



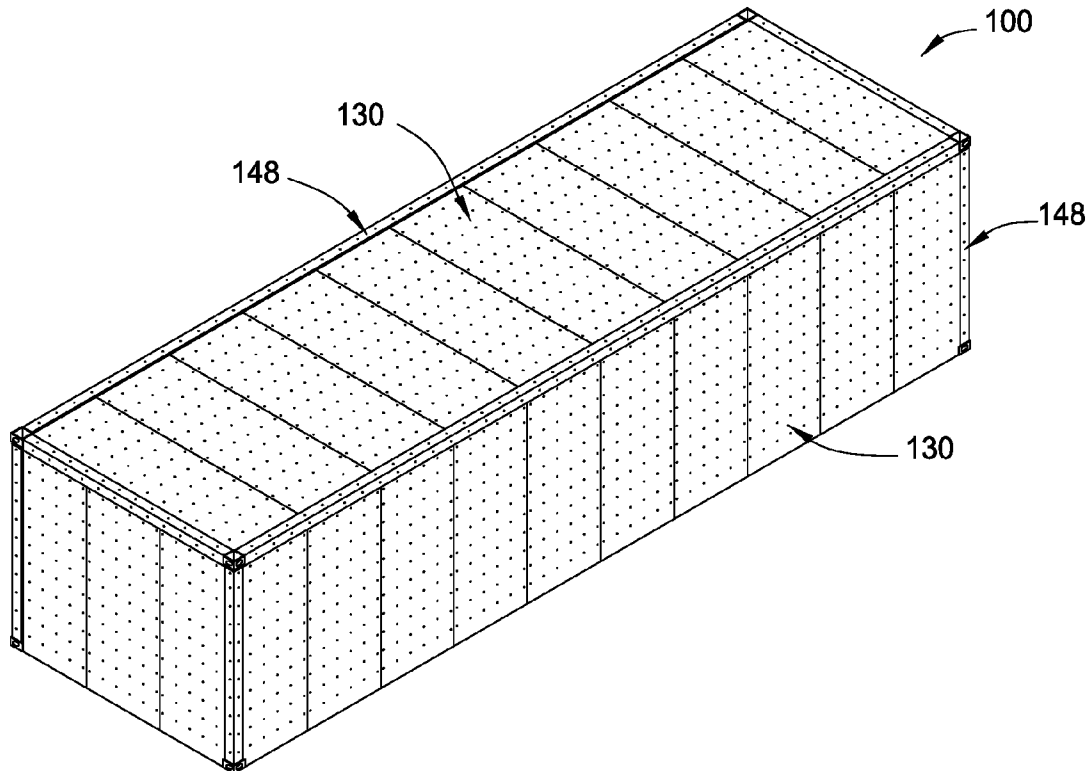
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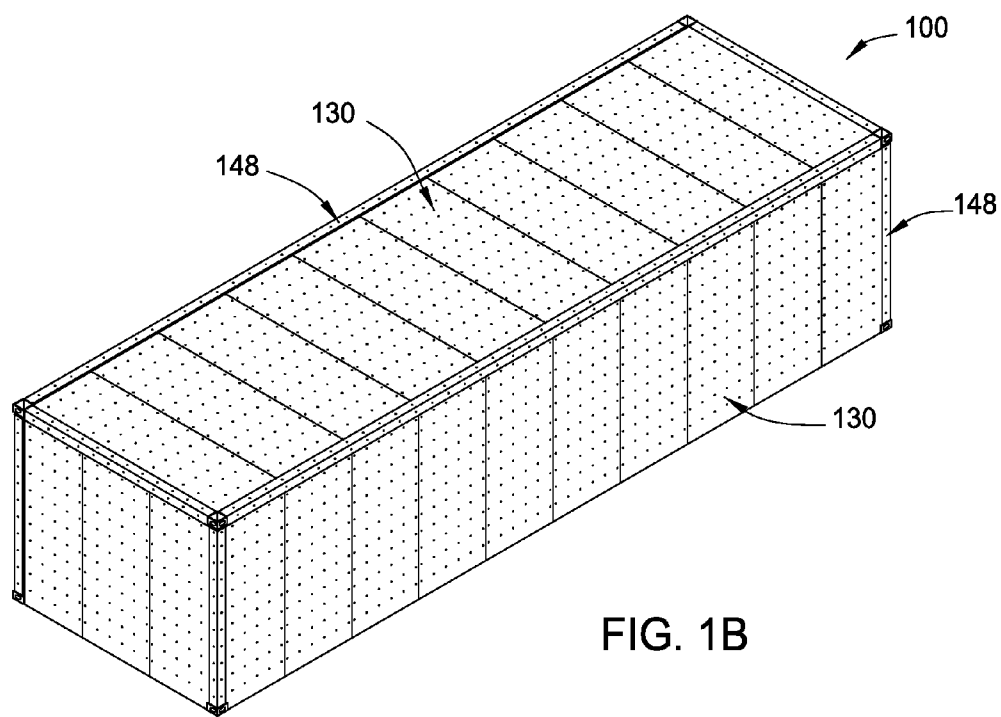
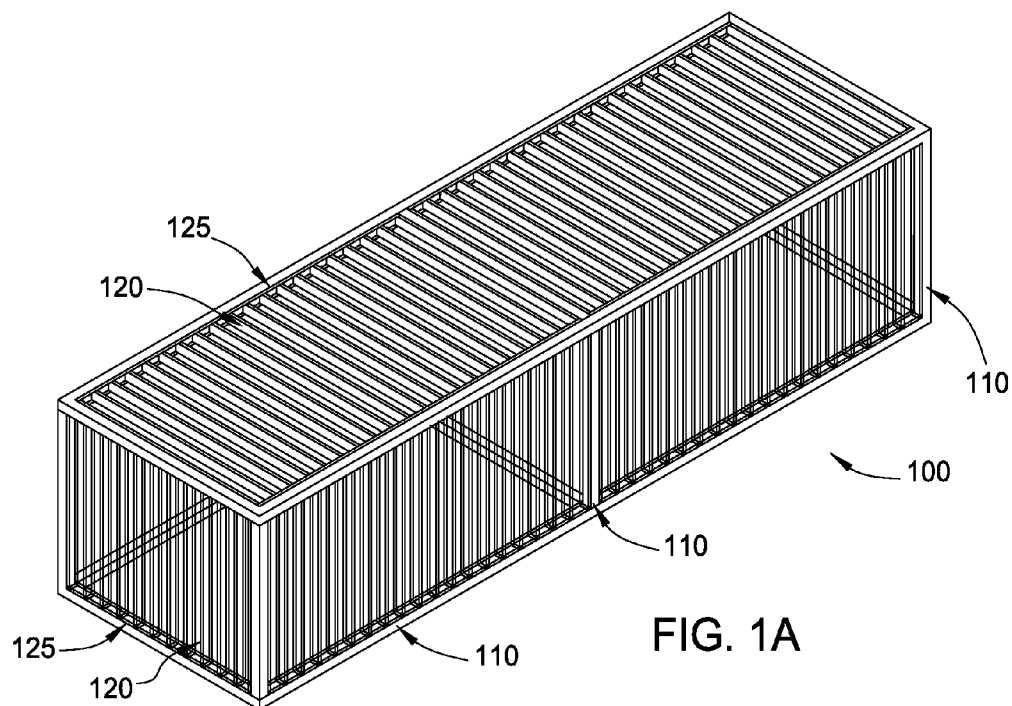
(19) **United States**(12) **Patent Application Publication**
HARPER et al.(10) **Pub. No.: US 2015/0322686 A1**(43) **Pub. Date: Nov. 12, 2015**(54) **BLAST RESISTANT STRUCTURE***E04C 2/08* (2006.01)(71) Applicant: **Harrison, Walker & Harper LP**, Paris,
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(US)(52) **U.S. Cl.**CPC .. *E04H 9/10* (2013.01); *E04B 1/24* (2013.01);
E04B 1/98 (2013.01); *E04C 2/08* (2013.01);
E04B 2/562 (2013.01); *E04B 2/58* (2013.01);
E04B 2001/2418 (2013.01); *E04B 2001/2481*
(2013.01); *E04B 2103/06* (2013.01)(21) Appl. No.: **14/483,369**(22) Filed: **Sep. 11, 2014****Related U.S. Application Data**(60) Provisional application No. 61/876,687, filed on Sep.
11, 2013.**Publication Classification**(51) **Int. Cl.***E04H 9/10* (2006.01)*E04B 2/58* (2006.01)

(57)

ABSTRACT

In one embodiment, a blast resistant structure includes a frame; a stud track attached to the frame; a plurality of studs attached to the stud track; a plurality of panels attached to the plurality of studs, wherein at least one panel comprises a composite board secured to a steel sheet; and a blast plate and a connector for securing the stud track to the frame.





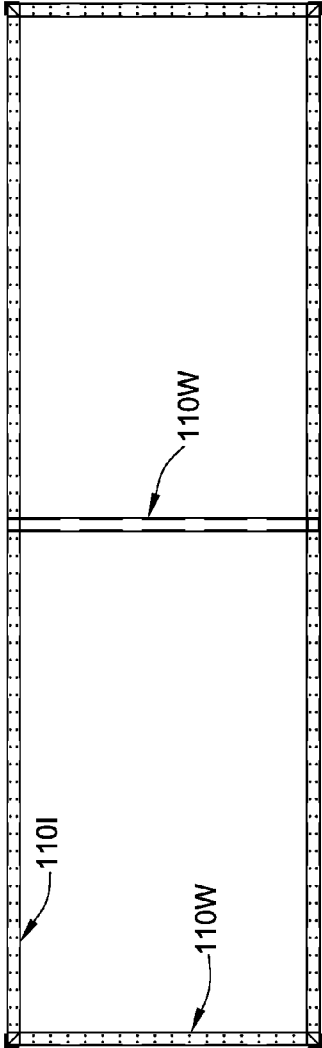


FIG. 2A

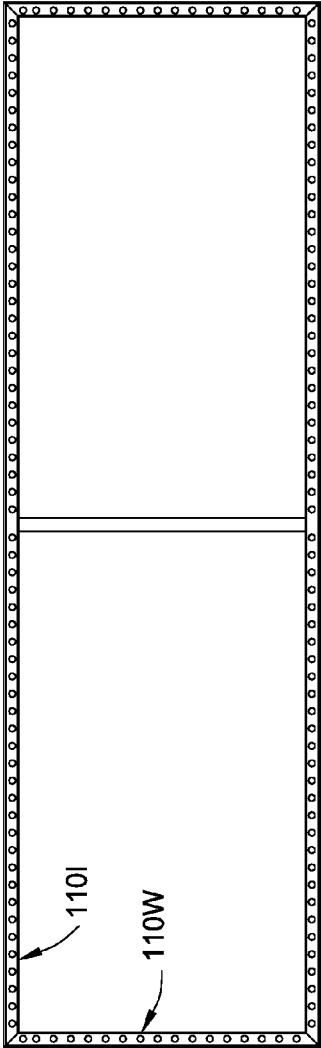


FIG. 2B

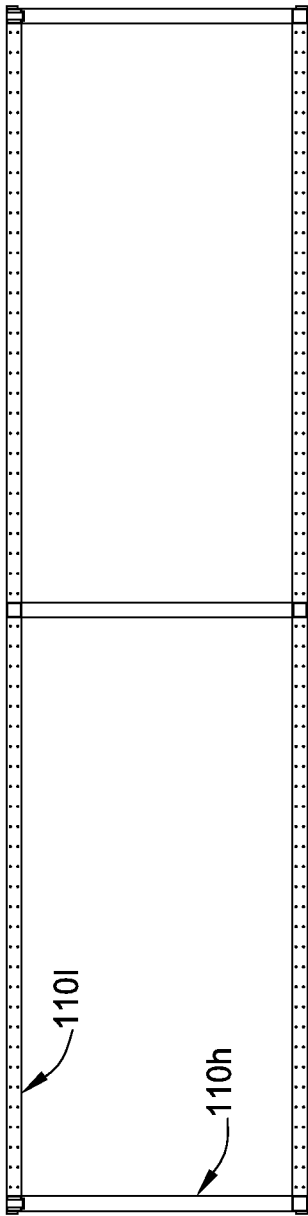


FIG. 2C

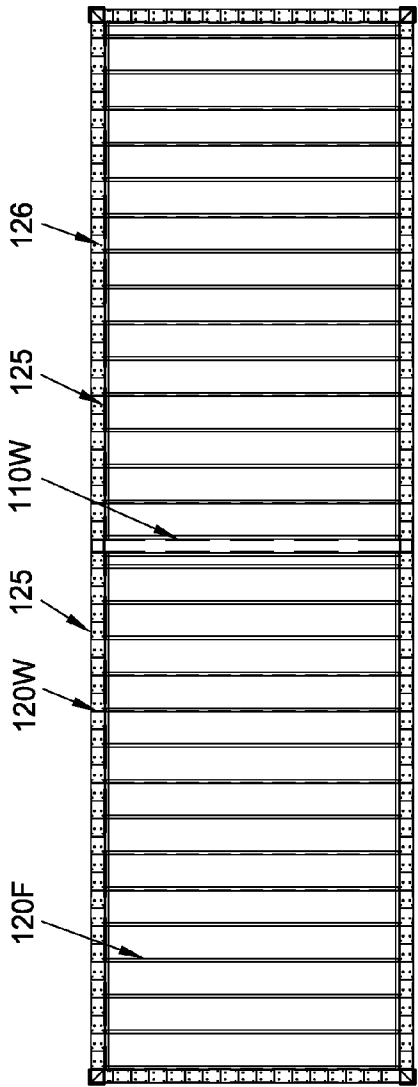


FIG. 3A

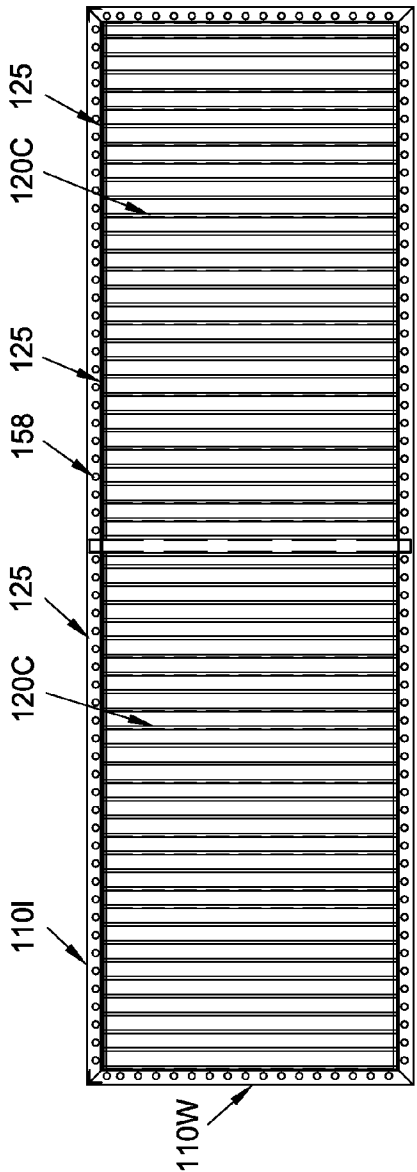


FIG. 3B

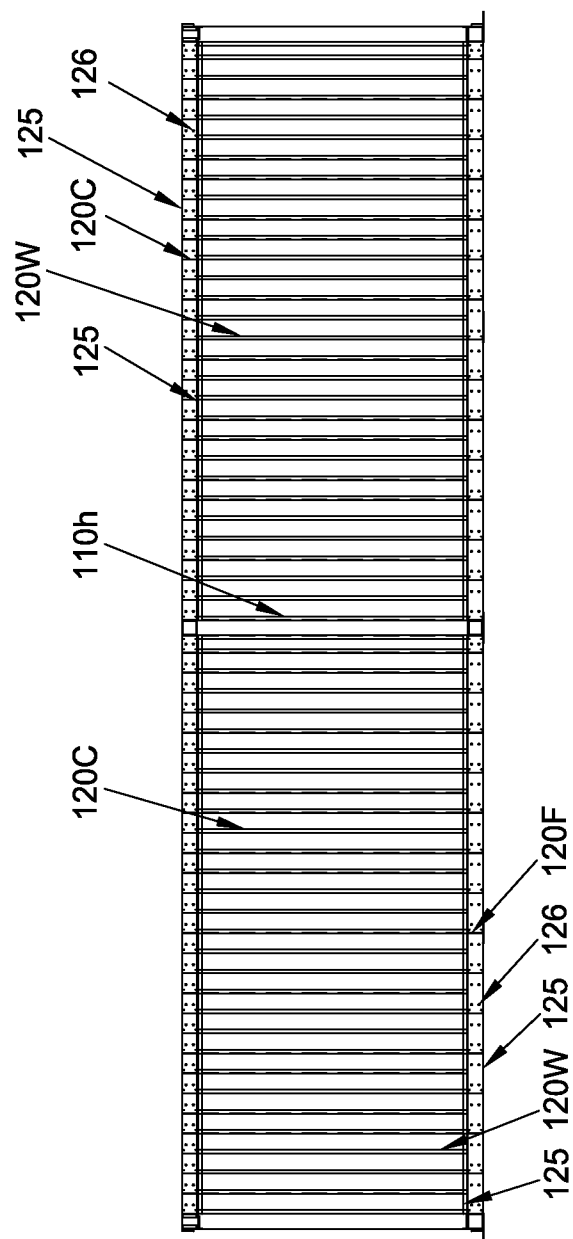
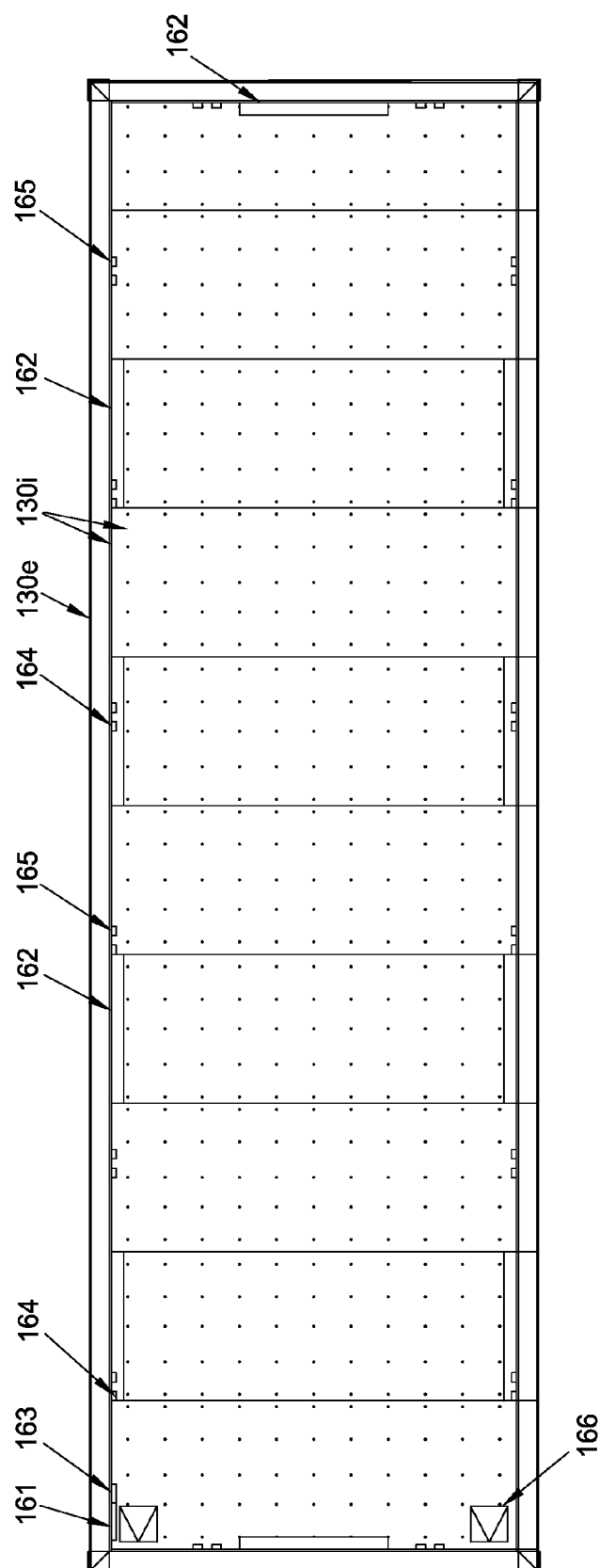


FIG. 3C



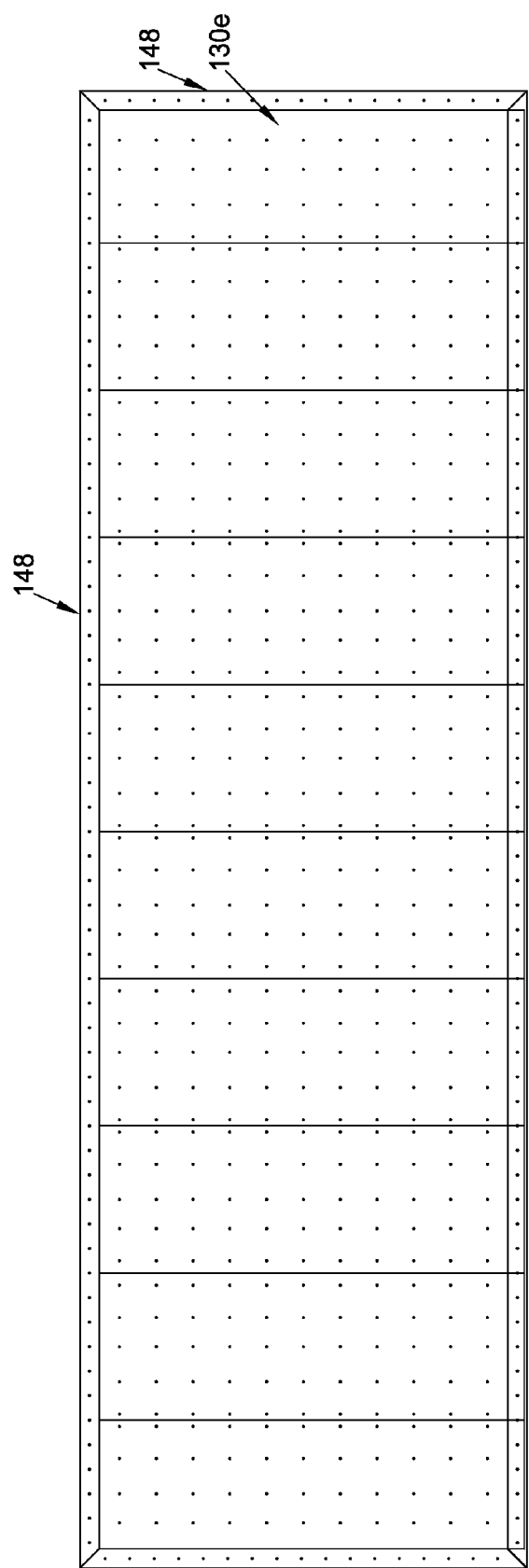


FIG. 4B

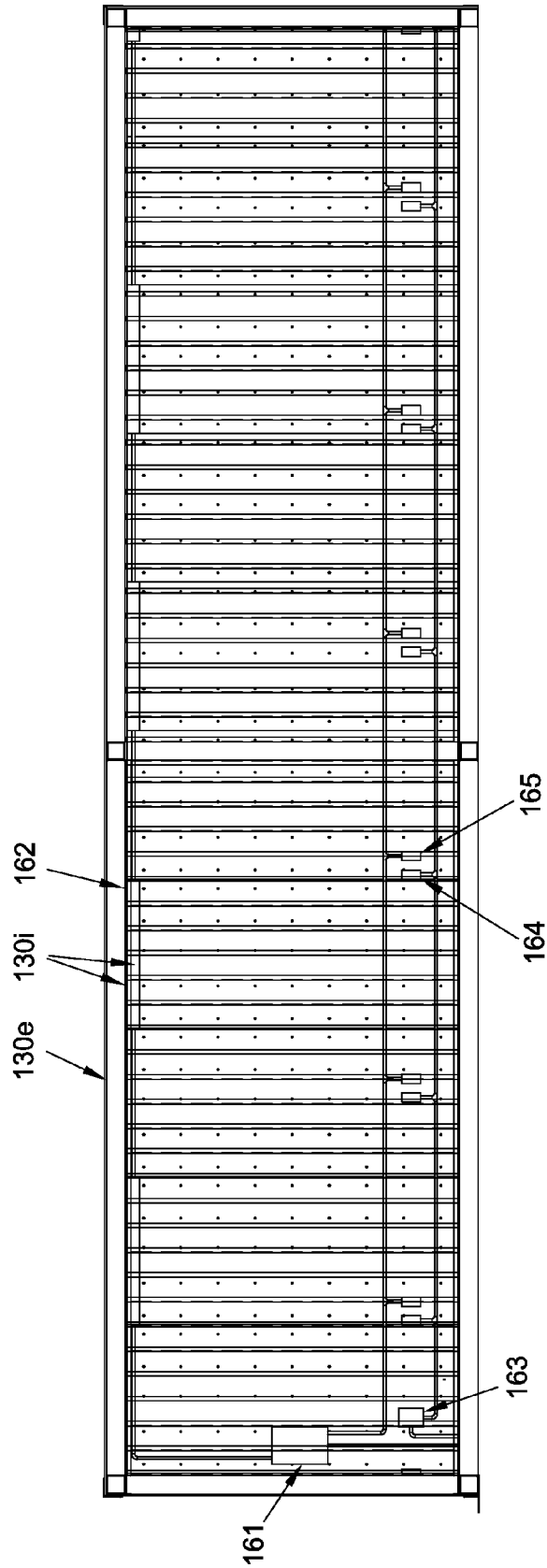
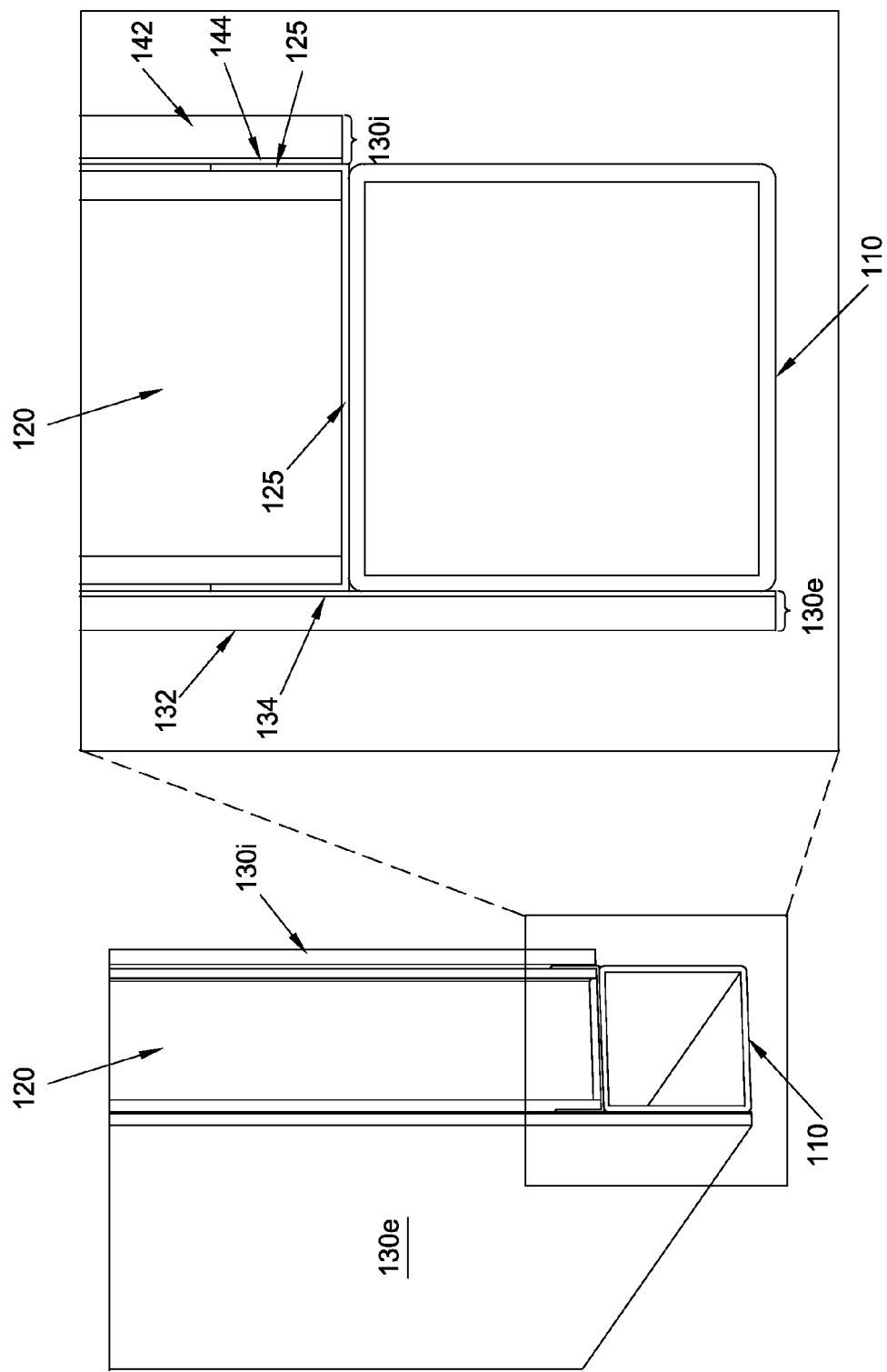


FIG. 4C



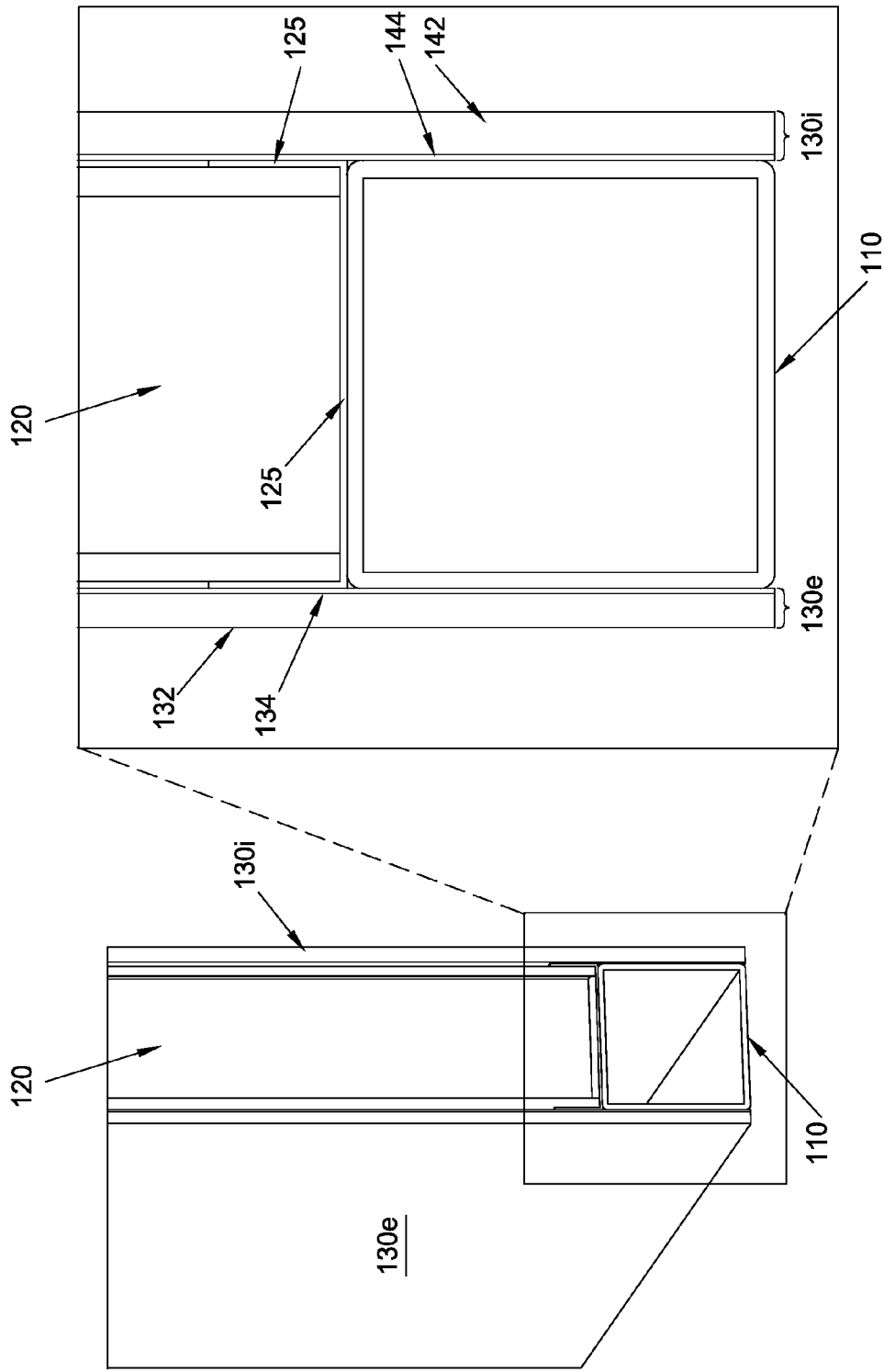


FIG. 5D

FIG. 5C

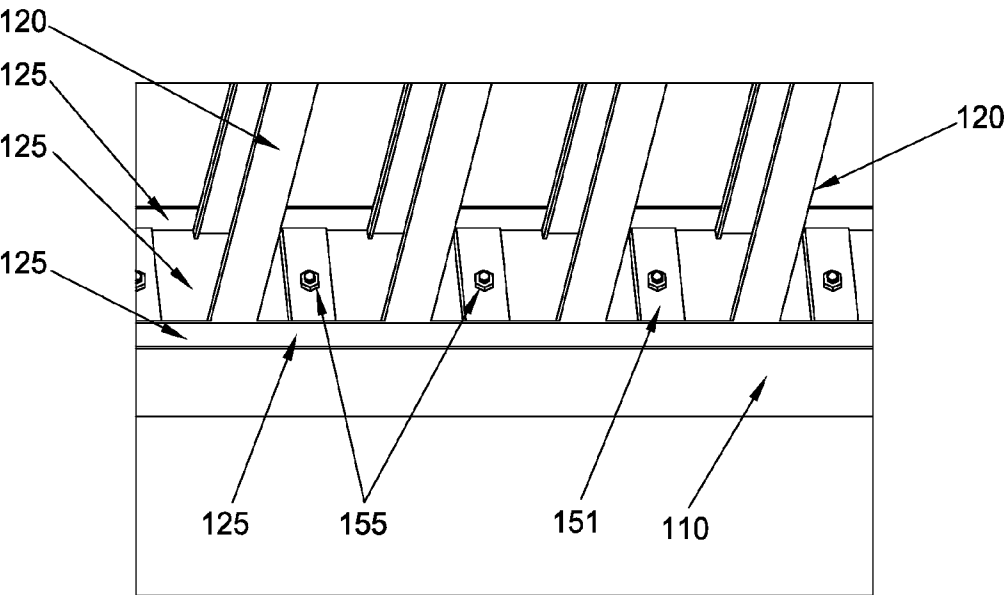


FIG. 6

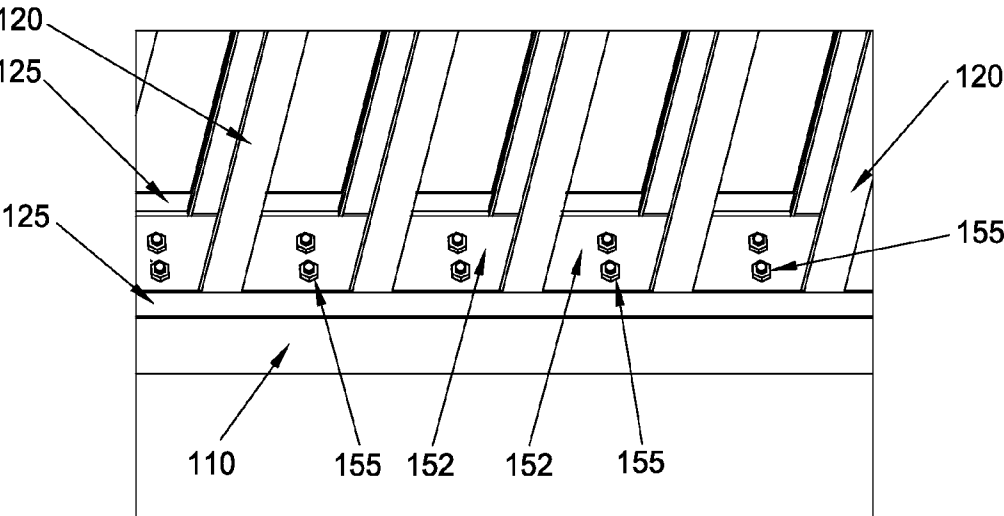


FIG. 7

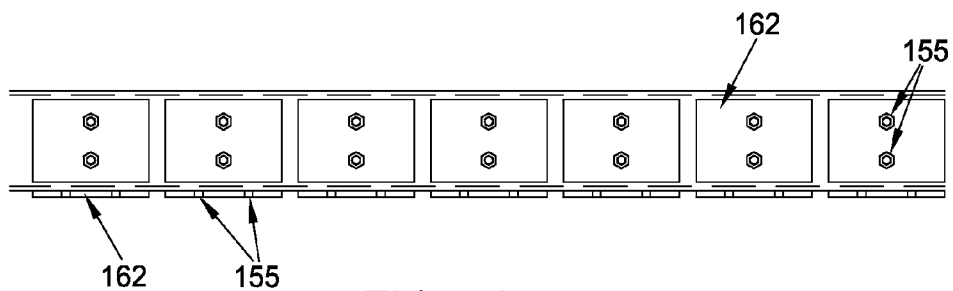


FIG. 7A

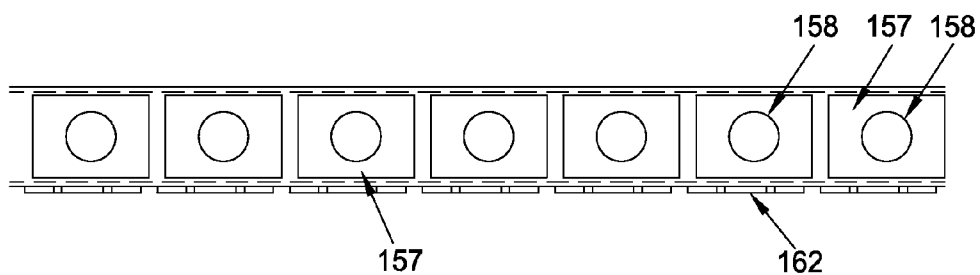


FIG. 8A

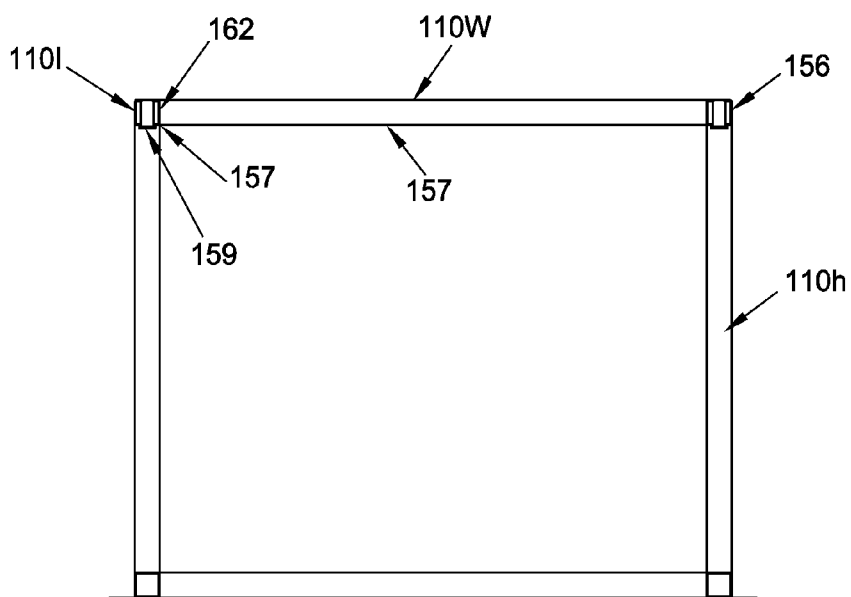


FIG. 8B

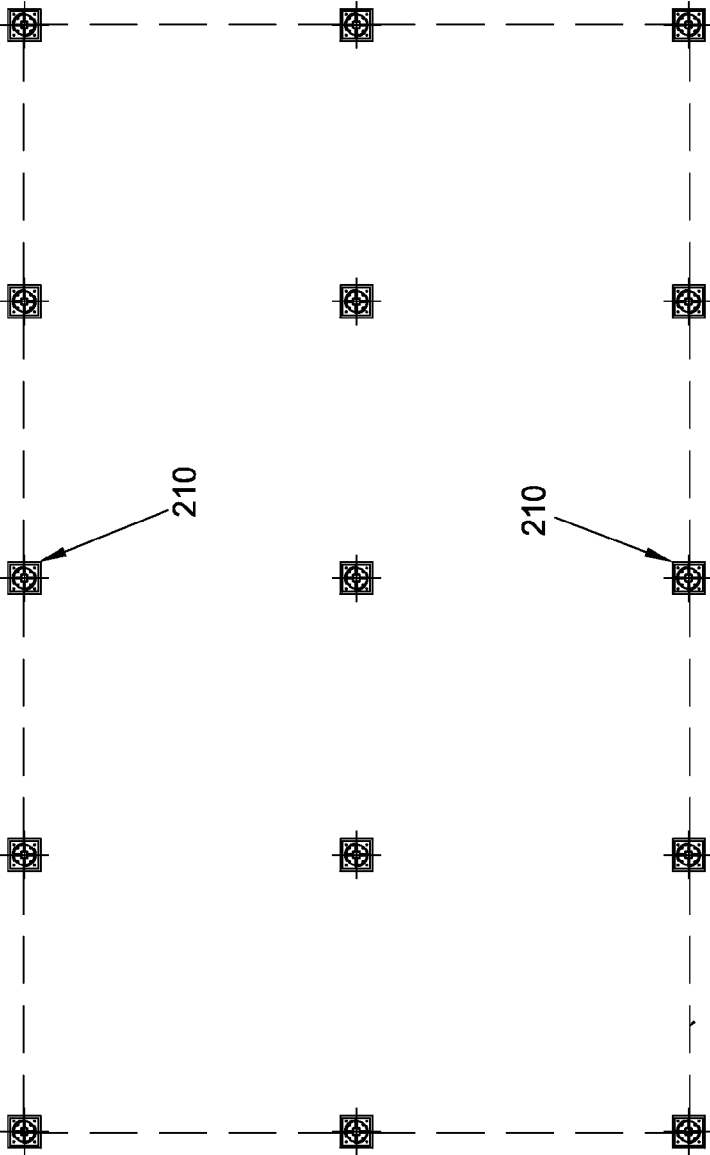


FIG. 9A

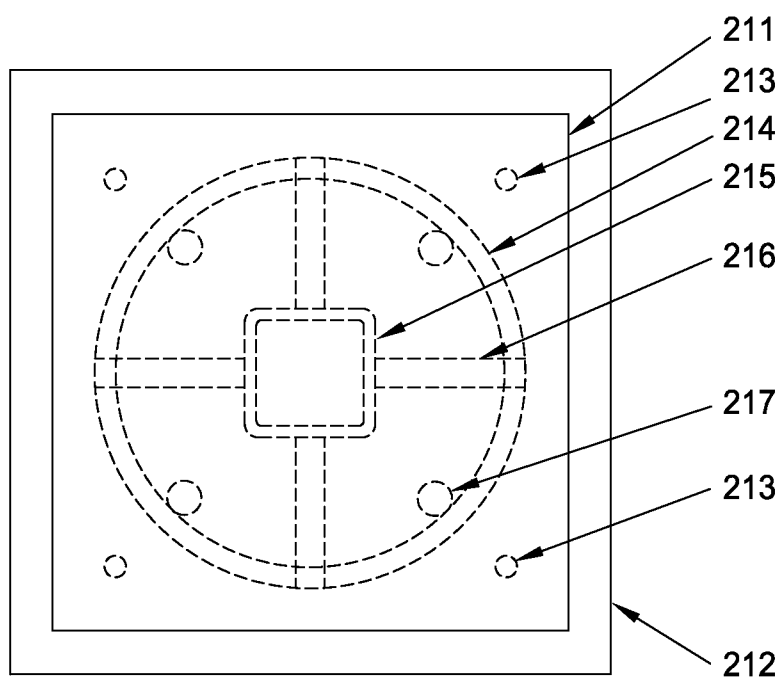


FIG. 9B

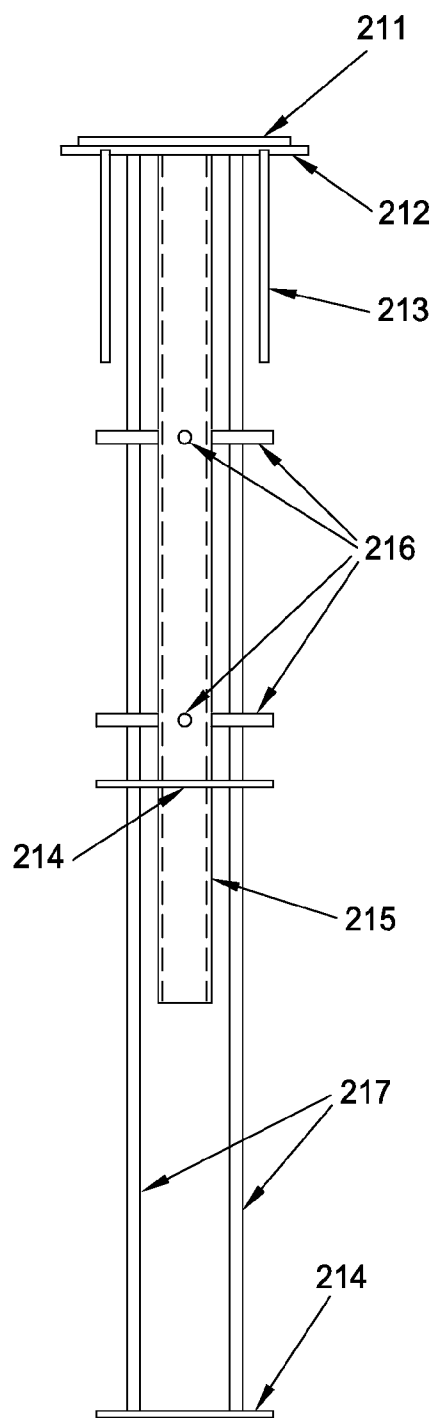


FIG. 9C

BLAST RESISTANT STRUCTURE**CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims benefit of U.S. Provisional Patent Application Ser. No. 61/876,687, filed Sep. 11, 2013, which application is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] Embodiments of the present invention generally relate to blast resistant structures configured to protect against a blast from an explosion.

[0004] 2. Description of the Related Art

[0005] An explosion is typically characterized by a blast or sharp increase in pressure that propagates in a wavelike manner outward from a point or area of origination. Whether intentionally or unintentionally initiated, such blasts can result in severe damage to buildings, vehicles, and personnel. For example, a blast from a bomb that is detonated in a car parked near a building can cause structural damage to the building, damage components therein, and/or injure people within the building. Similarly, ballistic and aerial explosive devices can cause costly damage to buildings and other types of structures.

[0006] The use of blast resistant structures for protection against blasts associated with explosions is known. For example, buildings at risk of blast damage during battle conditions are sometimes provided with a wall formed of concrete. The concrete walls provide a protective effect to the building by deflecting and/or attenuating the blast. In some cases, however, the blast may still stress the structural components beyond their yield strength, thereby damaging the building.

[0007] There is a need, therefore, for a more effective blast resistant structure for protection against an explosion.

SUMMARY OF THE INVENTION

[0008] Embodiments of the present invention generally relate to a blast resistant structure configured to protect against a blast from an explosion. In one embodiment, a blast resistant structure includes a frame; a stud track attached to the frame; a plurality of studs attached to the stud track; a plurality of panels attached to the plurality of studs, wherein at least one panel comprises a composite board secured to a steel sheet; and a blast plate and a connector for securing the stud track to the frame.

[0009] In one or more of the embodiments described herein, the blast plate is a rectangular plate.

[0010] In one or more of the embodiments described herein, the plurality of studs comprises vanadium. In one example, the plurality of studs comprise vanadium and steel alloy.

[0011] In one or more of the embodiments described herein, the frame includes hollow structure section steel tubes.

[0012] In one or more of the embodiments described herein, the plurality of panels are attached to an exterior surface of the plurality of studs. In another embodiment, the composite board comprises at least one of cement and gypsum. In yet another embodiment, some of the panels are attached to an interior surface of the plurality of studs. In a

further embodiment, an aggregate material is disposed between the panels attached to the interior and exterior surfaces of the plurality of studs.

[0013] In one or more of the embodiments described herein, a plurality of angle panels and/or bent plates are disposed at the perimeter edges of the structure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0015] FIGS. 1A and 1B illustrate an embodiment of a blast resistant structure. In particular, FIG. 1A illustrates the structural framing of the blast resistant structure, and FIG. 1B illustrates an isometric view of the structural panels on the blast resistant structure.

[0016] FIG. 2A illustrates the HSS tube floor plan. FIG. 2B illustrates the HSS tube roof plan. FIG. 2C illustrates a front view of the HSS tube wall plan.

[0017] FIG. 3A illustrates the floor framing plan. FIG. 3B illustrates the roof framing plan. FIG. 3C illustrates the framing plan for one of the walls.

[0018] FIG. 4A illustrates the floor panel plan. FIG. 4B illustrates the roof panel plan. FIG. 4C illustrates the panel plan for one of the walls.

[0019] FIG. 5A illustrates an enlarged, cross-sectional view of a bottom section of one of the walls. FIG. 5B illustrates an enlarged, partial view of FIG. 5A.

[0020] FIGS. 5C and 5D illustrate another example of a panel arrangement. FIG. 5C illustrates an enlarged, cross-sectional view of a bottom section of one of the walls. FIG. 5D illustrates an enlarged, partial view of FIG. 5B.

[0021] FIG. 6 illustrates an embodiment of a blast plate securing a track to the HSS frame.

[0022] FIG. 7 illustrates another embodiment of a blast plate securing a track to the HSS frame.

[0023] FIG. 7A illustrates another embodiment of a blast plate securing a track to the HSS frame.

[0024] FIG. 8A is an enlarged view of another embodiment of a blast plate. FIG. 8B is a cross-sectional view of one embodiment of a blast resistant structure.

[0025] FIG. 9A illustrates an exemplary anchor arrangement for anchoring the blast resistant structure in the soil. FIG. 9B illustrates a detail view of an embodiment of an anchor shown in FIG. 9A. FIG. 9C illustrates a cross-sectional view of the anchor of FIG. 9B.

DETAILED DESCRIPTION

[0026] In one embodiment, a blast resistant structure includes a frame; a vanadium stud track attached to the frame; a plurality of vanadium studs attached to the stud track; a plurality of panels attached to the plurality of studs, wherein at least one panel comprises a composite board secured to a steel sheet; and a rectangular blast plate and connector for securing the stud track to the frame.

[0027] FIGS. 1A and 1B illustrate an embodiment of a blast resistant structure 100. In particular, FIG. 1A illustrates the

structural framing of the blast resistant structure **100**, and FIG. **1B** illustrates an isometric view of the structural panels on the blast resistant structure **100**. As shown, the structure **100** is rectangular shaped having six walls, including 4 side walls, a roof, and a floor. The perimeter of the frame is formed using hollow structural section (“HSS”) tubes **110** made of steel, as shown in FIGS. **2A-C**. FIG. **2A** illustrates the HSS tube floor plan showing the HSS tubes **110l**, **110w** in the length and width dimensions, respectively. FIG. **2B** illustrates the HSS tube roof plan showing the HSS tubes **110l**, **110w** in the length and width dimensions, respectively. FIG. **2C** illustrates a front view of the HSS tube wall plan showing the HSS tubes **110l**, **110h** in the length and height dimensions, respectively. The HSS tubes **110** may be welded together or attached using any suitable methods. Exemplary cross-sectional sizes of the HSS tubes **110** include 6 inches by 6 inches and 8 inches by 6 inches. In this embodiment, the structure **100** is about 40 feet in length, about 12 feet in width, and about 10 feet in height. HSS tubes **110** may also be attached to the structure **100** at twenty foot intervals of the structure **100**. For example, because the structure **100** in FIG. **1** is 40 feet in length, HSS tubes **110w**, **110h** are provided in the middle of the structure **100** at the twenty foot mark. It is contemplated that the structure **100** may include any suitable sizes; for example, twenty feet or sixty feet in length, twenty feet in width, or twelve feet in height. In another embodiment, the length and/or width of the structure **100** may extend up to 60 feet or more in 4 foot increments. For example, the length of the structure may be between 20 feet and 60 feet or between 20 feet and 80 feet. In another example, the width of the structure may be between 10 feet and 30 feet, between 11 feet and 13 feet such as about 12 feet, or between 23 feet and 25 feet such as about 24 feet. The height of the structure may be between 8 feet and 16 feet such as about 10 feet. In yet another embodiment, a plurality of structures **100** may be stacked on top of each other, such as double stacked or triple stacked.

[0028] Studs **120** and stud tracks **125** are attached to the HSS tubes **110** for use as wall reinforcements, as shown in FIGS. **3A-C**. FIG. **3A** illustrates the floor framing plan, FIG. **3B** illustrates the roof framing plan, and FIG. **3C** illustrates the framing plan for one of the walls. The tracks **125** may be attached to the HSS tubes **110** using bolts **126** or any suitable connectors. The studs **120** may be screwed to the tracks **125** or attached using any suitable connectors. The studs **120w** for the side walls and the studs **120c** for the ceiling may be spaced at about 5 inches to about 20 inches on center (“o.c.”), or at about 8 inches to about 16 inches o.c. As shown, the wall studs **120w** are spaced at about 8 inches o.c. The studs **120f** for the floor may be spaced at about 5 inches to about 20 inches o.c., or about 8 inches to about 16 inches o.c. In yet another embodiment, the studs **120c**, **120f**, **120w** may be spaced at about 4 inches to about 24 inches o.c. It is contemplated that the studs **120** may be spaced at any suitable distance depending on the desired magnitude of the resistance against the blast. The studs **120** may be made of metal or alloy studs such as mild steel, vanadium, vanadium and steel alloy, and combinations thereof.

[0029] Structural panels **130** may be attached to the studs **120** to form one or more of the interior and exterior walls, floor, and roof of the structure **100**, as shown in FIGS. **4A-C** and FIGS. **5A** and **5B**. FIG. **4A** illustrates the floor panel plan, FIG. **4B** illustrates the roof panel plan, and FIG. **4C** illustrates the panel plan for one of the walls. FIG. **5A** illustrates an enlarged, cross-sectional view of a bottom section of one of

the walls. FIG. **5B** illustrates an enlarged, partial view of FIG. **5A**. In one embodiment, the structural panel **130** may include a gypsum wall board, a cementous wall board, a fiber reinforced gypsum wall board, and combinations thereof. In another embodiment, the structural panels **130e** for the exterior walls and roof (also referred to as “external panels”) may include a cementous wall board **132** secured to a steel sheet **134**. In one embodiment, the external panels **130e** may be made of Sure-Board® Series 200B panels **130**, which are composed of 0.5 inch Durock® cement board **132** secured to a 14 gage steel sheet **134**. In another embodiment, the structural panels **130i** for the interior walls and the floor may include a gypsum board **142** secured to a steel sheet **144**. The interior structural panels **130i** for the walls and the floor may be the same or different. For example, the interior panel **130i** for the wall may be 0.625 in. DenzArmor Plus® board **142** secured to a 22 gage steel sheet **144**. In another example, the interior panel **130i** for the floor may be made of 0.5 in. Mag® board secured to a 14 gage steel sheet. In one embodiment, the gypsum board or cementous board may be secured to the steel sheet using an adhesive such as glue or epoxy. It must be noted that any of the panels **130** for the exterior and interior surfaces may be the same or different type of structural panels. For example, cementous boards secured to a steel sheet may be used as an exterior wall panel **130e** and as an interior wall panel **130i** of a blast resistant structure **100**. In another example, DenzArmor® board may be used as a panel for both the interior wall and the floor. The ends of the interior panel **130i** and the exterior panel **130e** may extend to the base of the track **125** or any distance past the track **125**. For example, in FIGS. **5A** and **5B**, both of the interior panel **130i** and the exterior panel **130e** extend to the bottom of the HSS tubes **110**. FIGS. **5C** and **5D** illustrate another example of a panel arrangement. FIG. **5C** illustrates an enlarged, cross-sectional view of a bottom section of one of the walls. FIG. **5D** illustrates an enlarged, partial view of FIG. **5C**. In this example, the exterior panel **130e** extends to the bottom of the HSS tube **110**, and the interior panel **130i** extends to the base of the track **125**. In this respect, the tracks **125** for the floor studs **120** may attach directly to the HSS tube **110**.

[0030] The structural panels **130** may have a thickness ranging from about 0.25 in. to about 1.25 in., such as 0.5 in., 0.625 in., and 0.75 in. The steel sheets **132**, **144** may have a gage from about 26 gage to about 8 gage, such as 12, gage, 14 gage, and 16 gage. The steel sheets may be hot dipped galvanized coated steel sheets. Other high strength materials suitable for use as a thin sheet may be substituted for the steel sheet. Exemplary high strength material includes other metal, alloy, plastics, and combinations thereof. Exemplary overall dimensions of the structural panels **130** include 4 ft. by 8 ft., 4 ft. by 9.5 ft., 4 ft. by 10 ft., and 4 ft. by 12 ft. In one embodiment, the structural panels **130** may be attached to the frame **110**, **120** using screws spaced at about 8 in. o.c., although any suitable spacing or connectors may be used. In another embodiment, angle panels **148** may be attached to the perimeter edges of the structure **100**. In one example, 6 in. by 6 in. angle panels **148** are attached to the perimeter edges using screws spaced at 8 in. o.c. The angle panels **148** may prevent air infiltration between the external panels **130e** and the HSS tubes **110** at the perimeter edges of the structure **100**. The structural panels **130i** for the interior wall may optionally include tap and bed, fiberglass reinforced plastics coating, wall paper, and combinations thereof.

[0031] In another embodiment, the tracks **125** may be attached to the HSS frame **110** using a blast plate and bolt connection **150**. FIG. 6 illustrates blast plates **151** securing one or more of the wall, roof, and floor tracks **125** to the HSS frame **110**. In one embodiment, the blast plate **151** is a rectangular plate instead of a round washer. As shown, the blast plate **151** is positioned between two adjacent studs **120** and above the track **125**. A box bolt **155** connects the blast plate **151** and the track **125** to the HSS frame **110**, although more than one bolt may be used. In this embodiment, only one box bolt **155** is used to secure the blast plate **151**. The blast plate **151** may have a width that is greater than the length. A ratio of the width of the blast plate **151** to the width of the track may be from 0.5:1 to 1:1 or from 0.75:1 to 1:1. A ratio of the length of the blast plate **152** to the distance between two adjacent studs **120** may be from 0.2:1 to 0.8:1 or from 0.3:1 to 0.6:1. In one example, the blast plate **151** may be used to secure tracks **125** to an HSS framing for non-aggregate filled walls. In one example, the box bolt **155** is a 0.5 in. bolt and the blast plate **151** has dimensions of 2×5.75×0.375 in.

[0032] FIG. 7 illustrates another embodiment of blast plates **152** securing one or more of the wall, roof, and floor tracks **125** to the HSS frame **110**. In one embodiment, the blast plate **152** is a rectangular plate rather than a round washer. As shown, the blast plate **152** is positioned between two adjacent studs **120** and above the track **125**. The blast plate **152** may have a length that is greater than the width. A ratio of the width of the blast plate **152** to the width of the track may be from 0.5:1 to 1:1 or from 0.75:1 to 1:1. A ratio of the length of the blast plate **152** to the distance between two adjacent studs **120** may be from 0.5:1 to 1:1 or from 0.75:1 to 1:1. Two box bolts **155** connect the blast plate **152** and the track **125** to the HSS frame **110**, although one or three or more bolts may be used. As shown, the two bolts **155** are positioned along the width dimension of the track **125**. In another embodiment, the two bolts **155** are positioned at an angle up to 90 degrees relative to the width of the track **125**. In one example, the box bolt **155** is a 0.5 in. bolt and the blast plate **152** has dimensions of 5×7×0.375 in. In one embodiment, a bent plate may be used to attach the tracks **125** to the HSS tubes **110**. FIG. 7A illustrates another embodiment of blast plates **162** and bolts **155**. In FIG. 7A, the two bolts **155** connecting the blast plate **162** and the track **125** to the HSS frame **110** are positioned along the length dimension of the track **125**.

[0033] FIGS. 8A and 8B illustrate another embodiment of a blast plate connection for a blast resistant structure **100**. FIG. 8A is an enlarged view of the arrangement of the blast plates **157**, and FIG. 8B is a cross-sectional view of the structure. In one embodiment, the blast plate **157** is provided with a larger opening **158** through the blast plate **157**. The larger opening **158** may accommodate a tubular nipple **156** for introducing an aggregate material. The opening **158** is aligned with openings formed in the track **125** and in the HSS tube **110**, **110_w** framing the roof. The nipple **156** extends through the openings in the HSS tube **110**, **110_w**, the track **125**, and the blast plate **157**. The end of the nipple **156** positioned opposite the blast plate **157** may be flush with the HSS tube **110**, **110_w** and attached by welding or other suitable mechanism. The other end of the nipple **156** may extend through the blast plate **156** and has threads on its outer surface. A lock nut **159** may be used to secure the blast plate **157** and the track **125** to the HSS tubes **110**, **110_w**. The threads of the lock nut **156** engage the threads of the nipple **156**. It can be seen in FIG. 8B that the

bore of the nipple **156** extends through the HSS tubes **110**, **110_w** and fluidly communicates with the area below the HSS tubes **110**, **110_w**. In one embodiment, the opening **158** has a diameter of about 3 inches, although any suitable size may be used, such as between about 1 inch and about 4 inches. In one example, the blast plate **157** has dimensions of 5×7×0.375 in. It must be noted that although FIG. 8A is shown with the blast plate **162** from FIG. 7A, other embodiments of the blast plates, such as the blast plate **152** of FIG. 7 may be used.

[0034] It is contemplated that the blast plates such as blast plates **151**, **152**, **156**, **162** for the wall, roof, and floor track connections may be the same or different sizes. The length of the blast plates may be from about 4 in. to about 8 in., depending on the size of the track **125**. The width of the blast plates may be from about 1 in. to about 6 in. depending on the size of the track **125**. The thickness of the blast plates may be from about 0.125 in. to about 0.75 in. The blast plates may be made from steel, metal alloy, or any other suitable metal. It must be noted that the blast plates may also have a shape of a polygon having 8 or less sides. In one embodiment, the blast plates **152**, **156**, **162** may be used to secure tracks **125** to an HSS framing for aggregate filled walls.

[0035] In another embodiment, the space between the exterior panel **130_e** and the interior panel **130_i** of the walls may optionally be filled with an aggregate material. Exemplary materials include sand, gravel, rock, and combinations thereof. The aggregate material may be added to the one or more of the walls of the structure **100**, or any wall that is expected to experience reflected pressure. For example, the pipe nipple **156** may be used to facilitate filling of the wall space by the aggregate material. The aggregate material may advantageously add load to the walls and provide weight to the structure **100**. In this respect, the mass and flexural resistance of the walls of the structure **100** may be significantly increased. In one embodiment, a bag or a suitable container may be positioned between two studs **120** or the interior and the exterior panels **130_i**, **130_e** to receive the aggregate materials supplied through the nipple **156**. After filling the bag, a plug may be inserted into the nipple **156** to close the bore of the nipple **156**.

[0036] Embodiments of the blast resistant structure **100** are configured to effectively resist peak pressures in the range from about 10 psi to about 100 psi; preferably, from about 25 psi to about 90 psi; more preferably, from about 40 psi to about 75 psi. Also, embodiments of the blast resistant structure **100** are configured to limit the peak internal pressure to less than 3 psi; preferably, less than 2 psi; and more preferably, less than 1.0 psi.

[0037] Referring again to FIG. 4A, in use, the blast resistant structure **100** may be provided with one or more doors **166** and one or more windows at suitable locations in the structure **100**. Additionally, the blast resistant structure **100** may include one or more of an electrical panel and box **161**, led lights **162**, data/telecom panel and box **163**, data/telecom outlet **164**, and an electrical outlet **165**.

[0038] In another embodiment, the blast resistant structure may be a standalone structure or added to an existing or new building. If added to a building, the components of the blast resistant structure may be used to construct one or more rooms inside the building. In another embodiment, the components of the blast resistant structure may be used to construct a wall of the building. For example, wall may be constructed using the HSS tubes, studs and tracks, the structural panels, and blast plate connection discussed above.

[0039] FIGS. 9A-C illustrate an exemplary embodiment of an anchoring system **200** suitable for anchoring the blast resistant structure in a variety of soil types. FIG. 9A illustrates an arrangement of anchors **210** for anchoring the blast resistant structure in the soil. As shown, fifteen anchors **210** are used to attach the blast resistant structure. In this embodiment, the width of the blast resistant structure is about 24 feet. In another embodiment, the width of the blast resistant structure may be about 12 feet, and eight anchors **210** may be used to attach the blast resistant structure. FIG. 9B illustrates a detail view of an exemplary anchor **210**, and FIG. 9C illustrates a cross-sectional view of the anchor **210**. The anchor **210** may include two plates **211**, **212** that are welded together and are disposed at the upper end. The plates **211**, **212** may be square or rectangular shaped having a length and width dimensions between 8 in. and 24 in. or between 11 in. to 14 in. The plates **211**, **212** may be the same or different sizes or shapes. As shown, both plates **211**, **212** have a square shape, and the upper plate **211** is smaller than the lower plate **212**. For example, the upper plate **211** may be 12 in. and the lower plate **212** may be 14 in. In another embodiment, the plates **211**, **212** can have a rectangular shape and placed in overlapping position. A plurality of rods **213** may extend from the plates **211**, **212** into the soil. As shown, the rods **213** may be 12 in. long, between 11 in. and 13 in., or between 8 in. and 20 in. The rods **213** may be positioned at approximately 1.5 in., 1 in. to 2 in., or 0.5 in. to 4 in. from the perimeter of the lower plate **212**. A HSS tube **215** may extend from the center of the lower plate **212** into the soil. As shown, the HSS tube **215** may be approximately 4 ft. long, 3.5 ft. to 4.5 ft. long, or 2 ft. to 6 ft. long. A plurality of studs **216** approximately 3.5 in. long or between 3 in. and 5 in. long may extend from the HSS tube **215** in four directions and equally spaced along the length of the HSS tube **215**. A plurality of rebars **217** may extend from the plates **212** into the soil. As shown, the rebar **217** may be 6 ft. long or between 5 ft. and 7 ft. long, and positioned at approximately 3.125 in. or 3 in. to 4 in. from the perimeter of the lower plate **212**. A plurality of rebar stirrups **214** may be used tie the rebars **217** together. In one embodiment, a first rebar stirrup **214** is position at approximately the midpoint of the rebars **217**, and a second stirrup **214** is positioned at the bottom of the rebars **217**.

Examples

[0040] Three examples of a blast resistant structure ("BRM") were compared to a shipping container having corrugated steel walls in a blast experiment. The first two examples, BRM1 and BRM2, have hollow walls, and the third example, BRM3, has an aggregate filled wall. The BRMs and the container were arranged in a ring formation around an enhanced 9,000 lb. cylindrical ANFO charge (TNT equivalency of about 8,010 lbs.). The BRMs and the container were located at a standoff distance of 150 ft. to provide a direct comparison. All four were secured to the soil using an embed anchor system. Steel plates were welded to the BRMs to facilitate attachment to the anchor system, which extend approximately six feet into the ground. The anchor system prevents the BRMs and the container from sliding or tipping over during the blast loading and thus, provides a true test of the wall systems of the BRMs. Sensors were mounted to the front of the four structures to measure incident and reflected pressures, and a sensor was mounted in each structure to measure peak internal pressure.

[0041] Table 1 below is a summary of external peak pressures and impulses. As shown, the BRMs effectively resisted peak pressures in the range from 45-70 psi, which is considerably higher than a rating of 10-20 psi of a typical blast resistant structure.

TABLE 1

Summary of External Peak Pressures and Impulses			
Structure	Peak Reflected Pressure (psi)	Duration (ms)	Impulse (psi-ms)
BRM 1	46.62	18.0	275.9
BRM 2	71.17	15.4	315.2
BRM 3	66.55	18.2	345.9

[0042] Table 2 below is a summary of internal peak pressures experienced by the test structures. It is clear that the BRM structures performed much better than the ISO container. BRM2 showed a peak internal pressure of 1.2 psi, while BRM 3 only showed peak internal pressure of less than 1. In contrast, the ISO container showed an internal peak pressure 9.57 before the gage disconnected. Indeed, the ISO container was demolished by the blast, while the BRMs only showed minimal residual wall displacement. According to Table 3, BRM 3 showed close to zero residual deflection of the loaded wall.

TABLE 2

Internal Pressure-time Histories	
Structure	Peak Internal Pressure (psi)
BRM 2	1.20
BRM 3	0.98
ISO Container	9.57*

*prior to gage being disconnected

TABLE 3

Residual Deflections	
Structure	Maximum Residual Deflection
BRM 1	2"
BRM 2	1.75"
BRM 3	0.375"

[0043] In another embodiment, a method of forming a blast resistant structure includes forming a frame; securing a track to the frame using a blast plate and a connector; attaching a plurality of studs to the track; attaching a plurality of panels to the plurality of studs, wherein at least one panel comprises a composite board secured to a steel sheet.

[0044] In one or more of the embodiments described herein, the method further comprises introducing an aggregate material between an interior panel and an exterior panel.

[0045] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

1. A blast resistant structure, comprising:
 - a frame;
 - a stud track attached to the frame;

- a plurality of studs attached to the stud track;
a plurality of panels attached to the plurality of studs,
wherein at least one panel comprises a composite board
secured to a steel sheet; and
a blast plate and a connector for securing the stud track to
the frame.
2. The structure of claim 1, wherein the blast plate comprises a rectangular plate.
3. The structure of claim 1, wherein the plurality of studs comprise vanadium.
4. The structure of claim 1, wherein the frame comprises hollow structure section steel tubes.
5. The structure of claim 1, wherein the plurality of panels are attached to an exterior surface of the plurality of studs.
6. The structure of claim 5, wherein the composite board comprises at least one of cement and gypsum.
7. The structure of claim 5, wherein some of the panels are attached to an interior surface of the plurality of studs.
8. The structure of claim 7, further comprising an aggregate material disposed between the panels attached to the interior and exterior surfaces of the plurality of studs.
9. The structure of claim 8, further comprising a nipple disposed in the frame for introducing the aggregate material.
10. The structure of claim 5, wherein the panels attached to the interior surface and the panels attached to the exterior surface are made of different materials.
11. The structure of claim 1, further comprising a plurality of angle panels disposed at the perimeter edges of the structure.
12. The structure of claim 11, wherein the angle panels are disposed above the plurality of panels.
13. The structure of claim 1, wherein the structure is configured to effectively resist a peak pressure in a range from about 25 psi to about 90 psi.
14. The structure of claim 1, wherein the structure is configured to limit the peak internal pressure to less than 3 psi.
15. The structure of claim 1, wherein the connector is selected from the group consisting of bolt, nut, and combinations thereof.
16. The structure of claim 1, wherein at least two connectors are used to secure the blast plate and the stud track to the frame.
17. The structure of claim 16, wherein the at least two connectors are aligned along a width dimension of the track.
18. The structure of claim 1, wherein a ratio of a width of the blast plate to a width of the track is from 0.75:1 to 1:1.
19. The structure of claim 1, wherein a ratio of a length of the blast plate to a length of the track is from 0.75:1 to 1:1.

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