

EXAMPLE VII

Select embodiments of the present invention comprise a core 101 of a high-performance armor material, e.g., COR-TUF™, coupled with one or more combinations of polymer sheets (layers) 102, 103 with or without reinforcement 302, 303 added to one or more sides 104 of the core 101. For example, a polymer sheet (coating) 102, 103 that is sprayed on a core 101 may be supplemented with a *rigid*, yet elastic, polymer sheet 102, 103 that sandwiches a reinforcement mesh 302, 303 between the rigid, yet elastic, polymer sheet 102, 103 and the sprayed on sheet (coating) 102, 103 for enhanced protection. In select embodiments of the present invention, an alternative may be the use of multiple thin flexible polymer sheets (membranes) 102, 103 with a reinforcement mesh 302, 303 between each layer on one side 104 of the core 101 to improve penetration and blast resistance of a core 101 having but a single sheet (membrane) 102, 103 or rigid, yet elastic, polymer sheet 102, 103 on that one side 104. In select embodiments of the present invention, an alternative embodiment sprays a coating of a polyurethane and polyurea to create a sheet (coating) 102, 103 on a core 101 having existing elastic sheets (membranes) 102, 103 or rigid, yet elastic, polymer sheets 102, 103 already affixed in order to seal out moisture from the edges 107, to make it easier to handle by reducing sharp edges 107, and to further enhance resistance to blast and fragment penetration.

EXAMPLE VIII

Select embodiments of the present invention comprise one or more cores 101 of a high-performance armor material, e.g., COR-TUF™, each core 101 coupled with one or more polymer sheets (layers) 102, 103 with or without reinforcement cloth 302, 303 added to one

or more sides 104 of each core 101. For example, a polymer sheet (coating) 102, 103 that is sprayed on one or more sides 104 of one or more of the cores 101 may be supplemented with a rigid, yet elastic, polymer sheet 102, 103 that sandwiches a reinforcement cloth mesh 302, 303 between the rigid, yet elastic, polymer sheet 102, 103 and the sprayed on sheet (coating) 102, 103 for enhanced protection. In select embodiments of the present invention, an alternative embodiment may use multiple elastic thin polymer sheets (membranes) 102, 103 with a reinforcement cloth mesh 302, 303 between each two thin polymer sheets (membranes) 102, 103 and the one or more faces 104 of one or more cores 101 to improve penetration and blast resistance of those cores 101 having a single membrane 102, 103 or rigid, yet elastic, polymer sheet 102, 103 on those faces 104. Another alternative may involve spray coating a polyurethane and polyurea coating 102, 103 on one or more cores 101 having existing elastic membranes 102, 103 or rigid, yet elastic, polymer sheets 102, 103 already affixed to seal out moisture from the edges 107, to make it easier to handle by eliminating sharp edges 107, and to further enhance resistance to blast and fragment penetration.

Refer to FIG. 6 depicting, for clarity only, an elevation view of a single box-shaped base platform unit 600 and single panel 100 installed thereon as may be employed in select embodiments of the present invention. In select embodiments of the present invention, the frame module 1400 for holding the panels 100 comprises a number of tubular cross members 603, pairs of which are "movably arranged" in an "X" pattern (see FIG. 13) on each of the base platform unit's four sides to comprise a basic "backbone" in compression. Pairs of wires 602, such as braided wires, parallel to the respective side on which they are placed and located at the top and bottom of each side of the frame module 1400, provide tension between each end of each pair of parallel sides of the frame module 1400 to hold the frame module 1400 in position for accepting the panels 100. The cross members 603 are "movably" (loosely) pinned to permit limited pivoting on the pins (not shown separately) affixing the cross members 603 to the bottom 606 and top 607 plates and are joined in the center by joining means 604, such as a contained rod or a clevis pin, where each pair of cross members 603 cross along a side. The joining means 604 permit pivoting of the cross members 603 in the plane of the respective sides of the frame module 1400. Connection at the ends of each cross member 603 is by suitable means, such as clevis pins or rivets, the cross members 603 fitting in two slots 808 (FIG. 8) perpendicular one to the other, at the bottom 606 and top 607

plates that comprise the corners of the "foldable" portion (frame module 1400) of the base platform unit 600. Likewise, the pairs of wires 602 on each of the four sides of the frame module 1400 are connected perpendicular to and between each of the parallel sides by end connectors fitted to holes 805 in 811, 911 (FIGS. 8 and 9) in each of the top 607 and bottom 606 plates, respectively. Note that in select embodiments of the present invention the top tabs 911 may be used for z-bars 601 that provide a top support for bottom panels 100 and a bottom support for panels 100 placed on "stacked" frame modules 1400. Together with the adjustable bases 605 on which the basic frame module 1400 rests at each of four corners of the base frame module 1400, the panels 100 when mounted in z-bars 601 fitted to mounting tabs 809 at the top 607 and bottom 606 plates, respectively, of the longitudinal sides of length, L , provide the degree of physical protection specified by a user. The adjustable bases 605 comprise a top (or bearing) plate 605A, a bottom (or support) plate 605B, an adjusting through bolt 605C and necessary internal assemblies to support and permit one-handed adjustment of the height, h (FIG. 11), of the adjustable base 605. In select embodiments of the present invention, the top and bottom z-bars 601 for each frame module 1400 may be further secured by straps 1600 (FIG. 16) that are tensioned at each end by tensioning means, such as ratchets 1601, affixed to holes 804 (FIGS. 8, 9) in the bottom 606 and top 607 plates, respectively, at the time of installation as further explained below. In select embodiments of the present invention, the frame module 1400 is configured such that it may be disassembled and "collapsed" for transport as shown in FIG. 14, as discussed further below. The dimensions of length, L , width, W (FIG. 7), and height, H , are chosen to permit frame modules 1400 of select embodiments of the present invention to be carried and assembled without the use of lifting machinery.

Refer to FIG. 7, a top view, shown for clarity, of the base platform unit 600 of FIG. 6 that may be employed in embodiments of the present invention. The top z-bars 601 are evident along the length, L , of the base platform unit 600 as fitted onto tabs 809 (FIG. 8) parallel to the length, L , and along the "outside" edge of the top plates 607. Note that, although not evident in this view, a second set of z-bars 601 runs along the bottom of each of the front and back sides, L . Also evident in FIG. 7, are the top tensioning wires 602 as readily seen running parallel to the width, W , of the base platform unit 600. Note that, although not evident in this view, a second set of tensioning wires 602 runs along the bottom of each of the four sides, L and W and the top of sides, L . Note also that, in select

embodiments of the present invention, the z-bars 601 do not extend to the end of the sides, *L*, although the emplaced panels 100 may since the z-bars 601 have open ends. In select embodiments of the present invention, multiple panels 100 may be emplaced one upon the other in the slots of the z-bars 601 (that are made sufficiently deep to accommodate multiple "stacked" panels) to create a greater thickness, preferably in such a manner that the overlaying panels 100 cover the intersection between panels 100 in the layer below. In select embodiments of the present invention, a different thickness (either panel type or the total overlaid number of panels 100) may be used on each side, *L*, depending on a user's requirements.

Refer to FIG. 8, a top view A of a bottom plate 606, as well as elevation views B, C of the two outer sides of the bottom plate 606 that may be employed in embodiments of the present invention, one of four such bottom plates 606 on the frame module 1400. In the top view A, the opening 807 is for a pin (not shown separately) to both align and join the bottom plate 606 to either an adjustable base 605 or a top plate 607, the latter when extending the height of an installation of frame modules 1400. Also shown are openings 804 in the base 810 of the bottom plate 606 that may be used for affixing the end 1602 of a tension adjustment strap 1600 from a z-bar 601 to the bottom plate 606. The base 810 of the bottom plate 606 is shown with a channel 808 for securing at right angles one to the other two of the cross members 603 therein by means of pins (not shown separately) through holes 806 in the sides of the channel 808 as seen in the elevation views B, C. The pins are loosely fitted, permitting the pivoting of the cross members 603 in the plane of the securing tabs 811, i.e., along the edge of the frame module 1400 in which the cross member 603 lies. For the bottom plates 606, the tabs 809 are "folded" from the base plate in the same direction as the securing tabs 811 for affixing the cross members 603 and the tension wires 602. The connection tabs 809 may also serve as connection tabs for the z-bars 601 and are shown most clearly on the opposing corners of the outer edges of the base 810 of the bottom plate 606 as seen in the elevation views B, C. In select embodiments of the present invention, the tabs 809 are presented on both of the outer sides of the base 810 of the bottom plate 606 to permit the installation of frame modules 1400 at right angles to one another.

Refer to FIG. 9, a top view A of a top plate 607, as well as elevation views B, C of the two outer sides of the top plate 607 that may be employed in embodiments of the present invention, one of four such top plates 607 on the frame module 1400. In select embodiments

of the present invention, although similar to the bottom plates 606 with respect to all aspects including the two tabs 907 arising from the base 910, the top plates have connection tabs 911 on the opposite side of the base 910 from the two tabs 907. This arrangement facilitates mating the bottom 606 and top 607 plates to permit vertical stacking of the frame modules 1400. The top plates 607 also incorporate a rivet 905 and slot 906 arrangement in the two vertical tabs 907. The rivet 905 and slot 906 arrangement is provided for securing individual frame modules 1400 one to another at their respective tops, vertical tabs 907 of top plates 607 on one end of each of the top plates 607 having a slot 906 and on the other end of the top plate 607 having a rivet 905. The orientation of the rivet 905 and slot 906 arrangement of the top plates 607 is reversed at opposite ends of the frame module 1400 to permit connection of adjacent frame modules 1400. That is, in select embodiments of the present invention, the top plates 607 are specifically configured to fit to the bottom plates 606 so as to permit "stacking" of the frame modules 1400 to make a high protective barrier, an example of which is shown in FIG. 15 stacked two high.

Refer to FIG. 10, shown for clarity only, a cross section taken through the bottom of the corners of three adjacent frame modules 1400. FIG. 10 depicts a top view of the three bottom plates 606. FIG. 10 illustrates how in select embodiments of the present invention a corner is formed using three frame modules 1400, only two of which are shown with a panel 100 installed in the z-bars 601. Note the threaded adjustment rod 605C shown to indicate the position of the adjustable base 605 in relation to the three bottom plates 606 as installed in base platform units 600.

Refer to FIG. 11, an elevation view of an adjustable base unit 605 that may be used with embodiments of the present invention to adjust the height of individual frame modules 1400 to match frame modules 1400 connected therewith as base platform units 600. In select embodiments of the present invention, a threaded rod 605C with an appropriate end nut (not shown separately) for applying a socket wrench or the like, is threaded through a threaded collar 1101 in a rest plate 605A on which a corner of a frame module 1400 rests. The support base 605B for the adjustable base unit 605 is of the same general dimensions as the rest plate 605A, further including a collar 1103 reinforced via a ramped configuration 1102, the collar 1103 for receiving and supporting the threaded rod 605C.

Refer to FIG. 12 showing top and end 601A views of a z-bar 601 employed to hold panels 100 onto individual frame modules 1400 as may be used in embodiments of the

present invention. Note the slot configurations 1201 added to the z-bars 601 for affixing the z-bars 601 to the tabs 809, 907 along the length, L , at the bottom and top of frame modules 1400, respectively.

Refer to FIG. 13, a perspective of the basic structure of a frame module 1400 expanded for installation of z-bars 601 and panels 100 (not shown separately in FIG. 13), to include z-bars 601, compression 603 and members in tension 602 and top 607 and bottom 606 plates (connectors) that may be used with embodiments of the present invention. Note that, in select embodiments of the present invention, z-bars 601, and consequently panels 100, may be installed only on one longitudinal side, L , in some applications. Further, double thicknesses of panels 100, i.e., panels placed one on top of the other, may be installed in the z-bars 601 on one side, L , while a single panel is installed in the z-bars 601 on the opposing side, L , in select embodiments. Normally, no z-bars 601 and thus, no panels 100 are installed along the width, W , of the frame modules 1400. Rather, the configuration of FIG. 10 is used to change direction of the resultant barrier.

Refer to FIG. 14, as depicted for clarity only, a perspective of the basic structure of a frame module 1400 collapsed for transportation or storage, without z-bars 601 and members in tension (wires) 602, as may be used in select embodiments of the present invention. The necessity for "loose" fittings of the pins in the top 607 and bottom 606 plates as well as at the "tie" pin 604 (FIG. 6) at the mid-connection of cross members 603 in each side of the frame module 1400 is evident from FIG. 14, a frame module 1400 collapsed for storage or transport.

Refer to FIG. 15, an elevation view of one side of a "protective" wall 1500 comprised of box-shaped frame modules 1400 of select embodiments of the present invention. The section of wall 1500 comprises three long by two high interconnected frame modules 1400 and a single installed panel 100 thereon for illustration purposes only. Note that the bottom of each base platform unit 600 is "secured" to its neighbor by a common adjustable base unit 605 while the tab 905 and slot 906 arrangement available at the top plate 607 of each frame module 1400 secures the individual frame modules 1400 to each other at their respective tops.

Refer to FIG. 16, top A and elevation B views of a strap 1600 that may be employed to tighten a wire (not shown separately) used to constrain the z-bars 601 as installed with inserted panels 100 in the frame modules 1400 of an embodiment of the present invention.

The strap 1600 comprises a hook 1602 at one end for inserting in holes 804 in the top 607 or bottom 606 plates as appropriate and a ratchet 1601 at the other end for tensioning the wire (not shown separately) attached to the strap and one of the holes 804 in the top 607 or bottom 606 plate as appropriate. In select embodiments of the present invention, the wire attached to the strap 1600 is "pre-attached" one to each end of a z-bar 601 to facilitate shipping and installation of the z-bars 601 on the frame modules 1400.

In select embodiments of the present invention all modules (components) used in constructing a protective wall or enclosure are "man portable," i.e., no specialized mechanical equipment is required for handling, packaging for transport, or installing the components into a finished protective configuration.

The abstract of the disclosure is provided to comply with the rules requiring an abstract that will allow a searcher to quickly ascertain the subject matter of the technical disclosure of any patent issued from this disclosure. 37 CFR § 1.72(b). Any advantages and benefits described may not apply to all embodiments of the invention.

While the invention has been described in terms of some of its embodiments, those skilled in the art will recognize that the invention can be practiced with modifications within the spirit and scope of the appended claims. For example, although the system is described in specific examples for use in protecting assets, it may be used for any type of portable structure where physical or visual restriction or even noise suppression is desired. Thus select embodiments of the present invention may be useful in such diverse applications as mining, logging, construction, outdoor concerts, parades, and the like. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Thus, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface, in the environment of fastening wooden parts, a nail and a screw may be equivalent structures. Thus, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative rather than limiting, and the invention should be defined only in accordance with the following claims and their equivalents.

CLAIMS

We claim:

- 5 1. A configuration providing isolation of assets, comprising:
a quadrilateral frame module with an open top and an open bottom,
comprising:
one each mount of a first type at each of four corners of said module
establishing extremities of said top,
10 one each mount of a second type at each of said four corners
establishing extremities of said bottom,
wherein said mount of a first type is connectable to said mount of a second
type on another said module to permit vertical stacking of said frame modules,
and
15 wherein said mount of a first type is connectable to an abutted said mount of a
first type to permit horizontal connection of said frame modules one to
another;
a pair of cross members in compression on each of said four sides of
said frame module, each said cross member establishing a diagonal
20 connection between a said first type of mount and a said second type of
mount,
wherein each said cross member of said pair is pivotally joined at the center to
the other said cross member of said pair, and
wherein each said cross member is pivotally joined to one said mount of a first
25 type and one said mount of a second type to allow pivoting of said pair of
cross members in a plane parallel to said side containing said pair of cross
members; and
at least first and second members in tension on each said side, ends
of one first member in tension attached horizontally to each said
30 mount of a first type in each said side and ends of one second member
in tension attached horizontally to each said mount of a second type in
each said side;

at least one pair of z-bars comprising integral open channels facing opposite directions and raised slots at each end on one side for indexing said z-bar to said module, each said z-bar incorporating an adjustable tensioner at each end, wherein said z-bars are affixed along at least a first side of said frame module, each end of a first z-bar of said pair affixed to one of two said mounts of a first type at the extremities of the top of said first side and each end of a second z-bar of said pair affixed to two said mounts of a second type at the extremities of the bottom of said first side;

four leveling pads indexed to each bottom corner of said module via at least one first type of rod in each said pad that mates with an opening in said mount of a second type,

wherein each said pad is in operable communication both with at least one each said mount of a second type and a surface upon which said pads rest; and

wherein said second type of mount is connectable to said leveling pad when said second type of mount is employed in modules that are a base of said configuration, and

wherein said pads may accommodate up to at least three said mounts of a second type;

panels having a length, width and depth;

wherein said panels are mounted on at least one said side of said configuration in each said pair of z-bars to provide said isolation.

2. The configuration of claim 1 in which said leveling pads are adjustable at least in height.

3. The configuration of claim 2 in which said pads further comprise:

a bottom plate configured to accept a non-threaded end of a second type of rod having a threaded portion;

a top plate configured to accept said threaded portion of said rod of a second type in a matching threaded bearing in the center of said top plate;

wherein said rod is in operable communication with said bottom plate and said top plate and configured to be rotated and moved in relation to said top plate using a COTS tool for adjusting the height of said module.

- 5 4. The configuration of claim 1 in which all components of said configuration are man transportable and at least some said components comprise at least steel having at least a corrosion resistant finish.
- 10 5. The configuration of claim 1 in which the length, width and height of said frame modules are equal.
- 15 6. The configuration of claim 1 in which said z-bars comprise integral first and second open rectangular channels, the open portion of a first said channel facing to said top and the open portion of a second said channel facing to said bottom of said configuration, said channels incorporating open ends, said z-bars much longer in length than either width or depth.
- 20 7. The configuration of claim 1 in which said panels are quadrilateral in dimension, wherein said length and said width are much greater than said depth.
- 25 8. The configuration of claim 1, said panels further having a pre-specified resistance to penetration, wherein said panels having a pre-specified resistance to penetration provide protection of assets from physical damage due to dynamic force.
- 30 9. The configuration of claim 1 in which said members in tension comprise wires, wherein, for each said module, four said wires are employed with said mounts of a first type and four said wires are employed with said mounts of a second type.
- 30 10. The configuration of claim 1 in which said panels are installed on two opposing sides of said configuration.

11. The configuration of claim 1 comprising panels that overlap on at least one said side as installed in said z-bars.
12. The configuration of claim 1 in which said cross members have a quadrilateral cross section.
13. The configuration of claim 1, said frame modules foldable to facilitate storage and transport.
14. A method for isolating assets via a modular configuration, comprising:
- a) providing and unfolding a quadrilateral frame module with an open top and an open bottom, comprising:
 - one each mount of a first type at each of four corners of said module establishing extremities of said top,
 - one each mount of a second type at each of said four corners establishing extremities of said bottom,
- wherein said mount of a first type is connectable to said mount of a second type on another said module to permit vertical stacking of said frame modules, and
- wherein said mount of a first type is connectable to an abutted said mount of a first type to permit horizontal connection of said frame modules one to another;
- a pair of cross members in compression on each of said four sides of said frame module, each said cross member establishing a diagonal connection between a said first type of mount and a said second type of mount,
- wherein each said cross member of said pair is pivotally joined at the center to the other said cross member of said pair, and
- wherein each said cross member is pivotally joined to one said mount of a first type and one said mount of a second type to allow pivoting of said pair of cross members in a plane parallel to said side containing said pair of cross members; and

at least first and second members in tension on each said side, ends of one first member in tension attached horizontally to each said mount of a first type in each said side and ends of one second member in tension attached horizontally to each said mount of a second type in each said side;

b) providing at least one pair of z-bars comprising integral open channels facing opposite directions and raised slots at each end on one side for indexing said z-bar to said module, each said z-bar incorporating an adjustable tensioner at each end, affixing said z-bars along at least a first side of said frame module by indexing each end of a first z-bar of said pair to one of two said mounts of a first type at the extremities of the top of said first side and indexing each end of a second z-bar of said pair to two said mounts of a second type at the extremities of the bottom of said first side;

c) providing four leveling pads;

d) placing said pads on a level surface spaced to approximate the spacing of the four corners of a said frame module;

e) indexing each said pad to each bottom corner of a first said module via at least one first type of rod incorporated in each said pad that mates with an opening in said mount of a second type,

wherein each said pad is in operable communication both with at least one each said mount of a second type and a surface upon which said pads rest; and

wherein said second type of mount is connectable to said leveling pad when said second type of mount is employed in modules that are a base of said configuration, and

wherein said pads may accommodate up to at least three said mounts of a second type;

f) providing two additional said pads per a second and each succeeding said frame module to be connected to existing installed said modules to comprise said modular configuration, each said addition of said second and succeeding frame modules comprising:

1) repeating steps (a) and (b);

2) placing said two pads on a level surface, spaced to approximate the spacing of two of the four corners of an additional said frame module to be abutted to said installed frame module;

3) indexing each of two said pads employed in installing said installed frame module to each mount of a second type on the side of said additional frame module abutting said first frame module and in a similar manner indexing said additional two pads to remaining said mounts of a second type on said additional frame module;

4) adjusting the height of said leveling pads now associated with said additional frame module to permit connection of said mounts of a first type on the abutting sides of said installed and additional frame modules to be connected together and approximately level;

5) providing panels having a length, width and depth;

6) mounting said panels on at least one said side of said configuration in each said pair of z-bars in each said frame module incorporated in said configuration as a base of said configuration;

7) checking openings between installed panels,

8) re-adjusting the height of said installed modules to minimize any said openings above a pre-specified value;

9) setting tension of said adjustable tensioners to a pre-specified value; and

g) repeating steps a) - f) until a pre-specified length of said configuration is established.

15. The method of claim 14 further comprising installing said panels on two opposing sides of said configuration.

16. The method of claim 14 further comprising installing overlapped said panels on at least one said side of said configuration.

17. The method of claim 14 connecting said mounts of a first type via fitting rivet heads on a first abutting said frame module to rivet slots on a second abutting said frame module.

5 18. The method of claim 14 stacking additional said frame modules directly upon first installed said modules to increase the height of said configuration, further comprising.

a) providing and unfolding at least one said quadrilateral frame module;

b) providing at least one said z-bar;

10 c) indexing said z-bar along at least a first side of said frame module, affixing each end of a first z-bar of said pair to one of two said mounts of a first type at the extremities of the top of said first side and affixing each end of a second z-bar of said pair to two said mounts of a second type at the extremities of the bottom of said first side;

15 d) indexing each said mount of a first type on said installed frame modules to a below corresponding said mount of a second type on said additional stacked frame module via said at least one first type of rod;

e) adjusting the height of said leveling pads now associated with abutting said stacked frame modules to permit approximately level connection of said mounts of a first type on the abutting sides of said stacked frame modules;

20 f) providing said panels;

g) mounting said panels on at least one said side of said stacked frame modules;

h) checking openings between all said installed panels,

25 i) re-adjusting the height of said installed frame modules to minimize any said openings above a pre-specified value;

j) setting tension of said adjustable tensioners of said z-bars affixed to said stacked frame modules to a pre-specified value; and

30 k) repeating steps (a) – (j) until a pre-specified length of said configuration is established.

19. The method of claim 18 further comprising installing said panels on two opposing sides of said stacked frame modules.

20. The method of claim 18 further comprising installing overlapped said panels on at least one said side of said stacked frame modules.

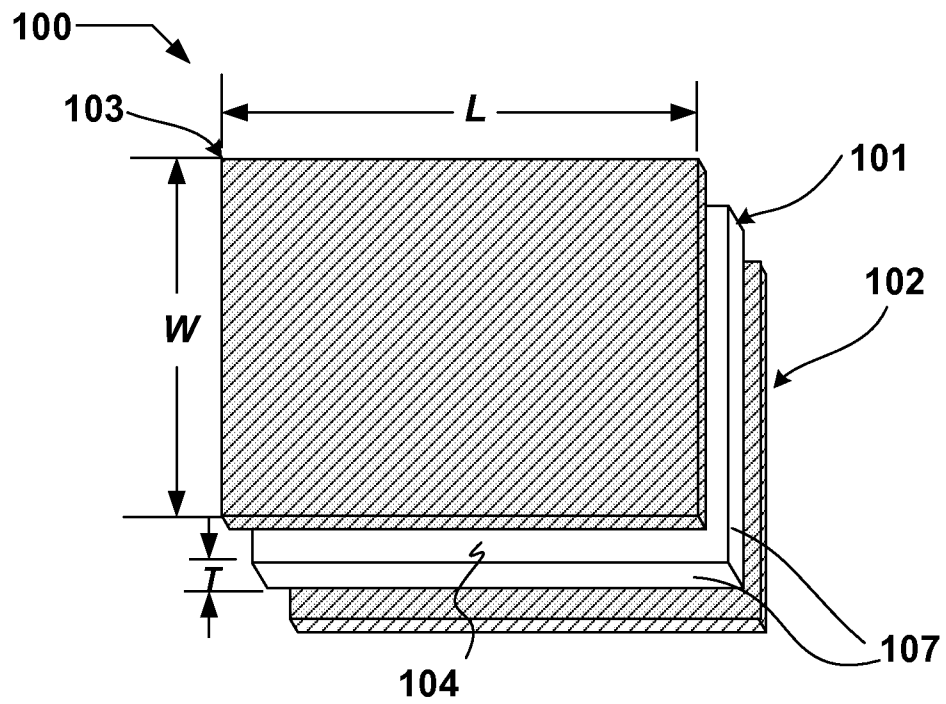


Fig. 1

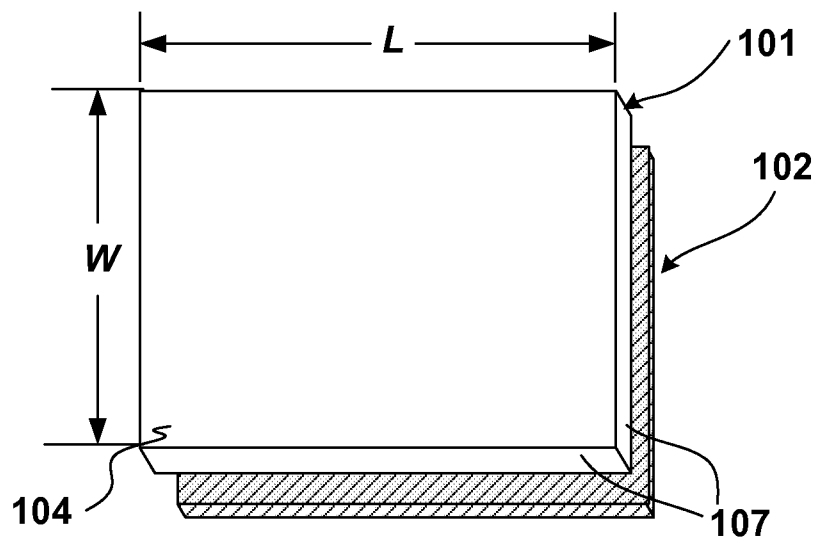


Fig. 2

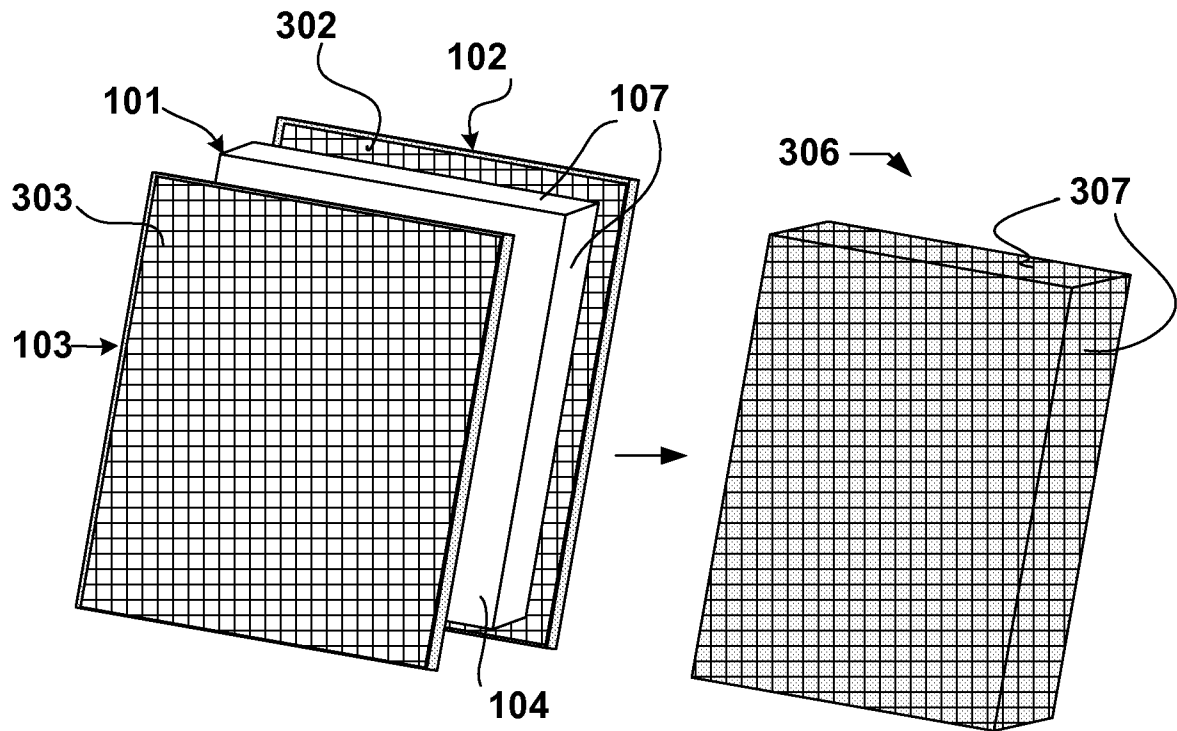


Fig. 3

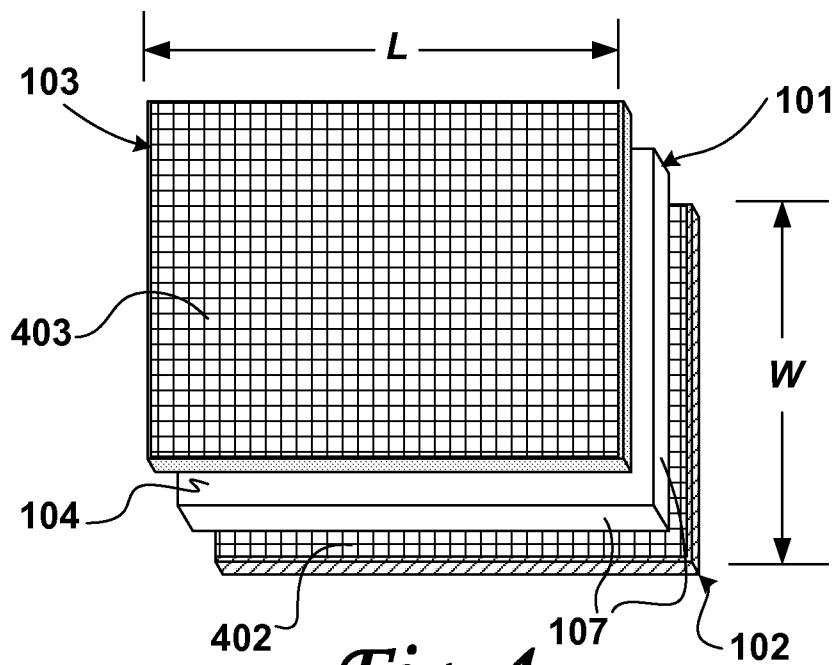


Fig. 4

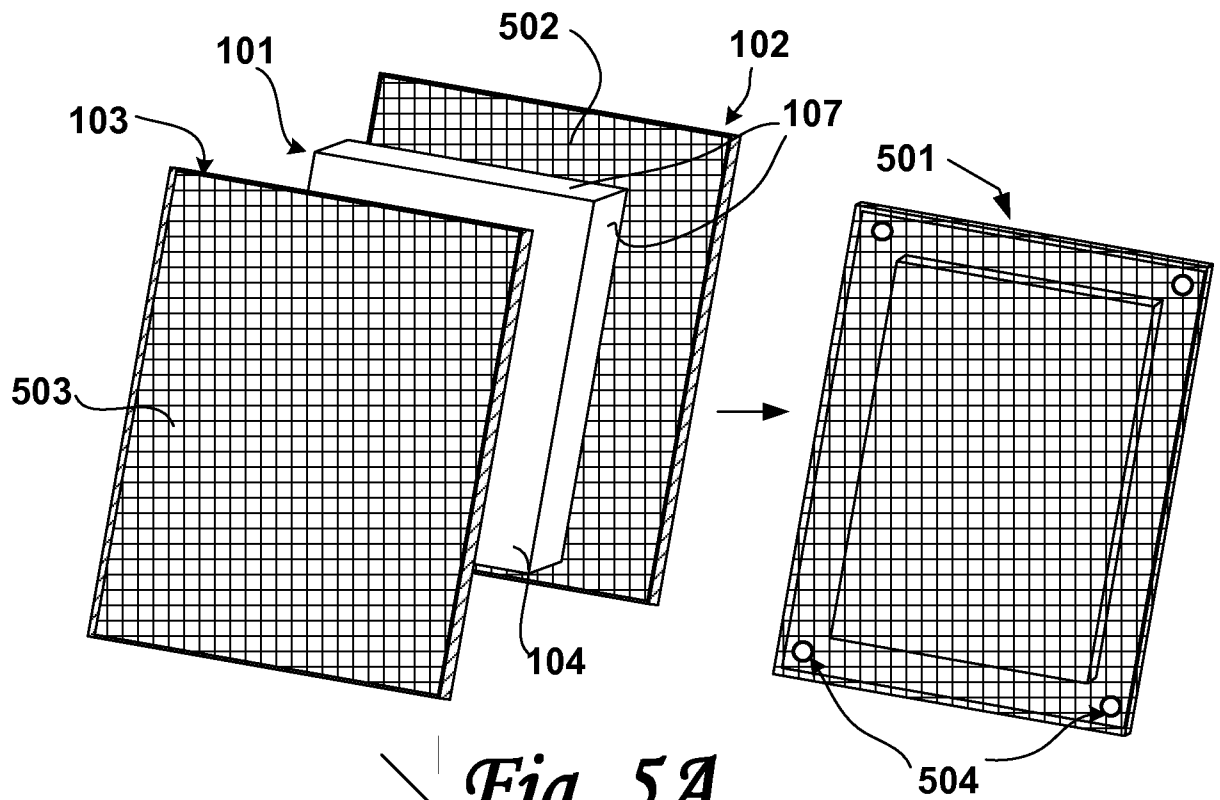


Fig. 5A

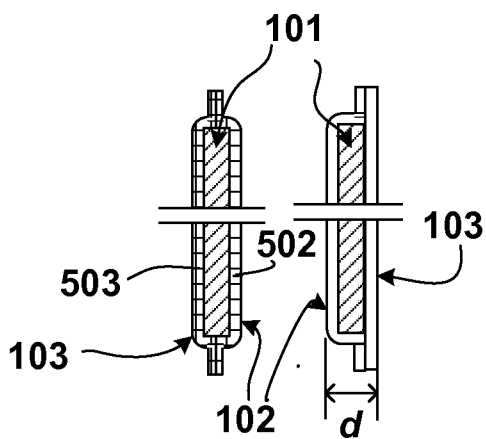


Fig. 5C

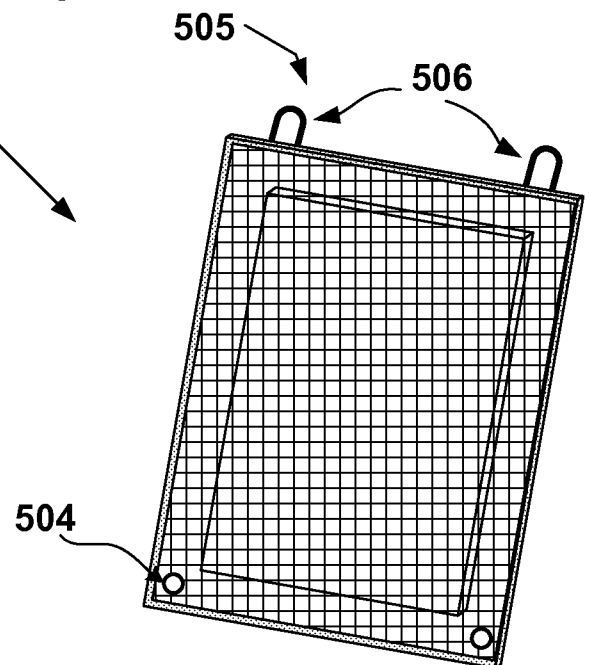
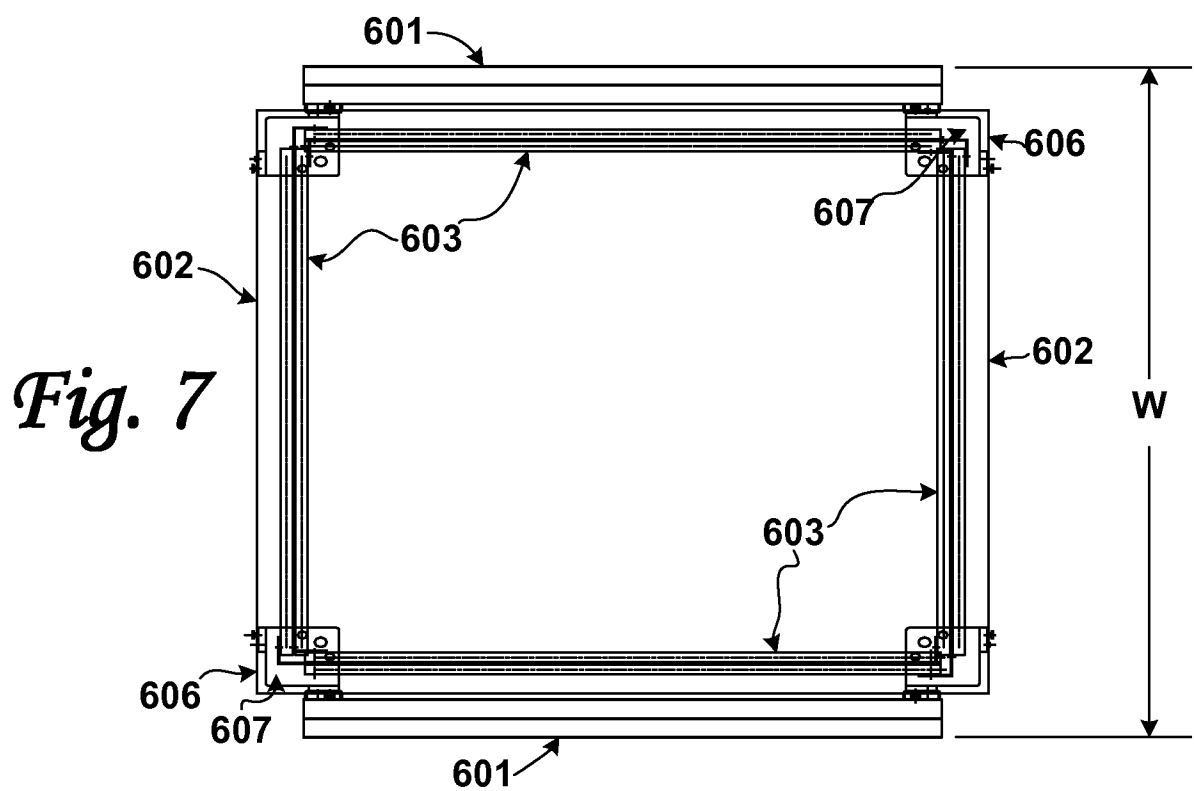
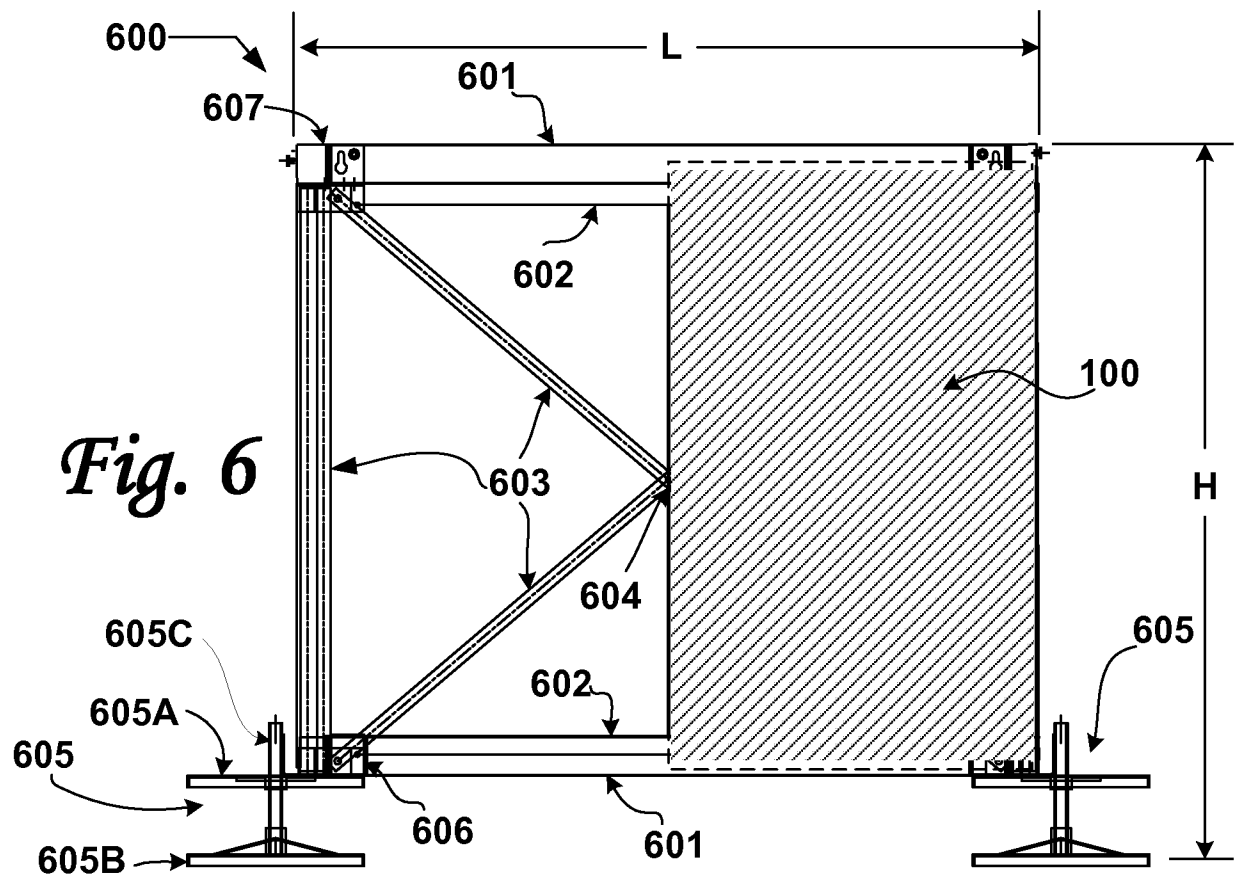


Fig. 5B



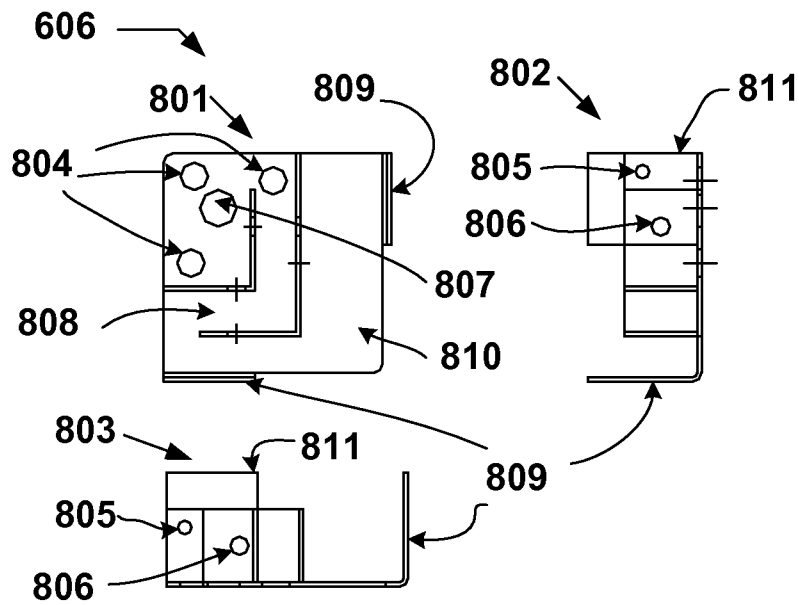


Fig. 8

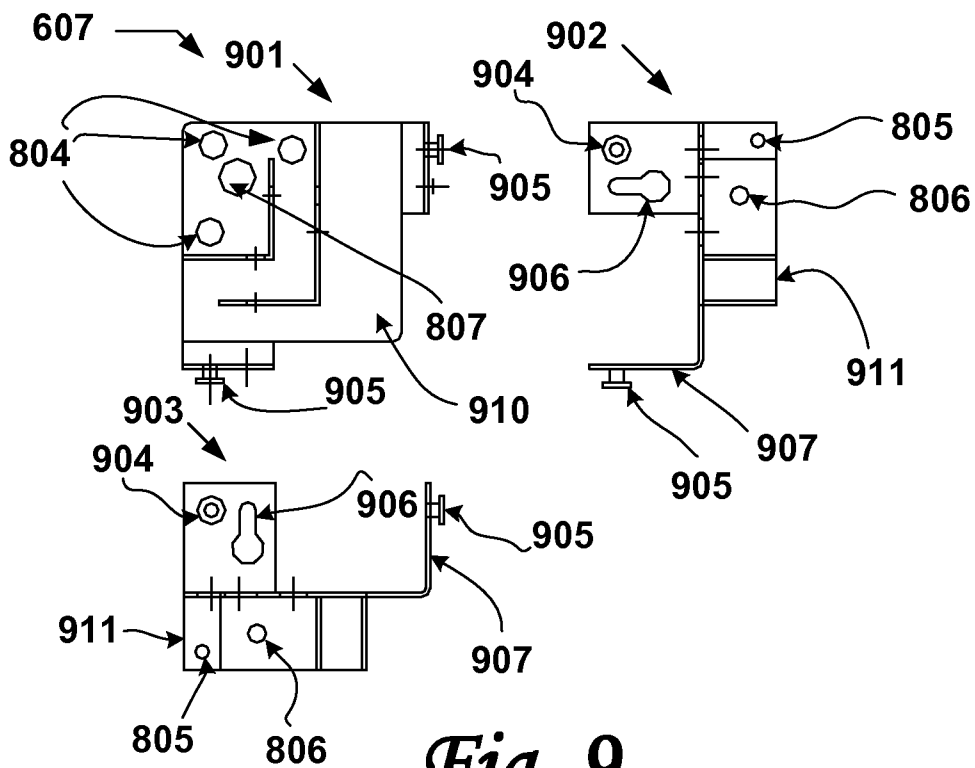
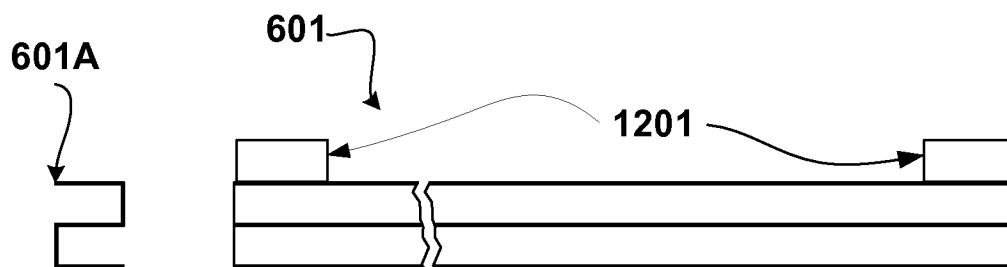
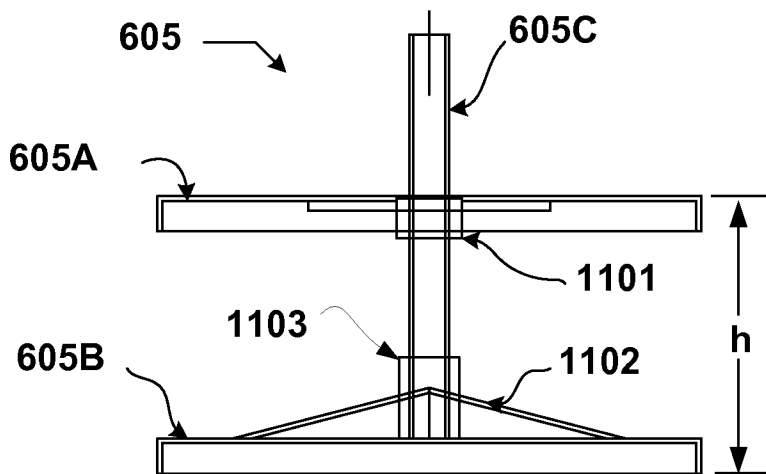
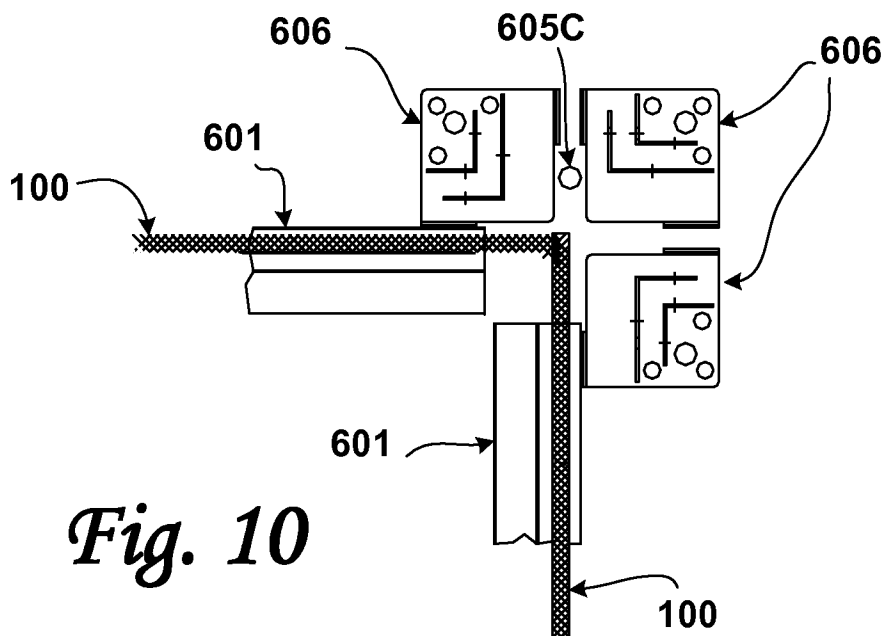


Fig. 9



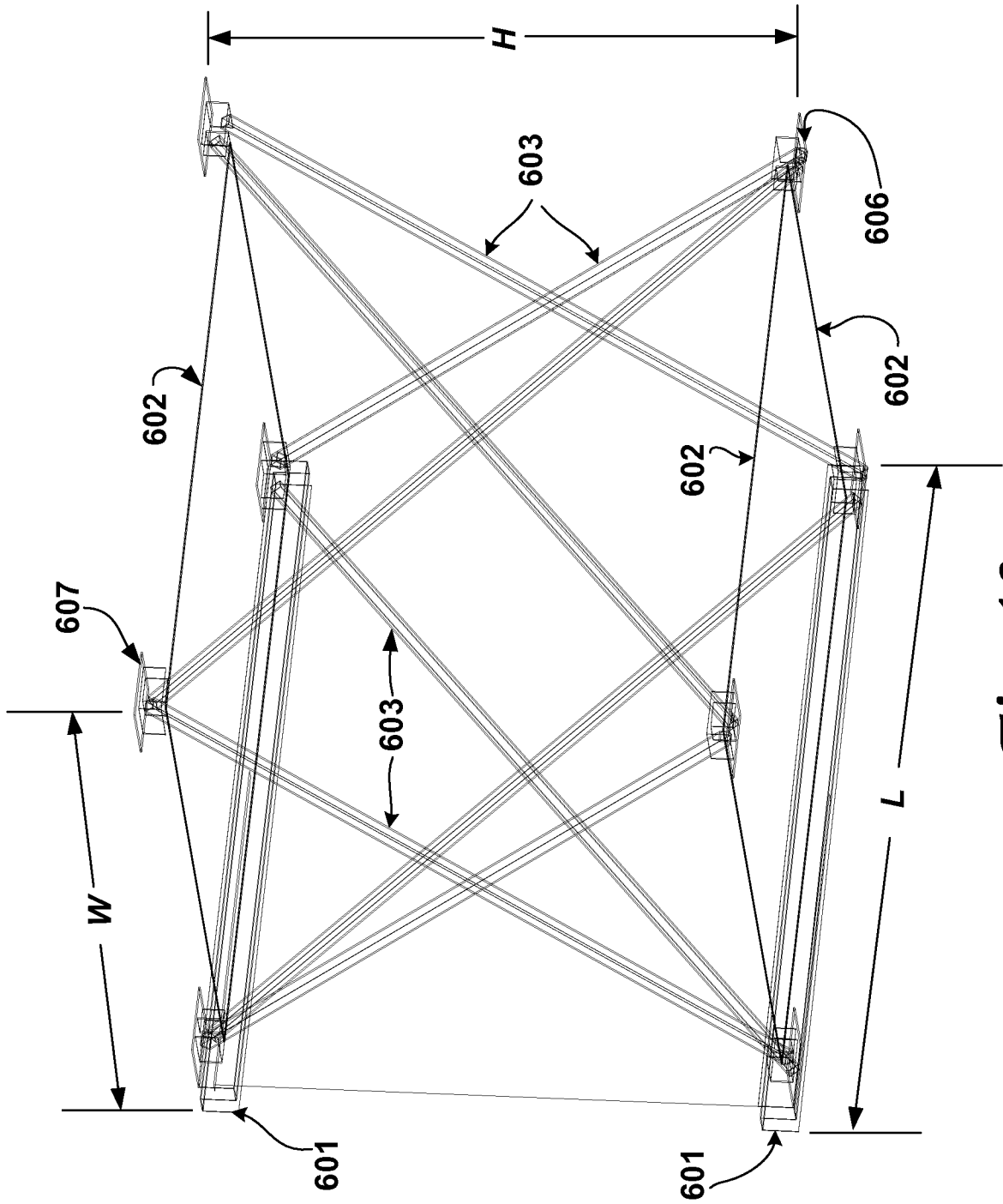


Fig. 13

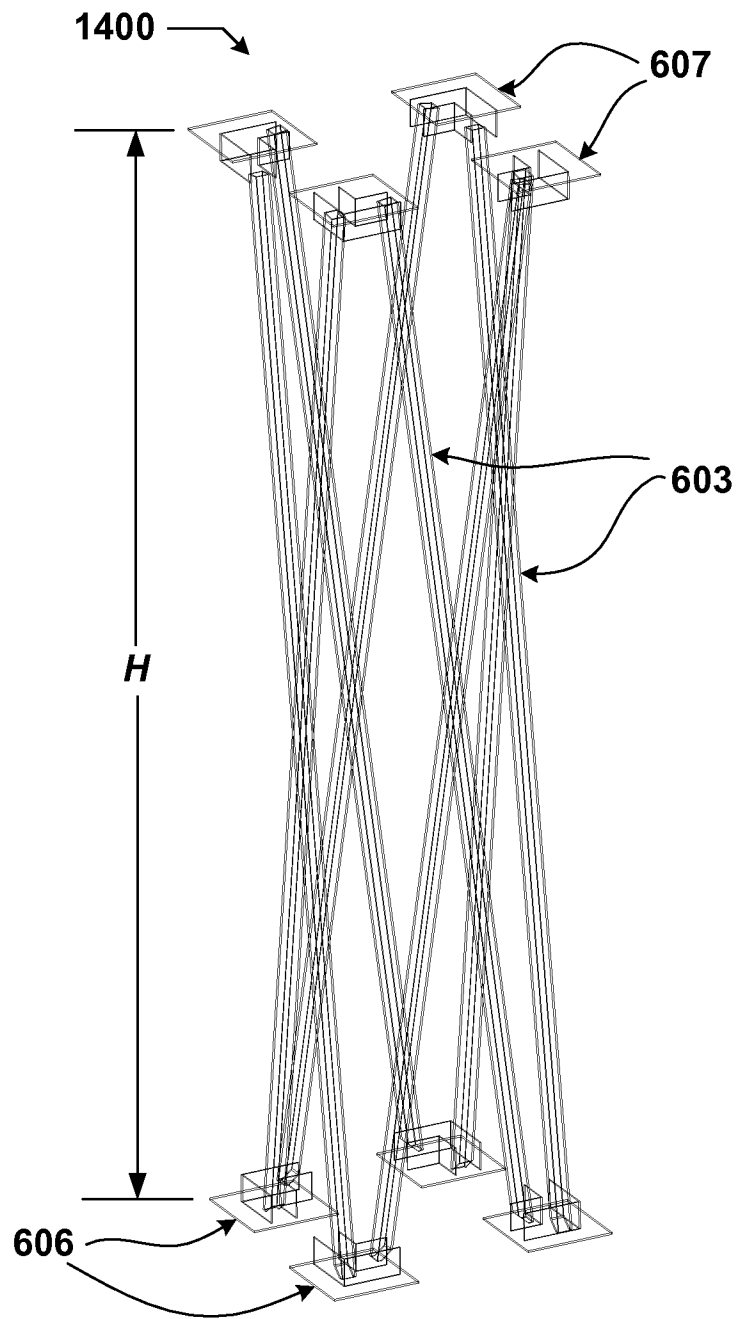


Fig. 14

