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Wallboard System and Methods of Installation and Repair

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ABSTRACT OF THE DISCLOSURE

A wallboard system composed of panels having weldable joint areas is disclosed. The panels are joined together by a connector that can also be utilized to align adjacent panels. Each panel has a reinforcement grid either embedded therein or attached thereto. Preferably, the reinforcement grid is made of a network of horizontal and perpendicular conduits that extend across the panel. The connector is interposed between the sidewalls of adjacent panels and the end portions of the conduits from each panel are configured to mate with respective areas of the connector, thereby forming a flush joint between adjacent panels. The connectors may include a generally L-shaped corner bead that fills the joint areas between panels forming inside or outside corners.

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Wallboard System and Methods of Installation and Repair

The following statement is a full description of this invention, including the best method of performing it known to me:

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PATENT

WALLBOARD SYSTEM AND METHODS OF INSTALLATION AND REPAIR

Background of the Invention

Field of the Invention

[0001] This invention generally relates to wallboard systems, and in particular, relates to a reinforced drywall system having weldable joints.

Description of the Related Art

[0002] Wallboards, such as drywall, plasterboard, cement fiberboard, mineral fiber panel, and sheet rock, generally refer to large rigid panels used in construction especially for sheathing the interior and exterior walls, ceilings, and floors of residential or commercial building structures. A conventional wallboard is typically made of a gypsum core sandwiched between two sheets of facing paper. The wallboards are mounted to a support frame such as a wooden stud or the like using nails, screws, or other similar fasteners. The edges of a wallboard panel are typically beveled or tapered so as to be generally thinner than the body of the panel. During installation, multiple sheets of wallboards are usually adjoined together in an abutting manner with the tapered edges of each sheet secured to a stud. Joint tape and compound are commonly applied to the recessed regions formed between the abutting tapered edges of adjoining sheets to provide a flat exterior wall surface.

[0003] While conventional wallboard systems are inexpensive and easy to manufacture, they have a number of drawbacks. For example, the paper facing material of the drywall is a source of nourishment for fungus, and thus promotes mold growth particularly in moist environments. Another problem often encountered in conventional drywall systems is nail pops. Nail pops generally refer to the condition whereby the fastener head has sunk or skewed past the paper facing into the gypsum inner lining which in turn causes the cosmetic joint compound to pop loose or causes the actual fastener to become visible, thereby forming an unsightly protrusion in an otherwise smooth wall surface. Nail pops in drywall are often caused by shrinkage or movement of the wooden stud relative to the wallboard after installation. While there are a variety of other reasons why nail pops occur, all of which can be traced to one or more fastener heads failing to remain stationary against a

thin piece of drywall cover paper. Another drawback associated with conventional wallboard systems is that during installation, each side edge of the wallboard panel must be nailed or secured to a stud to prevent the edges from jutting outwardly and also to ensure that the edges of adjoining panels are flush with one another. As such, each panel must be precisely positioned and sized so that the joint between two adjacent panels are aligned against a stud, which can be an inefficient and time consuming process.

[0004] It is thus an object of the present invention to provide a wallboard system and methods of installation and repair which will overcome or ameliorate one or more of the disadvantages of the prior art.

Summary of the Invention

[0005] As used herein, the term "wallboard" is a broad term and shall have its ordinary meaning and shall include, but not be limited to, gypsum board, plasterboard, cement fiberboard, mineral fiber panel, and Sheetrock used for forming interior walls, ceilings, or floors.

[0006] The term "drywall" is a broad term and shall have its ordinary meaning and shall include, but not be limited to, building materials such as sheets or panels comprised primarily of gypsum and used primarily for sheathing interior walls and ceilings.

[0007] The term "inside corner" is a broad term and shall have its ordinary meaning and shall include, but not be limited to, a corner formed by the exterior faces of two abutting wallboards wherein the exterior faces are positioned at an angle of less than 180 degrees relative to each other.

[0008] The term "outside corner" is a broad term and shall have its ordinary meaning and shall include, but not be limited to, a corner formed by the exterior faces of two abutting wallboards wherein the exterior faces are positioned at an angle of greater than 180 degrees relative to each other.

[0009] The term "exterior face" is a broad term and shall have its ordinary meaning and shall include, but not be limited to, the side of a wallboard that does not face the wall stud or ceiling joist to which the wallboard is fastened.

[0010] The term "corner bead" or "bead" is a broad term and shall have its ordinary meaning and shall include, but not be limited to, elongated corner reinforcements configured to finish the joint area of inside and outside corners.

[0011] In one aspect, the preferred embodiments of the present invention provide a wallboard system. The system generally includes a plurality of drywall panels, each of the panels having a plurality of conduits extending through the drywall panel between a first edge and a second edge. Each panel is preferably 4 feet by 8 feet and less than 1 inch thick, however, other size panels are available and equally adaptable, and depending on application may even be more advantageous. The system further includes a connector comprising a plurality of protrusions sized to fit within the respective conduits. Preferably, the connector comprises an elongated strip from which the protrusions project. In a preferred embodiment, the protrusions project from opposing surfaces of the strip. In another preferred embodiment, the connector has at least two surfaces that are disposed at an angle relative to each other and the protrusions project from the two surfaces. The conduits can be parallel and extend between opposite edges of each panel. In certain embodiments, the system further includes a second plurality of conduits which are orthogonal to the first plurality of conduits. In some implementations, the spacing between the conduits is the same for the first and second plurality of conduits. The conduits are preferably made of a material selected from the group consisting of polyvinyl chloride (PVC), polycarbonate, polystyrene, ABS, nylon, PET, acrylics or combinations thereof. In a preferred embodiment, the protrusions on the connector and the conduits are welded together, preferably solvent welded together.

[0012] In another aspect, the preferred embodiments of the present invention provide a drywall panel having a plurality of elongated reinforcements extending through from one edge to another. In one embodiment, the drywall panel further comprises indicia on the exterior of the panel indicating position of the reinforcements. In another embodiment, the drywall panel further comprises a gypsum core, wherein the elongated reinforcements are embedded in the gypsum core. The elongated reinforcements preferably comprise a network of horizontal and perpendicular reinforcements such as but not limited to conduits. Preferably, an end portion of each reinforcement protrudes outwardly from an edge of the panel. In one embodiment, the drywall panel further comprises a gusset disposed along the

edge of the panel. Preferably, the gusset has a plurality of openings configured to receive the end portions of the reinforcements.

[0013] In yet another aspect, the preferred embodiments of the present invention provide a plurality of panels comprised of gypsum, each of the panels having two opposing faces and an edge portion comprised of a material other than gypsum. The material has a bonding property which allows an edge portion of one panel to be attached to an edge portion of another panel by bonding so as to securely fasten the edge portions together. In one embodiment, the bonding property comprises a property which allows the material to be weldable to other materials. In another embodiment, the edge portion material is plastic. In yet another embodiment, the edge portion comprises a planar surface that is perpendicular to the opposing faces of the panel. In yet another embodiment, the edge portion of one panel is attached to the edge portion of another panel by bonding the edge portions to a connector that is disposed therebetween.

[0014] In yet another aspect, the preferred embodiments of the present invention provide a wallboard panel comprised of gypsum and the panel has an edge portion comprised of a plastic material. In one embodiment, the edge portion comprises the perimeter of the wallboard panel. In another embodiment, the edge portion comprises opposing edges of the panel. Preferably, the opposing edges being interconnected by reinforcements extending through the gypsum. In yet another embodiment, the edge portion comprises a frame that borders the edges of each panel. In some implementations, the plastic material is attached to a face of the wallboard panel.

[0015] In yet another aspect, the preferred embodiments of the present invention provide a corner bead for finishing a corner of abutted, non-overlapping drywall panels. The corner bead is configured to fit wholly between ends of the abutted panels without overlapping onto faces of the panels. In one embodiment, the corner bead comprises two elongated surfaces disposed at an angle relative to each other, wherein each surface is configured to contact an end of a respective abutting panel. In one implementation, the angle is preferably about 30, 45, 90, or 135 degrees. In another implementation, the angle is preferably adjustable. Preferably, the corner bead further comprises a plurality of protrusions extending from each of the elongated surfaces. In certain preferred embodiments, the corner

bead is configured to attach to the panels without taping or nailing. The corner bead can be configured for finishing an inside corner or an outside corner.

[0016] In yet another aspect, the preferred embodiments of the present invention provide a wallboard system. The wallboard system generally includes a pair of panels comprised of gypsum core wherein each of the panels has an edge portion comprised of material other than gypsum. The wallboard system further includes a corner bead between edges of adjacent panel. Preferably, the corner bead has a pair of surfaces disposed at an angle relative to each other. Preferably, the corner bead is comprised of a material, wherein the edge portion material and the corner bead material have bonding properties which allow respective edge portions of the panels to be attached to respective surfaces of the corner bead by bonding.

[0017] In yet another aspect, the preferred embodiments of the present invention provide a method of installing a plurality of wallboard panels. The method includes positioning a first drywall panel having an edge portion comprised of a material other than drywall adjacent to a second drywall panel having an edge portion comprised of a material other than drywall, and attaching the edge portion of the first drywall panel to the edge portion of the second drywall panel by a method selected from the group consisting of cement bonding, adhesive bonding, solvent welding, heat welding, ultrasonic welding, and combinations thereof. In one embodiment, the step of attaching the edge portions of the drywall panels comprises placing a connector adjacent a respective edge portion of each drywall panel and adhering the connector to the respective edge portions. In a preferred implementation, placing a connector adjacent to a respective edge portion comprises placing a connector having spaced protrusions extending therefrom adjacent an edge of the first drywall panel, inserting a plurality of the protrusions into the edge portion of the first panel, inserting another plurality of the protrusions into the edge portion of the second drywall panel, and adhering the inserted plurality of protrusions to the edge portion material. In one embodiment, adhering the inserted plurality of protrusions to the edge portion material comprises solvent bonding the protrusions to the edge portion material. In another embodiment, the method further includes inserting a fastener into a face of the drywall panel, through a conduit embedded in said panel, and into a support frame.

[0018] In yet another aspect, the preferred embodiments of the present invention provide a method of repairing a drywall panel. The method comprises cutting an opening in a drywall panel having a plurality of conduits extending therethrough, preparing a drywall insert sized to fit within the opening such that a plurality of conduits through the insert is parallel to the plurality of conduits in the panel, and inserting at least one connector into at least some of the conduits so as to fasten the insert into the panel. In one embodiment, the method further comprises orienting the inserts so that a second plurality of conduits of the insert orthogonal to the first plurality of the insert is parallel to a second plurality of conduits of the panel orthogonal to the plurality of conduits to the panel.

[0019] In yet another aspect, the preferred embodiments of the present invention provide a frame for mounting gypsum drywall. The frame comprises a perimeter edge portion configured to retain a panel of the gypsum drywall with plural edges of the panel adjacent respective plural edges of the perimeter edge portion. The frame further comprises a backing portion that is attached to the edge portion and disposed within a space defined by the perimeter of the edge portion. In one embodiment, the edge portion comprises a plurality of elongated sections defining a substantially rectangular area. Preferably, at least one elongated section is made of a plastic material. In another embodiment, at least two of the elongated sections are disposed orthogonally to each other thereby forming a corner. In one implementation, the edge portion is approximately 4 feet wide and 8 feet long. The backing portion preferably extends across the space defined by the perimeter of the edge portion. In one embodiment, the backing portion comprises a plurality of conduits.

[0020] In yet another aspect, the preferred embodiments of the present invention provide a method of applying a frame to a gypsum drywall panel. The method comprises the steps of providing a substantially rigid frame having a backing material disposed within a space defined by the frame and attaching the gypsum drywall panel to the frame. In one embodiment, the step of providing the frame comprises joining a plurality of elongated legs together in a manner such that at least two of the legs are disposed orthogonally to each other. In another embodiment, the step of attaching the gypsum drywall panel to the frame comprises attaching a face of the gypsum drywall panel to the elongated legs. In yet another embodiment, the step of forming the frame comprises attaching a backing material to at least

one edge of the frame. In a preferred embodiment, the backing material is in the form of a conduit. Preferably, attaching the gypsum drywall panel comprises attaching a face of the panel to the backing material.

Brief Description of the Drawings

[0021] FIGURES 1A-1B are schematic illustrations of a wallboard system of certain preferred embodiments of the present invention;

[0022] FIGURE 2 is a schematic illustration of the wallboard system of FIGURES 1A-1B showing two adjacent wallboard panels connected together by a welded joint;

[0023] FIGURES 3A-3B are schematic illustrations of one embodiment of a connecting member of the wallboard system of FIGURE 1A;

[0024] FIGURES 4A-4C are schematic illustrations of certain alternative embodiments of the connecting member of the wallboard system of FIGURE 1A;

[0025] FIGURES 5A-5C are schematic illustration of a wallboard panel of certain preferred embodiments of the present invention;

[0026] FIGURE 6 is a schematic illustration of one embodiment of the wallboard panel configured to reduce nail pops;

[0027] FIGURE 7 illustrates a manner in which the wallboard system of FIGURE 1A can be installed;

[0028] FIGURES 8A-8B illustrate a manner in which the wallboard system of FIGURE 1A can be repaired;

[0029] FIGURES 9A-9B illustrate a corner bead of one preferred embodiment of the present invention;

[0030] FIGURE 10 illustrates the corner bead of FIGURES 9A-9B being used to finish an outside corner of one preferred embodiment;

[0031] FIGURES 11A-11E are schematic illustrations of a corner bead of another preferred embodiment of the present invention; and

[0032] FIGURE 12 illustrates the corner bead of FIGURES 11A-11E being used to finish an inside corner of one preferred embodiment;

[0033] FIGURES 13A-13B are schematic illustrations of a wallboard frame of one preferred embodiment of the present invention configured to retrofit pre-formed drywall panels.

Detailed Description of Preferred Embodiments

[0034] Figures 1A is a schematic illustration of a wallboard system 100 of one preferred embodiment of the present invention. The wallboard system 100 generally includes a first wallboard panel 102a, a second wallboard panel 102b, and a connecting member 104 for aligning and joining the panels 102a, 102b together in a manner to be described in greater detail below. As shown in Figure 1A, each wallboard panel 102a, 102b is generally rectangular in shape, having two opposing faces 106a, 106b and sidewalls 108a-d extending therebetween. In a preferred embodiment, each wallboard panel is 4 feet by 8 feet and has a thickness of no greater than about 1 inch, preferably no greater than about $\frac{3}{4}$ inch, more preferably no greater than about $\frac{3}{8}$ inch, although it will be appreciated that a variety of different panel shapes and dimensions are contemplated to be within the scope of this invention.

[0035] As also shown in Figure 1A, each wallboard panel 102a, 102b comprises a core material 110 and reinforcements 112 extending therethrough. The core material 110 can include but is not limited to gypsum, concrete, fiberglass, and combinations thereof. The reinforcements 112 preferably comprise a substantially rigid material that is selected to provide strength and reinforcement to the panels 102a, 102b. Preferably, the reinforcements 112 are made of a material that can be adhered to the connecting member 104 using a variety of known techniques such as solvent welding, heat welding, ultrasonic welding, cement bonding and the like. In a preferred embodiment, the reinforcements 112 are made of a solvent weldable or solvent bondable material such as polyvinyl chloride (PVC), polycarbonate, polystyrene, ABS, nylon, PET, acrylics, or combinations thereof. Solvent welding or solvent bonding is a known technique used for joining parts formed of certain plastic materials. Generally, the solvent dissolves the surface of the two mating parts and allows the materials to flow together. After the solvent evaporates, what is left is a material-to-material bond. A more detailed description regarding solvent bonding or solvent welding

is provided in U.S. Patent No. 5,821,293, which is hereby incorporated by reference in its entirety.

[0036] In the embodiment shown in Figure 1A, the reinforcements 112 are in the form of a plurality of conduits such as plastic tubing. The diameter of each tubing is preferably approximately 1 inch wide. The conduits form a reinforcement grid that is preferably embedded in the core material 110. The reinforcement grid is comprised of a first group of parallel conduits 114a extending between a pair of opposing edges 115a, 115b of the panel 102a, 102b and a second group of parallel conduits 114b extending between a second pair of opposing edges 117a, 117b of the panel. Preferably, the first and second groups of conduits 114a, 114b are orthogonal to each other so as to form a network of uniformly spaced horizontal and perpendicular conduits. In one implementation, the spacing between adjacent conduits in the first group of conduits 114a is the same as the spacing between conduits in the second group 114a. In a preferred implementation, the spacing between adjacent conduits extending in the same direction is about 4 inches. As will be described in greater detail below, the reinforcements 112 are configured to provide numerous advantages to the wallboard system shown in Figure 1A, including but not limited to, reinforcing the strength of the individual drywall panels, facilitating the alignment of the panels during installation, and forming weldable joints between adjacent panels.

[0037] As shown in Figure 1A, the end portions of each reinforcement 112 are preferably substantially flush with at least one sidewall 108a-d of the panel so as to form a plurality of openings 116 in the sidewalls 108a-d. The connecting member 104 of the wallboard system 100 comprises an elongated strip 118 having two opposing surfaces 120a, 120b and a plurality of protrusions 122 extending from each surface 120a, 120b. The protrusions are preferably configured to be received by a respective opening 116 formed in the sidewalls 108a-d of the wallboard panel 102a, 102b. Preferably, once inserted, the protrusions 122 establish contact with the conduit by way of an interference fit. In some implementations, the connecting member 104 also serves as an alignment guide in aligning adjacent panels together by inserting the protrusions into the appropriate openings on the sidewalls of the panels. As such, the wallboard systems advantageously utilize the connecting member 104 to quickly and conveniently guide the alignment of two adjacent

wallboard panels through an interference fit of the protrusions on the connecting member and the openings formed on the panel sidewalls. In certain preferred embodiments, the connecting member is also made of a bondable material such as PVC and can be solvent bonded, cemented, or adhered to the conduits.

[0038] During installation, the connecting member 104 is preferably sandwiched between the sidewalls 108a, 108b of adjacent wallboard panels such that protrusions 122 on one surface 120a of the connecting member 104 are inserted into openings 116 in the sidewall 108b of the first wallboard panel 102a while protrusions 122 on the other surface 120b of the connecting member 104 are inserted into openings formed in the sidewall 108a of the second panel 102b. Preferably, each inserted protrusion contacts the respective conduits therein. In one embodiment, a solvent or solvent primer is applied to the protrusion prior to insertion into the sidewall openings so as to allow the connecting member 104 to be solvent welded or bonded to the conduits. In another embodiment, a volume of the solvent can be encapsulated in the conduits and can be released upon pressure exerted by the protrusion. In yet another embodiment, the conduits and the connecting member can be welded together using heat welding, ultrasonic welding or other known methods. Advantageously, the conduits in the wallboard panels in conjunction with the connecting member allow adjacent abutting panels to be fixedly bonded to each other and form a joint that is flush with the exterior face of the panels.

[0039] Figure 1B illustrates an alternative embodiment of the wallboard system 100 in which the reinforcements 112 extend outwardly from at least one sidewall 108a-d of the panel 102a, 102b and the end portions 124 of the reinforcements 112 protrude from the sidewalls. In this embodiment, the connecting member 104 comprises an elongated base 118 having a plurality of openings or indentations 126 formed therein. The openings 126 are configured to receive the end portions 124 of the reinforcements 112 that protrude from the sidewalls 108a-d of the wallboard panels 102a, 102b. The end portions 124 of the reinforcements 112 can be bonded to the connecting member 104 via solvent welding, heat welding, ultrasonic welding, cementing, adhesives or other known methods. While the preferred embodiments illustrated herein show the reinforcements as comprised of conduits, it will be appreciated that the reinforcements can assume a variety of other configurations,

such as non-tubular form and/or non-hollow without departing from the spirit of the invention.

[0040] Figure 2 is a schematic illustration of the wallboard system 100 of Figure 1 showing the first and second wallboard panels 102a, 102b being securely fastened to each other by bonding, such as by welding, at least some of the conduits of each panel to the same connecting member. As shown in Figure 2, the two wallboard panels 102a, 102b form a joint area 200 that is flush with the exterior faces 202 of the panels 102a, 102b. The flush joint area 200 substantially eliminates the need for joint compound to fill the joint regions which are recessed in most conventional drywall systems. Additionally, since the panel sidewalls are fixedly bonded to each other, the joint area between the panels can be positioned between studs as there is no longer a need to nail the individual panel edges to studs. Hence, there is also no longer a need to bevel the edges of drywall panels to facilitate nailing to the studs.

[0041] Figures 3A and 3B are partial schematic illustrations of the connecting member 104 of one preferred embodiment. Figure 3A is a partial side view of the connecting member 104 showing the protrusions 122 extending from the first surface 120a of the connecting member 104. In one embodiment, the protrusions are semicircular and have a diameter of about 7/8 inch. However, it will be appreciated that the protrusions and the connecting member can take on the form of a variety of other shapes and dimensions. Figure 3B is a partial cross-sectional view thereof, showing protrusions 122 extending from generally the same location on opposing surfaces 120a, 120b of the connecting member 104. The protrusions 122, preferably semicircular in shape, are configured to be received in respective openings formed in the sidewalls of adjoining panels.

[0042] Figures 4A, 4B and 4C are partial schematic illustrations of the connecting member 104 of other preferred embodiments. Figure 4A is a partial side view of the connecting member 104 showing the protrusions 122 extending from the first and second surfaces 120a, 120b are offset from each other. Figure 4B is a partial cross-sectional view thereof, further showing the offset protrusions 122. Connecting members with offset protrusions are particularly useful in embodiments which the conduit openings extending across the length of the panel are offset from openings extending across the width. Figure 4C

is a partial cross-section view of a connecting member 104c of another embodiment in which the protrusions 122 extend from only a first surface 123 of the connecting member 104 while a second, opposing surface 125 remains substantially flat. As will be described greater detail below, connecting members with protrusions extending from only one side or one surface are particularly useful in embodiments where there is limited space for maneuvering the panels such as when repairing or replacing a portion of a wallboard panel.

[0043] Figure 5A is a schematic illustration of a wallboard panel 500 of another preferred embodiment. As shown in Figure 5A, the wallboard panel 500 generally comprises a gypsum core 502, a plurality of substantially rigid reinforcements 504 such as conduits extending through the core, and a rigid frame 506 made of a material other than gypsum. Preferably, the rigid frame is positioned along the edges of the panel. Advantageously, the frame 506 provides the wallboard with uniformly dimensioned and planar edges which facilitates formation of flush joints between abutting panels. In one embodiment, the frame 506 is comprised of gussets made out of a plastic material such as PVC. In certain preferred embodiments, the wallboard panel does not include paper facing which further reduces mold growth. As will be described in greater detail below, the conduits 504 which are attached to the frame 506 provide a matrix for the supporting the gypsum within the frame 506 so that the gypsum 502 does not become detached from the frame 506.

[0044] A conventional gypsum wallboard is typically manufactured by pre-mixing ingredients including calcium sulfate hemi hydrate into an aqueous slurry, which is then deposited between two sheets of facing paper. As the slurry is deposited onto a first sheet of facing paper, the other sheet of facing paper is placed on top of the deposited slurry and bonded to the edges of the first facing paper. The slurry is then allowed to set between the two sheets of the paper to form a gypsum board. As such, the two sheets of facing paper constrain and limit the flow of the slurry, thereby allowing the slurry to set into board form. Additional descriptions of the formation of a gypsum core board are disclosed in U.S. Patent No. 6,902,821, which is hereby incorporated by reference in its entirety.

[0045] The wallboard panel of the preferred embodiments such as that shown in Figure 5 can be manufactured without the facing papers as the frame 506 is configured to constrain or limit the slurry flow. In one embodiment, the wallboard panel can be

manufactured by first forming a generally rectangular frame 506 comprising gussets interconnected by reinforcements using methods known in the art, followed by applying a slurry comprising gypsum or other curable material onto the framework, and then allowing the gypsum or other curable material to set and cure into solid panel form. Since the slurry will be confined within the area defined by the frame and supported by the reinforcements, facing papers can be eliminated in the formation of the gypsum wallboard panels in these embodiments.

[0046] Persons of ordinary skill in the art will understand that the composition of such other slurry materials will vary for each general type of wallboard. In addition, depending on various factors including, among others, material cost and the panel's intended application, variations of the basic core composition may exist within each general category of wallboard type (drywall, plasterboard, cement fiber board, mineral fiber panel, Sheetrock, etc.).

[0047] As also shown in Figure 5A, the reinforcements 504 embedded in the gypsum core are preferably plastic tubing having a substantially circular cross-section, however it will be appreciated that the number of plastic tubing shown is for illustrative purposes only and do not represent the only embodiment or the preferred embodiment. Figure 5A also shows that the frame 506 preferably comprises elongated, rectangular plastic pieces that provide added strength to the wallboard panel 500. In one embodiment, the frame 506 is also made of a PVC material. In another embodiment, the frame 506 is positioned along the outer border of the gypsum core 502 and serves as a sidewall of the panel.

[0048] As also shown in Figure 5A, a series of openings 508 can be formed in the frame 506 and configured to receive end portions 510 of the reinforcements 504. Preferably, the end portions of the reinforcements 504 such as the plastic tubing as shown in Figure 5A are positioned in a manner such that they are flush with the exterior surface 512 of the frame 506. In some preferred embodiments, the openings 508 in the frame 506 have a substantially oval shape while the plastic tubing has a circular cross-section. The opening in the frame and the diameter of the plastic tubing are configured such that the openings in the frame compress and slightly flatten the plastic tubing when the end portions of the tubing are inserted into the opening. In one embodiment, the opening has a width of about 7/8 inch. As will be

described in greater detail below, the compressed PVC tubing will provide a certain amount of flex when a nail or fastener is inserted through the tubing.

[0049] In other implementations as shown in Figure 5B, the frame 506 can be attached to the edges of a conventional drywall panel 570. The reinforcements 504 can also extend across a face 572 of the drywall panel 570 as opposed to being embedded in the gypsum core. Figure 5C illustrates a wallboard panel 550 of yet another preferred embodiment. As shown in Figure 5C, the wallboard panel 550 comprises a gypsum core 552 and a substantially rigid reinforcement 554 embedded therein. In one embodiment, the reinforcement 554 comprises a plastic sheet having perforated openings 508 formed therein. Preferably, the plastic reinforcement sheet extends to at least one edge 505 of the panel 550 to provide a bondable surface 556. The perforated openings 508 are formed in the plastic reinforcement sheet 554 to reduce weight and improve bonding with the gypsum core 552.

Reduce Nail Pop

[0050] Figure 6 is a partial schematic illustration of one embodiment of the wallboard panel 102a that is designed to substantially reduce nail pops. As shown in Figure 6, a recess 600 is formed in the core material 110 adjacent to a conduit 112. A fastener 602 such as a nail is extended into the recess 600, through the conduit 112, and into a wall stud 604. When the fastener 602 is inserted through the conduit, an upper portion 603 of the conduit wall is slightly pressed downwards toward a lower portion 605 of the conduit wall. After the fastener 602 is extended into the conduit 112, the upper portion of the conduit wall 603 flexes slightly upwards, thus stabilizing the fastener and limiting its movement. The recess 600 is then patched using a resin or other patching material 608 known in the art in a manner such that a space 606 is left between the resin 608 and the fastener 602. As such, when there is movement between the stud and the drywall panel, movement of the fastener would be reduced because it is secured and stabilized by the conduit which is comprised of a material more rigid than the core material which is typically gypsum or the like. Moreover, even if the fastener is shifted or moved after installation, the spacing 606 between the fastener and the patching material further reduces the likelihood of the fastener showing through the exterior surface 610 of the walls.

Eliminates Need to Align Panel Edge to a Stud

[0051] Figure 7 illustrates the manner in which the wallboard system 100 is installed. As shown in Figure 7, individual wallboard panels 102a, 102b are positioned adjacent to each other in a manner such that the joint area 700 can be located anywhere, such as between studs 702. Since the edges of adjacent panels are configured to be securely attached to each other such as by welding, there is no need to nail the edges to individual studs as commonly practiced in the prior art. The panels can be mounted to the building frame 702 by inserting a nail or any other type of fastener through any of the plurality of reinforcement conduits extending through the panel. In some embodiments, indicia 704 are positioned on the exterior surface 610 of the panel to indicate locations of the reinforcement conduits. The reinforcement conduits and frame in the wallboard panels provide structural reinforcement to the wallboard panel. The orthogonal arrangement of the conduits provides a network of reinforcements, which is particularly useful in reinforcing interior walls of a building structure.

Facilitate Drywall Repair

[0052] Figures 8A and 8B show the manner in which the wallboard system 100 illustrated in Figures 1A and 1B allow for easy repair and replacement of portions of the wallboard. As shown, to replace a portion 802 of a wallboard panel 800, a replacement piece 804 and replacement connecting members 806 can be cut out and attached to the panel 800 via solvent welding, heat welding, ultrasonic welding, cementing or other known processes to form a flush joint. As shown, the conduits 112 extending throughout the panel 800 in a grid pattern permit for easy alignment of replacement piece 804. In practice, a properly sized and configured replacement piece 804 is cut out to match the section 802 in the wallboard panel that needs repair. Properly sized connecting members 806 are also cut out to attach the replacement piece 804 to the panel. Preferably, connecting members with protrusions 807 extending from only one side 809 or surface is used in this embodiment. The protrusions 807 are inserted into respective openings formed by the conduits in the replacement piece and bonded to the conduits thereby leaving a strip of bonding surface 211 along each edge of the replacement piece 804. The replacement piece 804 is then joined to and aligned with the rest of the wallboard panel by securely attaching the bonding surface 211 to the conduits in the

connecting members 806 by welding, cementing, or other known processes. Since the reinforcement grid extends across the entire panel, any section of the wallboard panel can be replaced in this manner with replacement pieces.

Corner Beads

[0053] Figures 9A and 9B illustrate a corner bead 900 of one preferred embodiment configured to be inserted between the abutting edges of two adjoining, non-overlapping wallboard panels positioned at a relative angle to each other to form an outside corner. As shown in Figure 9A, the corner bead 900 generally includes an elongated body 902 having at least two interior surfaces 904a, 904b extending along the length of the body 902 and disposed at an angle 906 relative to each other. The angle 906 is preferably configured to correspond to the angle between the edges of the abutting and non-overlapping panels forming the outside corner. In one embodiment, the angle 906 is preferably 30°, 45°, 90°, or 135°. The corner bead 900 is configured to fit between the ends of the abutted panels in a manner such that the interior surfaces of the corner bead are in contact with a respective panel edge. In certain preferred implementations, the width of each interior surface 904a, 904b is substantially the same as the thickness of the wallboard panel, preferably 3/8 inch, 1/2 inch, 3/4 inch, or 1 inch. The length of the corner bead can also be sized to match the height of the wallboard. Additionally, the corner bead is preferably made of a plastic material that is solvent or adhesive bondable to other plastic materials.

[0054] As also shown in Figure 9A, a plurality of protrusions 906 are formed along each interior surface 904a, 904b of the corner bead. The protrusions 906 are configured to be inserted into the conduits spaced along the edges of the wallboard panels as described above. In alternative embodiments, recesses are formed along each surface 904a, 904b to receive the ends of the conduits or reinforcements that protrude outwardly from the abutting edge of the panels. Preferably, the corner bead 900 is inserted between and securely attached to the abutting wallboard panels forming the outside corner. In one embodiment, the protrusions 906 on the corner bead 900 are attached to the conduits and/or reinforcements spaced along the edges of each wallboard panel using known bonding techniques such as solvent welding, adhesive bonding, cement bonding, ultrasonic welding, or heat welding. In another embodiment, the protrusions 906 are attached to each wallboard panel via an

interference fit with the conduits spaced along the panel edge. However, it will be appreciated that there are embodiments in which the corner bead does not contain the protrusions and that the interior surfaces of the corner bead are directly bonded to the side edges of the panels.

[0055] As illustrated in Figure 9A, the corner bead 900 also has one or more exterior surfaces 905 which provide a finish to the outside corner of certain preferred embodiments. As shown in Figure 9B, the exterior surface 905 can assume a variety of different configurations such as standard orthogonal 908, bull nosed 910, diagonal 912, or ornamental 914.

[0056] Figure 10 illustrates the corner bead 900 being used to finish an outside corner formed by two abutting, non-overlapping drywall panels 1002, 1004 of one preferred embodiment. The drywall panels 1002, 1004 are preferably gypsum panels having a plurality of conduits extending therethrough and a plastic frame 1003 along its four edges such as that shown and described in Figure 5A and 5B. Since the abutting panels are positioned in a manner such that the side edge of one panel does not overlap onto the face of the adjacent panel, the joint area 1008 between the panels needs to be filled in order to finish the outside corner. As shown in Figure 10, the outside corner is finished by attaching the interior surfaces of the corner bead 900 to the edges of the two drywall panels 1002, 1004. In one embodiment, the protrusions 906 on the interior surfaces of the corner bead are bonded to conduits spaced along the side edges of the frame 1003. The exterior surface 905 of the corner bead forms the corner between the two panels. Advantageously, the corner bead 900 can be easily installed and fills the joint area without overlapping onto the face of the panels which helps form a smooth, finished exterior corner surface.

[0057] Figure 11A illustrates a corner bead 1100 of another preferred embodiment configured to finish an inside corner of one preferred embodiment. As shown in Figure 11A, the corner bead 1100 comprises an elongated body 1102 having a first and second surfaces 1112a, 1112b positioned at an angle 1114 relative to each other. Preferably, the angle 1114 is selected to correspond to the angle formed between two abutting wallboard panels forming the inside corner, such as between the ceiling panel and wall panel or between adjacent wall panels at an inside corner. In a preferred embodiment, the width of each

surface 1112a, 1112b corresponds to the width of the wallboard panel, such as 3/8 inch, 1/2 inch, 3/4 inch, or 1 inch. The corner bead 1100 further includes protrusions 1106 that extend outwardly from the surfaces 1112a, 1112b of the elongated body 1102 as shown in Figure 11A. The protrusions 1106 are configured to be inserted into conduits spaced along the edges of the wallboard panels so as to secure the corner bead to the wallboard panels. Preferably, the corner bead is made of a plastic material that can be bonded to other plastic materials.

[0058] Figures 11B-11E illustrate the manner in which the corner bead 1100 of one embodiment can be formed. As shown in Figure 11B, the corner bead 1100 can be formed from a plastic strip 1114 that is foldable along a longitudinal axis 1104. The plastic strip 1114 further includes pre-formed tabs or protrusions 1106 that can be extended outwardly from a surface 1103 of the strip 1114 in a manner as shown in Figure 11C. Figure 11D is a cross-section view of the corner bead 1100 showing the tabs 1106 extending from the body 1102 of the corner bead 1100. In one embodiment, the tabs 1106 are configured to be inserted into the conduits extending across the wallboard panels as described above. As shown in Figure 11E, the corner bead 1100 is bendable along the longitudinal axis 1104 to form an angle suitable for placement between two wallboard panels. In one embodiment, this angle can be adjusted depending on the angle of the inside corner.

[0059] Figure 12 illustrates the manner in which the corner bead 1100 of Figures 11A-E is used to finish an inside corner formed of two wallboard panels 1200, 1202 positioned at an angle. As shown in Figure 12, the surfaces 1112a, 1112b of the corner bead are in contact with an edge of each respective wallboard panel 1200, 1202. In one embodiment, the protrusions on the corner bead are inserted in and bonded to the conduits spaced along the edges of the panels. In another embodiment, the surfaces are directly bonded to the plastic frame formed along the edges of the panel. As shown in Figure 12, an edge portion 1122 of the corner bead 1110 which connects the two surfaces fills the joint area between the two panels without overlapping onto the face of the panels. Advantageously, the corner inserts 1000, 1100 for inside and outside corners facilitate formation of flush and substantially seamless corners in the wallboard system of the preferred embodiments. Moreover, the corner inserts fill the joint areas without overlapping onto the face of the panels which result in a much

smooth exterior corner surface. The corner inserts 1000, 1100 can be easily installed as they are configured with protrusions adapted to fit into the openings formed in the sidewalls of the panel as described above, or in other embodiments they can be directly bonded to plastic frames formed along the panel.

Wallboard Frame

[0060] In certain preferred embodiments, the wallboard panel can be made by retrofitting a pre-formed gypsum drywall panel with a frame so that the framed drywall panel can be installed in the manner as described above and also have the advantageous features as described above. Figure 13A is a schematic illustration of a wallboard frame 1300 of one preferred embodiment configured to retrofit a conventional drywall panel so that the panel would have with a uniform, planar sidewall and/or weldable edges. As shown in Figure 13A, the frame 1300 includes a plurality of elongated sidewalls 1302a-d joined together to define a generally rectangular space 1304. In one embodiment, the rectangular space 1304 is approximately 4 feet by 8 feet and configured to receive a pre-formed drywall panel. However, it will be appreciated that the frame 1300 can assume a variety of different dimensions and shapes. In a preferred embodiment, the frame 1300 is made of a plastic material in which each sidewall 1302 a-d comprises a rigid plastic material such as PVC. In certain preferred implementations, the sidewalls are dimensioned and shaped substantially similarly as the gussets described above. As also shown in Figure 13A, the frame 1300 further includes a backing portion 1306 preferably in the form of a plurality of reinforcements extending between opposing sidewalls. In one embodiment, the backing portion 1306 comprises a plurality of conduits spaced apart in a grid pattern as described above. The backing portion 1306 provides a mounting support for the drywall panel that will be mounted in the space 1304 defined by the frame 1300.

[0061] In a preferred embodiment, a lower exterior surface 1308 of the reinforcements 1306 is substantially flush with a lower exterior surface 1310 of the sidewalls 1302 a-d of the frame 1300. This allows the frame to be nailed to a stud through the reinforcements 1306 without bending the frame. In another preferred embodiment, the reinforcements 1306 are positioned such that the distance between an upper exterior surface 1312 of the reinforcements 1306 and a plane defined by an upper exterior surface 1314 of the

sidewalls 1302 a-d is substantially the same as the thickness of the drywall panel. As such, the drywall panel will fit flushly in the frame with the exterior facing of the mounted drywall panel substantially flush with the frame.

[0062] As also shown in Figure 13A, openings 1316 are preferably formed along the sidewalls 1302 a-d of the frame 1300 to receive end portions 1318 of the reinforcements 1306. In the embodiment as shown in Figure 13A, the reinforcements comprise a plurality of conduits. As described in other embodiments above, the conduits and openings provide an alignment and attachment system between adjacent drywall panels. In some embodiments, the frame 1300 can be provided in a disassembled kit form. The kit preferably includes disassembled sidewalls having adjustment slots thereon that would allow quick assembly of the frame into various different dimensions. For example, if a frame of non-standard dimensions is required, the disassembled sidewalls can be cut to the desired length on the job site and the adjustment slots spaced along the sidewalls can facilitate quick assembly of the sidewalls to form the frame.

[0063] A pre-formed drywall panel 1320 can be mounted in the frame 1300 in the manner as shown in Figure 13B. Preferably, the panel 1320 is positioned such that a face 1322 of the panel 1320 is attached to and supported by the backing portion 1306. Preferably, the face of the panel 1322 is adhered to the reinforcements by adhesive. As shown in Figure 13B, when the panel 1320 is mounted, an exterior face 1324B is preferably flush with the upper surface 1314 of the frame 1300 thereby providing the wallboard panel a uniform, planar exterior surface. In some embodiments, the panel 1320 can be attached to the upper exterior surface 1314 of the frame sidewalls 1302 a-d. In other embodiments, the frame 1300 can be first mounted to a wall stud or building support structure before attaching the drywall panel 1320 to the frame.

[0063] Although the above-disclosed embodiments have shown, described, and pointed out the fundamental novel features of the invention as applied to the above-disclosed embodiments, it should be understood that various omissions, substitutions, and changes in the form of the detail of the devices, systems, and/or methods shown may be made by those skilled in the art without departing from the scope of the invention. Furthermore, it will be

appreciated that the dimensions of certain features shown in the figures may be exaggerated for illustrative purposes.

Throughout the description and claims of this specification the word "comprise" and variations of that word, such as "comprises" and "comprising", are not intended to exclude other additives, components, integers or steps.

WHAT IS CLAIMED IS:

1. A wallboard system, comprising:
a plurality of panels, each of said panels having a plurality of conduits extending through the panel between a first edge and a second edge; and
a connector comprising a plurality of protrusions sized to fit within the respective conduits.
2. The wallboard system of Claim 1, wherein the conduits extend between opposite edges of each panel.
3. The wallboard system of Claim 1, further comprising a second plurality of conduits, wherein the second plurality of conduits are orthogonal to the first plurality of conduits.
4. The wallboard system of Claim 1, wherein the connector comprises an elongated strip from which the protrusions project.
5. The wallboard system of Claim 4, wherein the protrusions project from opposing surfaces of the strip.
6. The wallboard system of Claim 1, wherein the conduits are made of a plastic material selected from the group consisting of PVC, polycarbonate, polystyrene, ABS, nylon, PET, acrylics, or combinations thereof.
7. The wallboard system of Claim 1, wherein the protrusions on the connector and the conduits are welded together.
8. The wallboard system of Claim 1, wherein the connector has at least two surfaces that are disposed at an angle relative to each other, wherein said protrusions project from the two surfaces.
9. The wallboard system of Claim 1, wherein the panel is drywall.
10. The wallboard system of Claim 1, wherein the panel is plasterboard.
11. The wallboard system of Claim 1, wherein the panel is cement fiberboard.
12. The wallboard system of Claim 1, wherein the panel is mineral fiber.
13. A drywall panel having a plurality of elongated reinforcements extending through from one edge to another.

14. The drywall panel of Claim 13, further comprising indicia on the exterior of the panel indicating position of the reinforcements.

15. The drywall panel of Claim 13, wherein said elongated reinforcements comprise a network of horizontal and perpendicular reinforcements.

16. The drywall panel of Claim 13, wherein an end portion of each reinforcement protrudes outwardly from an edge of the panel.

17. The drywall panel of Claim 16, further comprising a gusset disposed along the edge of the panel, said gusset having a plurality of openings configured to receive the end portion of the reinforcement.

18. A plurality of panels comprised of gypsum, each of the panels having two opposing faces and an edge portion comprised of a material other than gypsum, said material having a bonding property which allows an edge portion of one panel to be attached to an edge portion of another panel by bonding so as to securely fasten the edge portions together.

19. The panels of Claim 18, wherein the bonding property comprises a property which allows the material to be weldable to other materials.

20. The panels of Claim 18, wherein the edge portion material is plastic.

21. The panels of Claim 18, wherein said edge portion comprises a planar surface that is perpendicular to the opposing faces of the panel.

22. The panels of Claim 18, wherein the edge portion of one panel is attached to the edge portion of another panel by bonding both edge portions to a connector that is disposed therebetween.

23. A wallboard panel comprised of gypsum, said panel having an edge portion comprised of a plastic material.

24. The wallboard panel of Claim 23, wherein the edge portion comprises opposing edges of the panel, said opposing edges are interconnected by reinforcements extending across the gypsum.

25. The wallboard panel of Claim 24, wherein the edge portion comprises a frame that borders the edges of the panel.

26. The wallboard panel of Claim 23, wherein said plastic material is attached to a face of the wallboard panel.

27. A corner bead for finishing a corner of abutted, non-overlapping drywall panels, said corner bead configured to fit wholly between ends of the abutted panels without overlapping onto faces of the panels.

28. The corner bead of Claim 27, further comprising two elongated surfaces disposed at an angle relative to each other, wherein each surface is configured to contact an end of a respective abutting panel.

29. The corner bead of Claim 27, further comprising a plurality of protrusions extending from each of said elongated surfaces.

30. The corner bead of Claim 27, wherein said corner bead is configured to attach to the panels without taping or nailing.

31. The corner bead of Claim 27, wherein said corner bead is configured for finishing an inside corner.

32. The corner bead of Claim 27, wherein said corner is configured for finishing an outside corner.

33. The corner bead of Claim 28, wherein the angle between the elongated surfaces of the corner bead is adjustable.

34. A wallboard system comprising:

a pair of panels comprised of gypsum core, each of the panels having an edge portion comprised of material other than gypsum; and

a corner bead between edges of adjacent panels, said corner bead having a pair of surfaces disposed at an angle relative to each other, said corner bead comprised of a material, wherein the edge portion material and the corner bead material have bonding properties which allow respective edge portions of the panels to be attached to respective surfaces of the corner bead by bonding.

35. A method of installing a plurality of wallboard panels, comprising:

positioning a first drywall panel having an edge portion comprised of a material other than drywall to a second drywall panel having an edge portion comprised of a material other than drywall; and

attaching the edge portion of the first drywall panel to the edge portion of the second drywall panel by a method selected from the group consisting of cement bonding, adhesive bonding, solvent welding, heat welding, ultrasonic welding, and combinations thereof.

36. The method of Claim 35, wherein the step of attaching the edge portions of the drywall panels comprises placing a connector adjacent a respective edge portion of each drywall panel and adhering said connector to said respective edge portions.

37. The method of Claim 36, wherein placing a connector adjacent a respective edge portion comprises placing a connector having spaced protrusions extending therefrom adjacent an edge of the first drywall panel, inserting a plurality of the protrusions into the edge portion of the first panel, and inserting another plurality of the protrusions into the edge portion of the second drywall panel, and adhering the inserted plurality of protrusions to the drywall material.

38. The method of Claim 37, further comprising inserting a fastener into a face of the drywall panel, through one of a plurality of conduits embedded in the drywall, and into a support frame.

39. A method of repairing a drywall panel, comprising:

cutting an opening in a drywall panel having a plurality of conduits extending therethrough;

preparing a drywall insert sized to fit within the opening such that a plurality of conduits through the insert is parallel to the plurality of conduits in the panel; and

inserting at least one connector into at least some of the conduits so as to fasten the insert into the panel.

40. The method of Claim 39, further comprising orienting the inserts so that a second plurality of conduits of the insert orthogonal to the first plurality of the insert is parallel to a second plurality of conduits of the panel orthogonal to the plurality of conduits to the panel.

41. A frame for mounting gypsum drywall, comprising:

a perimeter edge portion configured to retain a panel of said gypsum drywall with plural edges of the panel adjacent respective plural edges of said perimeter edge portion; and

a backing portion attached to said edge portion and disposed within a space defined by the perimeter of the edge portion.

42. The frame of Claim 41, wherein said edge portion comprises a plurality of elongated sections defining a substantially rectangular area.

43. The frame of Claim 42, wherein at least one elongated section is made of a plastic material.

44. The frame of Claim 42, wherein at least two of the elongated sections are disposed orthogonally to each other thereby forming a corner.

45. The frame of Claim 42, wherein plural openings are formed in at least one elongated section.

46. The frame of Claim 41, wherein said edge portion is approximately 4 feet wide and 8 feet long.

47. The frame of Claim 41, wherein the backing portion extends cross the space defined by the perimeter of the edge portion.

48. The frame of Claim 41, wherein the backing portion comprises a plurality of conduits.

49. A method of applying a frame to a gypsum drywall panel, comprising:
providing a substantially rigid frame having a backing material disposed within a space defined by said frame; and

attaching said gypsum drywall panel to said frame.

50. The method of Claim 49, wherein providing said frame comprises joining a plurality of elongated legs together in a manner such that at least two of the legs are disposed orthogonally to each other.

51. The method of Claim 50, wherein attaching said gypsum drywall panel to said frame comprises attaching a face of said gypsum drywall panel to said elongated legs.

52. The method of Claim 49, wherein forming said frame comprises attaching a backing material to at least one edge of the frame.

53. The method of Claim 52, wherein said backing material comprises a conduit.

54. The method of Claim 52, wherein attaching said gypsum drywall panel comprises attaching a face of the panel to said backing material.

55. A wallboard system, substantially as hereinbefore described with reference to the accompanying drawings.

56. A drywall panel of claim 13, substantially as hereinbefore described with reference to the accompanying drawings.

57. A plurality of panels of claim 18, substantially as hereinbefore described with reference to the accompanying drawings.

58. A wall board panel of claim 23, substantially as hereinbefore described with reference to the accompanying drawings.

59. A corner bead, substantially as hereinbefore described with reference to the accompanying drawings.

60. A method of installing a plurality of wall board panels, substantially as hereinbefore described with reference to the accompanying drawings.

61. A method of repairing a drywall panel, substantially as hereinbefore described with reference to the accompanying drawings.

62. A frame for mounting gypsum drywall, substantially as hereinbefore described with reference to the accompanying drawings.

63. A method of applying a frame to a gypsum drywall panel, substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 4th day of October 2005

Harvey MISBIN
by his Patent Attorney

Ian S Rose
Middletons Lawyers

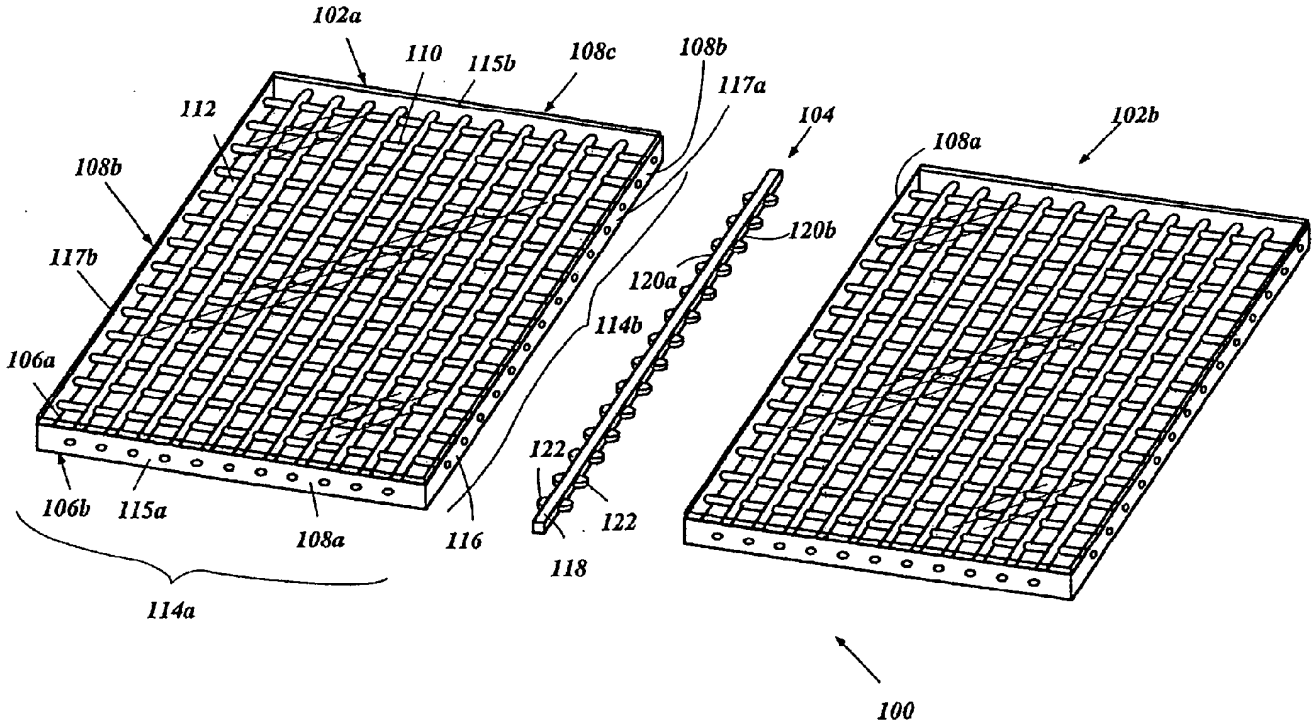


FIG. 1A

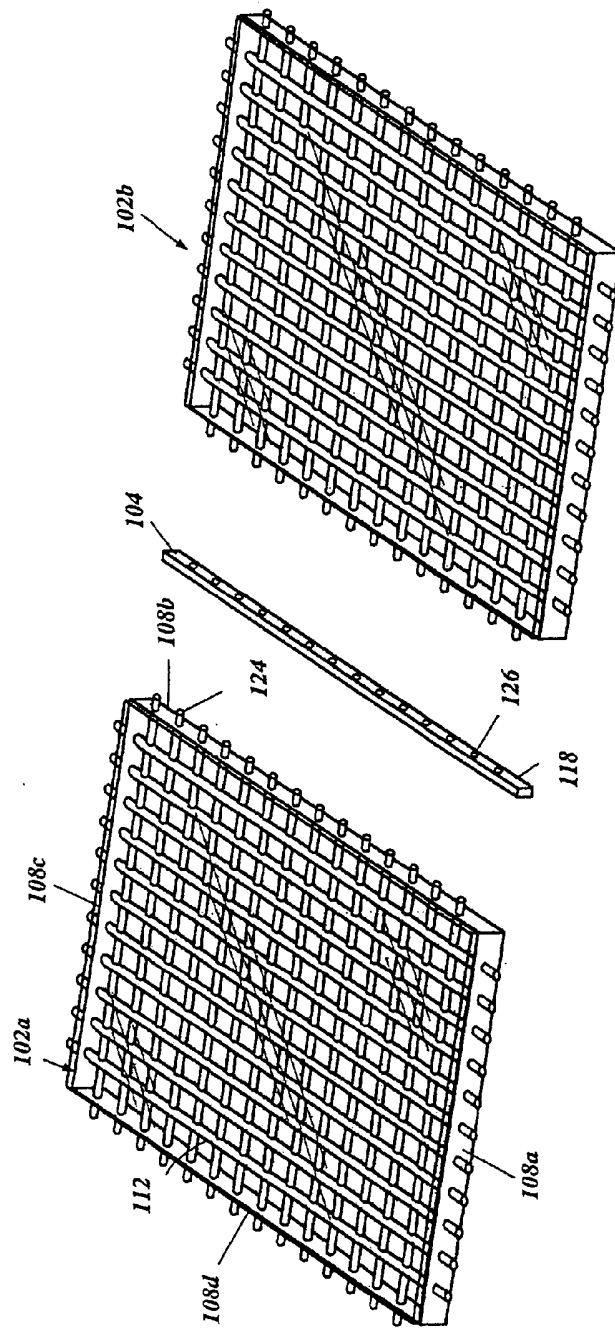


FIG. 1B

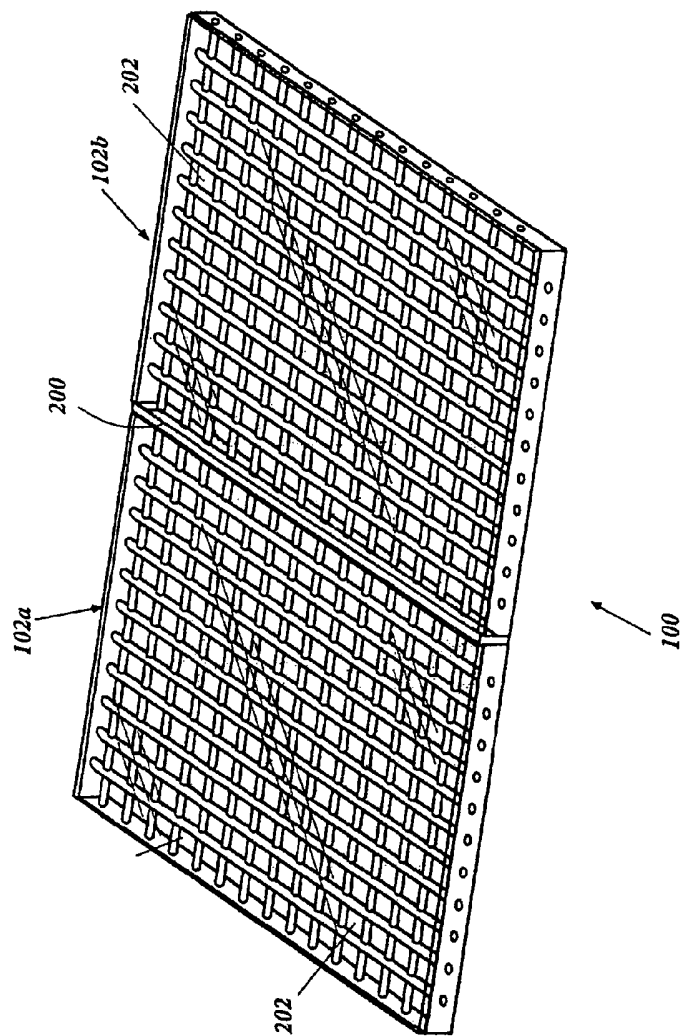


FIG. 2

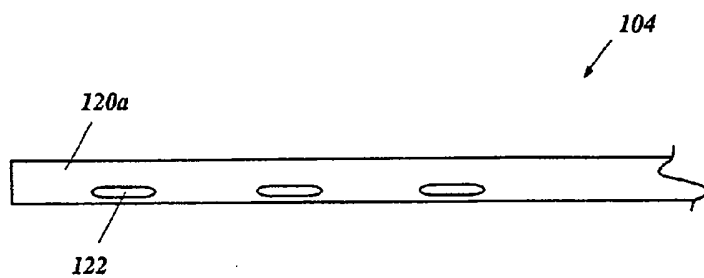


FIG. 3A

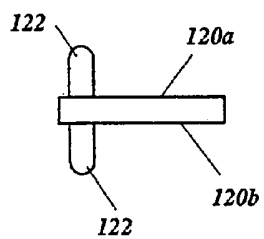


FIG. 3B

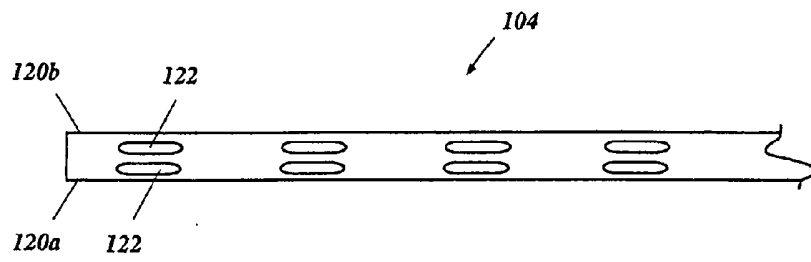


FIG. 4A

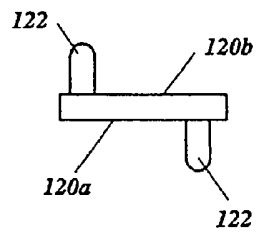


FIG. 4B

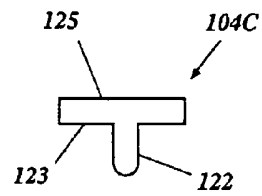


FIG. 4C

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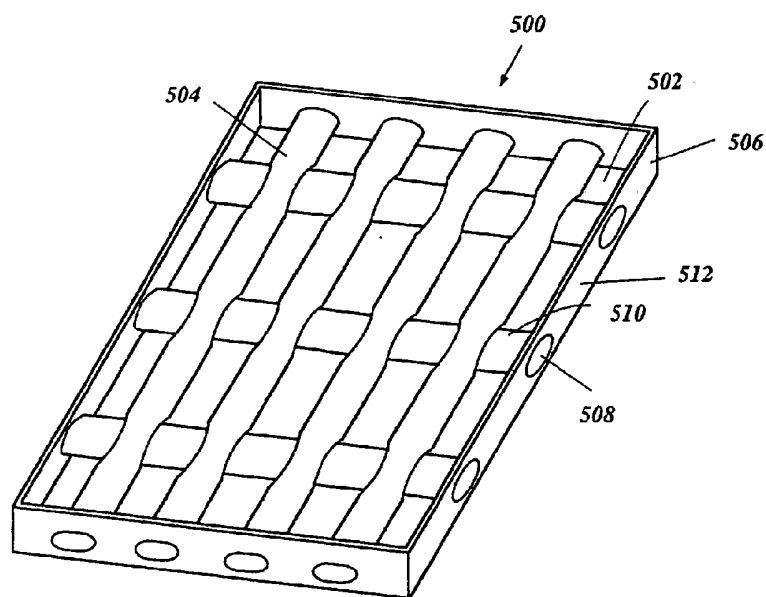


FIG. 5A

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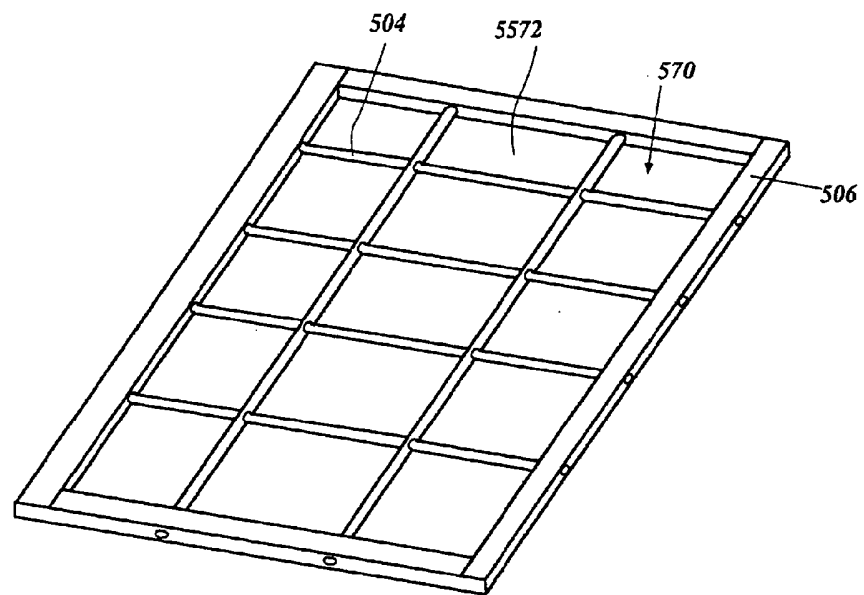


FIG. 5B

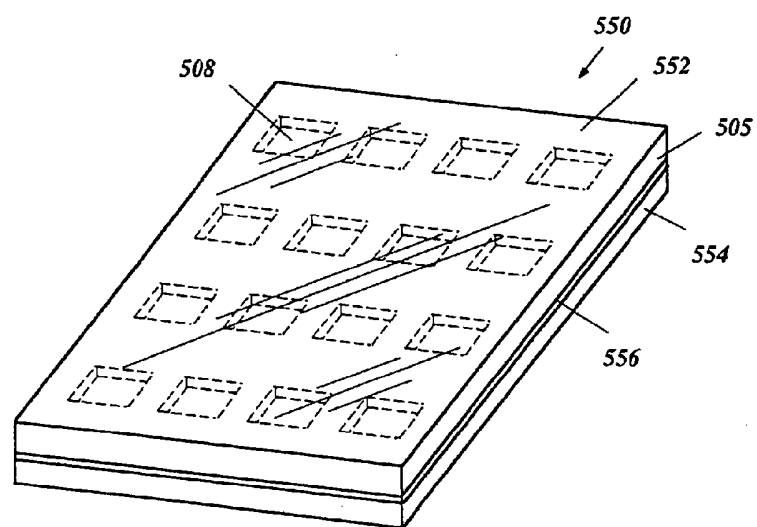


FIG. 5C

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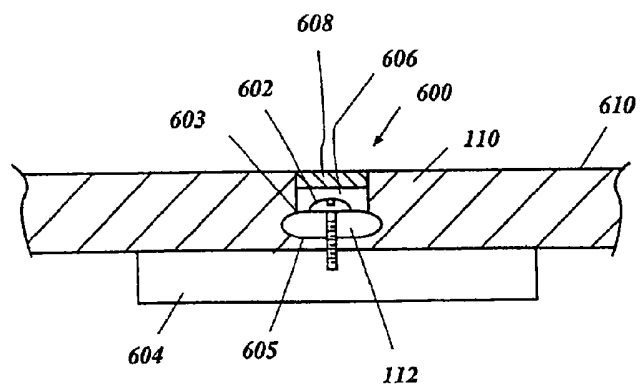
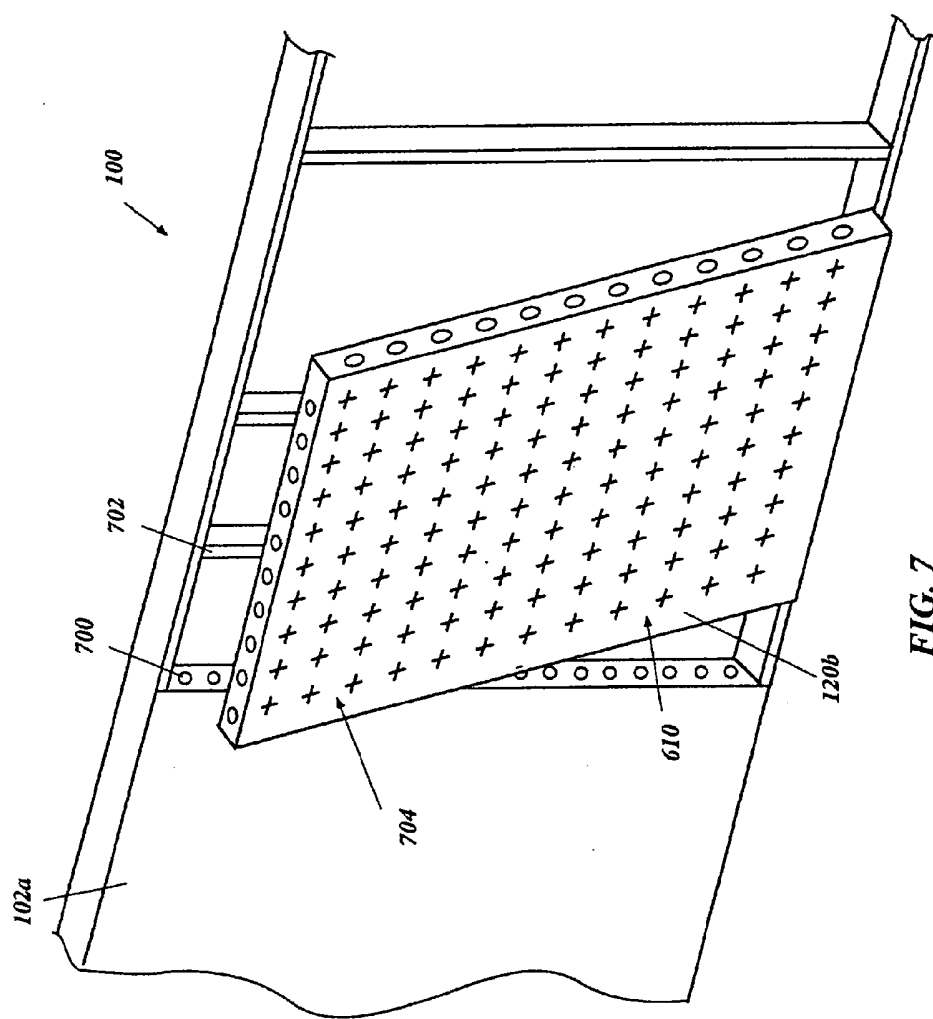


FIG. 6

10/18



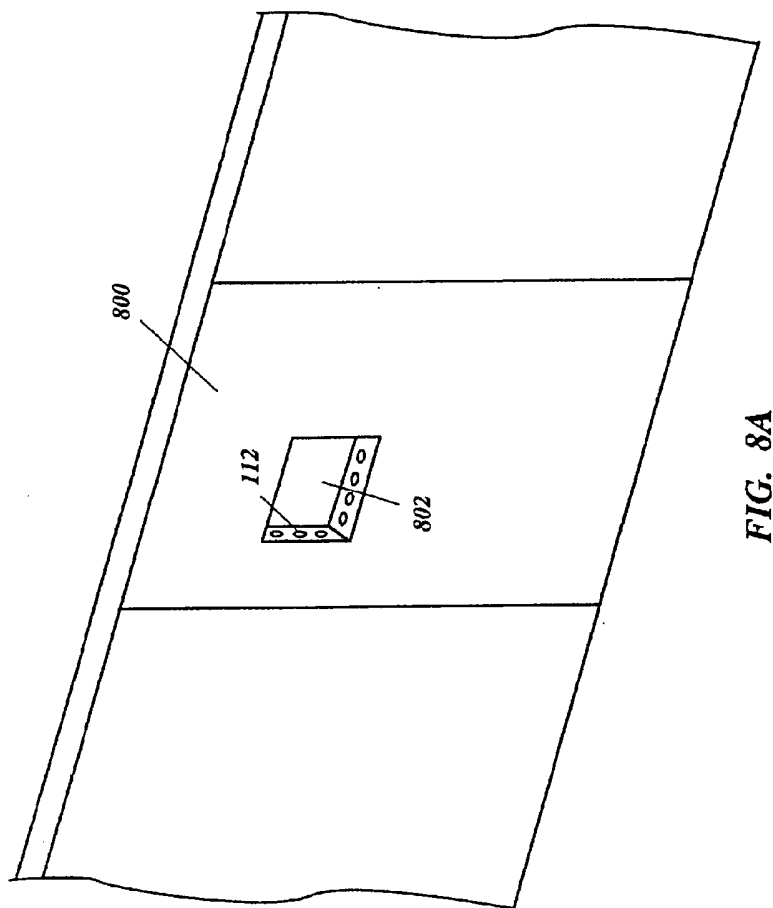


FIG. 8A

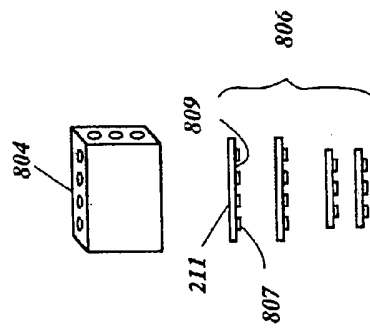


FIG. 8B

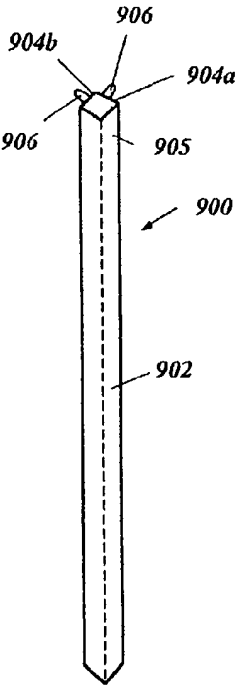


FIG. 9A

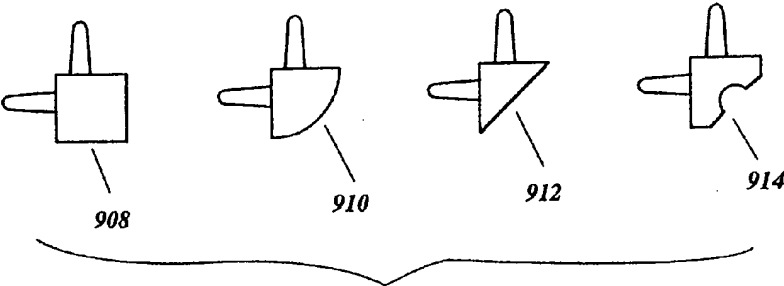


FIG. 9B

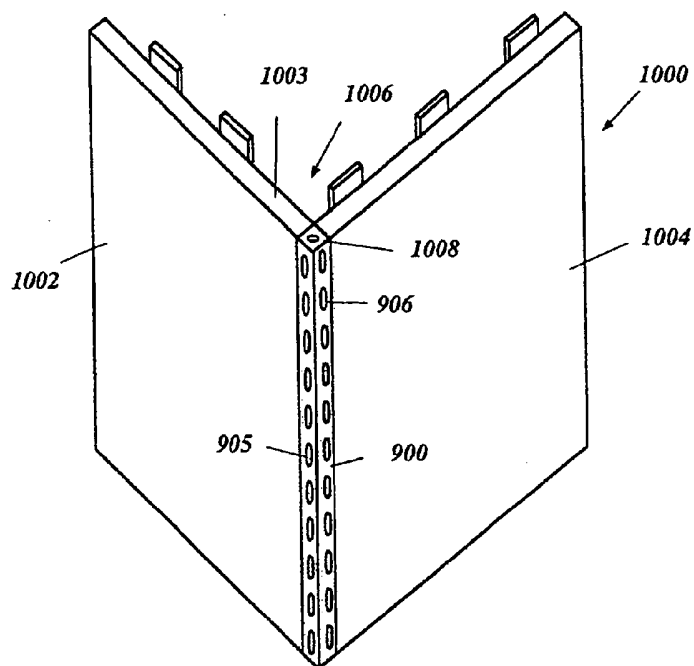


FIG. 10

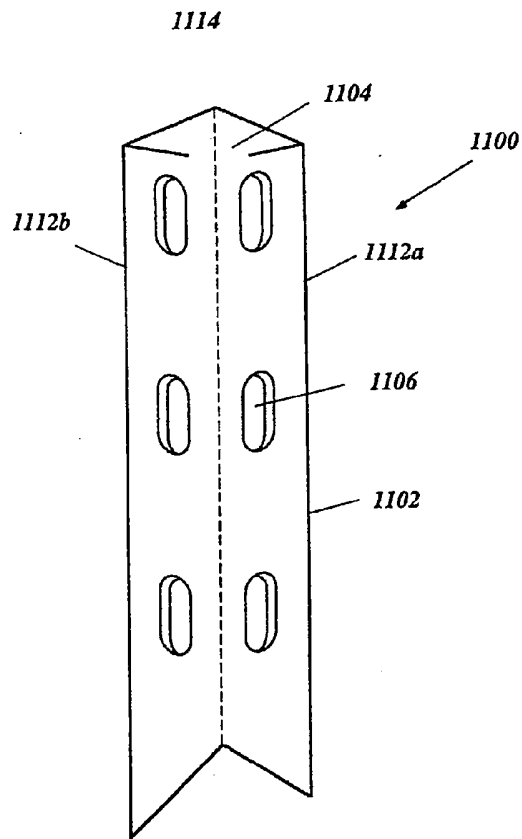
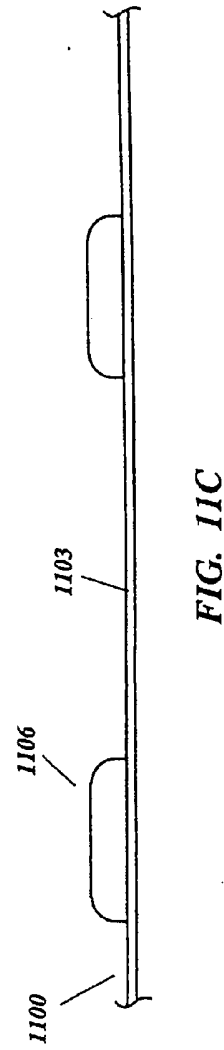
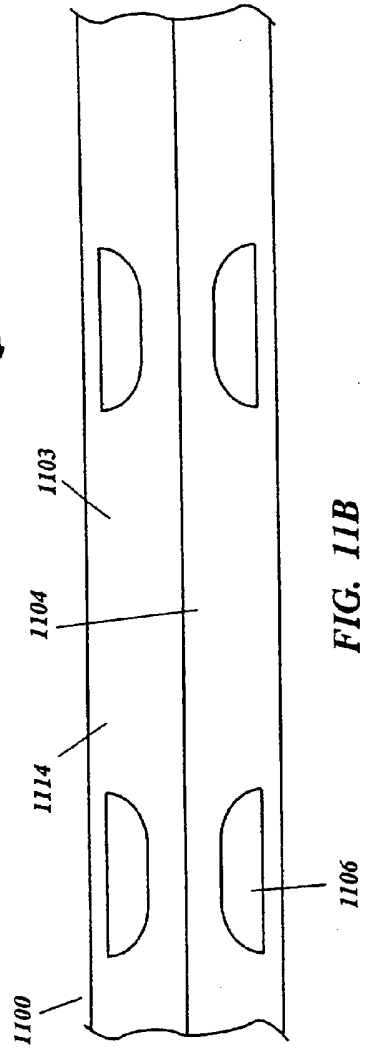
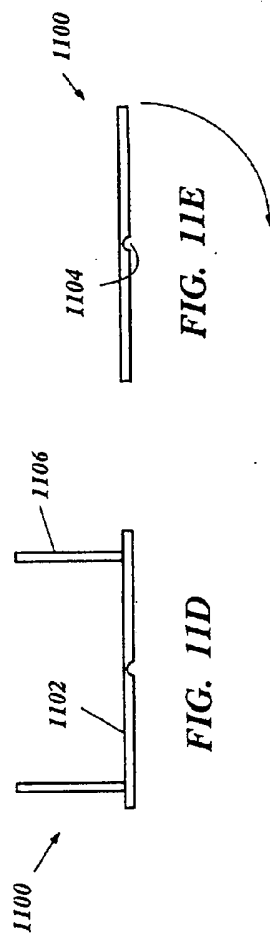


FIG. 11A



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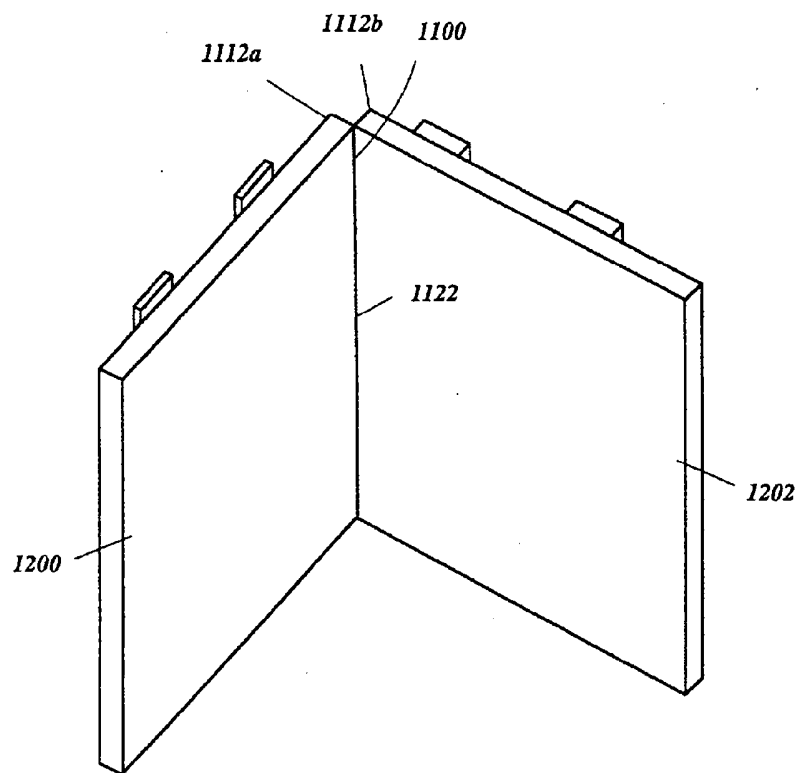


FIG. 12

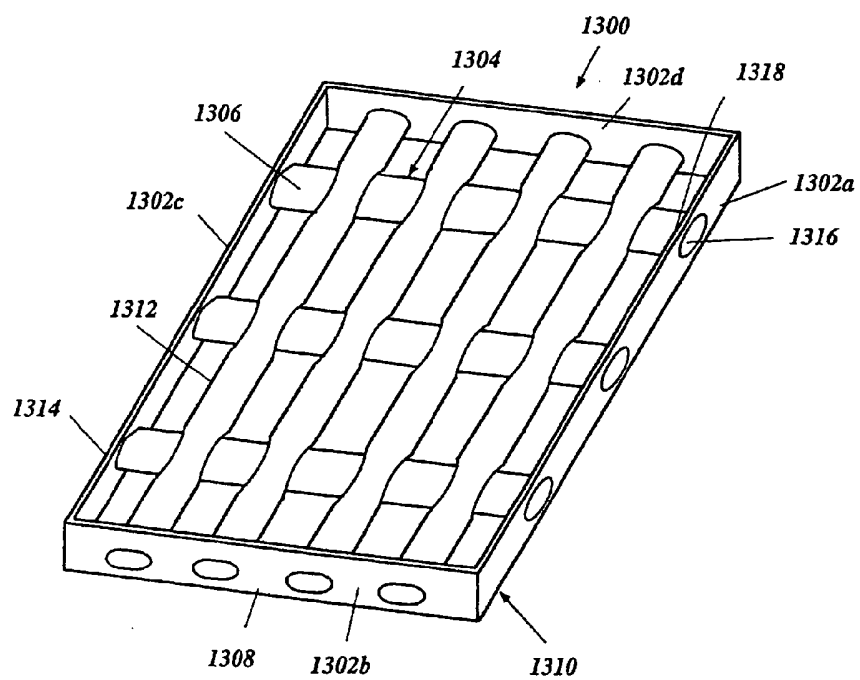


FIG. 13A

