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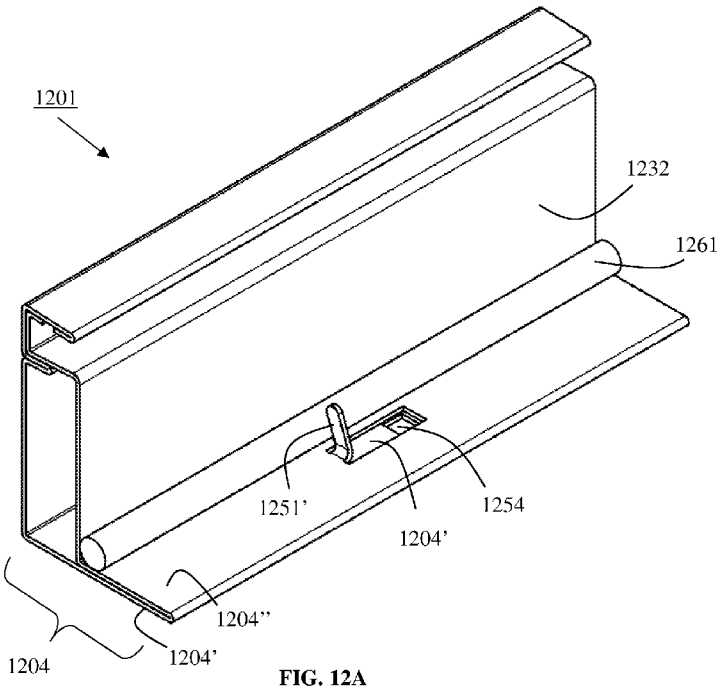

FIG. 12A

(57) Abstract: A frame for at least partially enclosing or supporting a panel is disclosed. The frame may include at least a first frame section characterized by a first end and a second end defining a lengthwise dimension corresponding to an edge of the panel. The first frame section may include a frame sidewall provided at an outer portion of the frame section, the frame sidewall characterized by a height extending from a base portion of the frame section. The first frame section may include a frame support wall provided at an inner portion of the frame section,, the frame support wall characterized by a height extending from a base portion of the frame section. The first frame section may further include a panel containment structure provided at an upper portion of the frame sidewall, the panel containment structure including a lower shelf. The first frame section may further include one or more wire management features. The frame sidewall, support wall, lower shelf, and wire management features may be formed at least in part from a single

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piece of framework material.

FRAMES FOR SOLAR PANELS

CROSS-REFERENCE TO RELATED APPLICATION

This application is a PCT International Application claims claiming priority to and the benefit of United States Provisional Patent Application No. 63/289,936 filed on December 15, 2021, entitled "FRAME FOR SOLAR PANELS" the contents of which are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

The present disclosure relates to various embodiments for frame structures for panels such as solar panels.

BACKGROUND

Photovoltaic solar panels for residential and commercial use are relatively large and heavy. For example, a typical rectangular solar panel may weigh about 20 – 30 kg, have a width of about 1 meter, a length of about 1.6 to 2.5 meters, and a thickness of about 3 to 5 cm. A photovoltaic solar panel may typically be a multilayer laminated structure (sometimes referred to as a PV laminate) and may include photovoltaic cells encapsulated between a top glass and a protective back-sheet. A solar panel can further include appropriate wiring and junctions so that solar-generated electricity (typically DC) may be transmitted to a desired load, grid, or energy storage unit. While having some physical toughness, significant additional strength to the panel may be provided by including it in a frame. A frame may allow for easy attaching of a photovoltaic solar panel to a rack. A framed PV laminate is sometimes referred to as a PV module.

One of the practical difficulties with solar panels has been handling the substantial amount of wiring associated with the panels. Very little attention has been paid to this important issue. It is common for manufacturers and installers to simply use inexpensive plastic zip ties to bundle wiring and cables. However, solar panels are designed to last at least 20 years or longer, whereas plastic zip ties have a much shorter life span, especially under potentially extreme environmental conditions. If wires and cables become loose, wind and other forces can cause wear that may result in panel failure. For example, excessive flexing of the cables can

lead to breaks of internal wires through metal fatigue. Additionally, the cable coating may wear out due to chafing or rubbing against rough or sharp surfaces to thereby allow water or other environmental elements into the cable and degrade performance. A preventive maintenance measure may be to periodically replace zip ties, but many such wire bundles are often difficult to access, and such maintenance is an extra financial burden and environmental waste.

As many countries and industries are installing very large solar farms and even gigawatt power plants, the issue of wire management becomes increasingly important. For example, a gigawatt power plant may use over 2 million solar panels and each panel may use multiple zip ties. Not only is the zip tie longevity issue a problem as mentioned above, powerplant installation itself is burdened with the costs, inventory, environmental impact, and general hassle of using perhaps tens to hundreds of millions of zip ties.

Thus, in order to further expand the adoption of renewable solar energy, there is a continuing desire to simplify manufacturing and installation, reduce costs, and increase the lifetime of solar panels.

SUMMARY

The present application includes a variety of aspects, which may be selected in different combinations based upon the particular application or needs to be addressed. In various embodiments, the present application may include frame for at least partially enclosing or supporting a panel is disclosed. The frame may include at least a first frame section characterized by a first end and a second end defining a lengthwise dimension corresponding to an edge of the panel. The first frame section may include a frame sidewall provided at an outer portion of the frame section, the frame sidewall characterized by a height extending from a base portion of the frame section. The first frame section may further include a frame support wall provided at an inner portion of the frame section, the frame support wall characterized by a height extending from a base portion of the frame section. The first frame section may further include a panel containment structure provided at an upper portion of the frame sidewall, the panel containment structure including a lower shelf. The first frame section may further include one or more wire management features. The frame sidewall, lower shelf, and wire management features may be formed at least in part from a single piece of framework material.

Embodiments of wire management features may provide one or more of the following advantages: reduced material cost, reduced labor cost, faster installation of PV modules, higher

installation yield, longer PV module cycle life, lower environmental waste, or some other advantage.

Naturally, further objects, goals and embodiments of the present application are disclosed throughout other areas of the specification, claims, and drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1A is a plan view of a non-limiting example of a framed panel structure according to some embodiments.

FIG. 1B is a cross-sectional view of a non-limiting example of a framed panel structure along cutline B—B of FIG. 1A according to some embodiments.

FIG. 1C is the cross-sectional view from FIG. 1B showing a non-limiting example of just the frame according to some embodiments.

FIG. 2A is a plan view of a non-limiting example of a frame precursor structure and a panel prior to assembling a framed panel structure according to some embodiments.

FIG. 2B is a cross-sectional view of a non-limiting example of a frame precursor structure and a panel along cutline B—B of FIG. 2A according to some embodiments.

FIG. 2C is the cross-sectional view from FIG. 2B showing a non-limiting example of just the frame precursor structure according to some embodiments.

FIG. 2D is a side view with slight elevation of a non-limiting example of a frame precursor structure according to some embodiments.

FIG. 2E is a plan view of a non-limiting example of a frame precursor structure and a panel at an intermediate stage of assembly according to some embodiments.

FIG. 3 is a plan view showing a non-limiting example of assembling a frame using four frame precursor structures according to some embodiments.

FIG. 4A is a perspective view of a non-limiting example of a frame that includes a cross bar according to some embodiments.

FIG. 4B is a zoomed in view of area B from FIG. 4A according to some embodiments.

FIG. 5 is a schematic diagram of a non-limiting example of a manufacturing process line for making frame precursor structures according to some embodiments.

FIG. 6A is a perspective view of a cutaway portion of a non-limiting example of a frame section including a support wall according to some embodiments.

FIG. 6B is a cross-sectional view of the frame section from FIG. 6A according to some embodiments.

FIG. 6C is a plan view of a non-limiting example of a portion of framework material according to some embodiments.

FIG. 6D is a cross-sectional view of a non-limiting example of a framed panel structure according to some embodiments.

FIG. 6E is like FIG. 6B but with the approximate enclosed shape of the box frame marked according to some embodiments.

FIG. 6F is like FIG. 6B but with the approximate panel containment shape marked according to some embodiments.

FIGS. 7A – 7AA are cross-sectional views of some non-limiting examples of frame sections according to some embodiments.

FIG. 8A is a perspective view of a non-limiting example of a portion of a frame section having a WM feature according to some embodiments.

FIG. 8B is a perspective view of a non-limiting example of a portion of a frame section where the wire management (WM) feature engages wiring according to some embodiments.

FIG. 8C is a cross sectional view of FIG. 8B.

FIG. 9 is a cross-sectional view of a non-limiting example of a framed panel structure according to some embodiments.

FIG. 10A is a perspective view of a non-limiting example of a portion of a frame section having a WM feature according to some embodiments.

FIG. 10B is a perspective view of a non-limiting example of a portion of a frame section where the WM feature engages wiring according to some embodiments.

FIG. 10C is a cross sectional view of FIG. 10B.

FIG. 10D shows a non-limiting example of a portion of a frame section having a WM feature that comprises a pry-point to aid when using a tool to bend it into position.

FIG. 10E shows a non-limiting example of a portion of a frame section having a WM feature that comprises additional bends so that it wraps or partially wraps around the wiring.

FIGS. 11A and 11B are perspective views of a non-limiting example of a portion of a frame section having a WM feature according to some embodiments.

FIG. 11C is a perspective view of a non-limiting example of a portion of a frame section where the WM feature engages wiring according to some embodiments.

FIG. 11D is a cross sectional view of FIG. 11C.

FIG. 12A is a perspective view of a frame section where a WM feature engages wiring according to some embodiments.

FIG. 12B is a cross-sectional view of FIG. 12B.

FIG. 13A is a perspective view of a non-limiting example of multiple WM features according to some embodiments.

FIG. 13B is similar to FIG. 13A but showing the multiple WM features in a different orientation.

FIG. 14A is a perspective view of a non-limiting example of WM features having interlocking elements according to some embodiments.

FIG. 14B illustrates the WM features with interlocking elements engaged to form an interlocked WM feature which in some cases may wrap around wiring (not shown).

FIG. 15A is a perspective view of a non-limiting example of WM features having interlocking elements according to some embodiments.

FIG. 15B illustrates the WM features with interlocking elements engaged to form an interlocked WM feature.

FIG. 16A is a perspective view of a non-limiting example of a frame feature and a WM feature having interlocking elements according to some embodiments.

FIG. 16B and 16C illustrate the WM feature with engaged with the slot to form an interlocked WM feature.

FIG. 17 is a perspective view of a non-limiting example of a portion of a frame section and a WM feature according to some embodiments.

FIG. 18A is a perspective view of a portion of a frame section having a WM feature according to some embodiments.

FIG. 18B is a perspective view showing the WM feature engaging wiring after bending in place.

FIG. 19 is a side view of wiring in contact with a curved WM feature.

FIG. 20 is a side view of a portion of a WM feature having a rounded edge.

DETAILED DESCRIPTION

It should be understood that embodiments include a variety of aspects, which may be combined in different ways. The following descriptions are provided to list elements and describe some of the embodiments of the present application. These elements are listed with initial embodiments; however, it should be understood that they may be combined in any manner and in any number to create additional embodiments. The variously described examples and embodiments should not be construed to limit embodiments of the present application to only the explicitly described systems, techniques, and applications. The specific embodiment or embodiments shown are examples only. The specification should be understood and is intended as supporting broad claims as well as each embodiment, and even claims where other embodiments may be excluded. Importantly, disclosure of merely exemplary embodiments is not meant to limit the breadth of other more encompassing claims that may be made where such may be only one of several methods or embodiments which could be employed in a broader claim or the like. Further, this description should be understood to support and encompass descriptions and claims of all the various embodiments, systems, techniques, methods, devices, and applications with any number of the disclosed elements, with each element alone, and also with any and all various permutations and combinations of all elements in this or any subsequent application.

It is to be understood that the drawings are for purposes of illustrating the concepts of the disclosure and may not be to scale. Additional details of certain embodiments of the present application may be found in co-pending PCT application PCT/US2020/037092 filed on June 10, 2020, co-pending US provisional application 63/176,803 filed on April 19, 2021, co-pending US provisional application 63/176,824 filed April 19, 2021, co-pending US provisional application 63/189,591 filed May 17, 2021, co-pending US provisional application 63/213,541 filed June 22, 2021, co-pending US provisional application 63/224,271 filed July 21, 2021, co-pending US provisional 63/272,086 filed Oct. 26, 2021, and co-pending US provisional application 63/288,556, the entire contents of each application are incorporated herein by reference for all purposes.

FIG. 1A is a plan view of a non-limiting example of a framed panel structure **100** (e.g., a framed solar panel structure or PV module) including panel **190** (e.g., a solar panel) encased in a frame **101** according to some embodiments. FIG. 1B is a cross-sectional view of the framed

panel structure **100** along cutline B—B. For added perspective, XYZ coordinate axes are also shown. FIG. 1C is the cross-sectional view as in FIG. 1B but excluding the panel to further illustrate some of the features of the frame **101**.

In some embodiments and as discussed in more detail herein, frame **101** may be formed from substantially a single frame precursor structure that is bent in predetermined regions to accommodate three corners of the solar panel, perhaps with the fourth corner forming a joint between two ends of the frame precursor structure. That is, frame **101** may include a first corner bend **112** corresponding to a first corner of panel **190**, a second corner bend **114** corresponding to a second corner of panel **190**, a third corner bend **116** corresponding to a third corner of panel **190**, and a corner joint **118** corresponding to a fourth corner of panel **190**.

Referring to FIGS. 1B and 1C, frame **101** may include a framework material that has been cut and folded into a desired shape. Frame **101** may be characterized by a height **H** and may include a lengthwise fold **102** defining an intersection of a frame sidewall **103** with a bottom flange **104**. The frame may further include a series of folds to form a panel containment structure including a lower shelf **105**, a pocket wall **106**, a top lip **107**, and perhaps even a pocket region **108**. In some embodiments, the bottom flange may generally represent, or be provided at, the base of the frame or framed panel structure. The panel **190** may be received into a portion of the pocket region and secured in place, optionally with a sealant that may have adhesive properties (not shown). Some non-limiting examples of sealants may include curable liquid silicone, urethane, epoxy, resin, any other liquid seal, or the like. Alternatively, or in combination, a pressure sensitive adhesive tape may optionally be used to secure the panel in the pocket region. In some embodiments, a panel containment structure may include only a lower shelf, or alternatively, only a lower shelf and a pocket wall. In such embodiments, the panel may optionally be secured in place using a sealant or pressure sensitive adhesive as described above. In some embodiments, only some of the frame sections may include a panel containment structure, for example, only frame sections on one set of opposing sides of a rectangular or square panel.

Although FIGS. 1B and 1C show non-limiting examples where the bottom flange, the lower shelf, and the top lip all extend away from the frame sidewall to an equal extent, any of these features may be shorter or longer than the others. The angle between the frame sidewall and bottom flange is shown to be approximately 90°, e.g., in a range of about 85° to about 95°,

but in some other embodiments, the angle may be outside of that range, e.g., in a range of about 45° to about 135° depending on other features of the structure and overall system design. In some embodiments, the lower shelf and bottom flange may remain approximately parallel, e.g., within about 40°, alternatively within about 30°, 20°, 15°, 10°, or 5°, regardless of the angle between the frame sidewall and the bottom flange. The top lip is shown to be parallel with the lower shelf, but in some embodiments, it may be at a slight angle or curved at the end so that the opening of the pocket region is larger or smaller than the pocket wall. In the embodiment illustrated in FIGS. 1B and 1C, the lower shelf **105** is shown as being formed from, or including multiple layers of, framework material. In some embodiments, any or all of the other frame features (e.g., the frame sidewall, bottom flange, pocket wall, top lip, support wall, or the like) may be formed from or include multiple layers of framework material. In some cases, multiple layers may provide increased strength to the frame.

FIGS. 1A, 1B, and 1C illustrate a conventional rectangular panel shape that may be common for solar panels. However, there is no particular limitation on the shape of the panel which may be any polygon having 3, 4, 5, 6 7, 8 or more sides. The sides of the polygon may have the same length, or alternatively some sides may be longer or shorter. The corner angles of the polygon may all be the same, or alternatively, some corner angles may have smaller or larger angles than others. Although frames and frame sections herein are generally shown as having a bottom flange, in some embodiments, one or more frame sections may not include a bottom flange. In some embodiments where the frame has a rectangular shape, the frame sections corresponding to the shorter sides of the frame may not include a bottom flange whereas the frame sections corresponding to the longer sides of the frame may include a bottom flange.

Making the frame or a frame section substantially from a single piece of framework material may have considerable manufacturing, assembly, and cost advantages. However, the panel containment structure in some embodiments may be formed using alternative methods and materials. For example, the shelf may be a piece of shelf material bonded (e.g., welded, brazed, soldered, glued, or the like) to an upper portion of the frame sidewall. Similarly, the top lip may include a piece of top lip material bonded to the top of the frame structure. Alternatively, the entire panel containment structure may be a separate structure designed to sit on, slip over, or otherwise mate with the frame sidewall. As discussed elsewhere herein, rather than one

elongated piece of framework material, a 4-sided frame may be formed from 2, 3, or even 4 frame separate frame sections (or more if the frame has more than 4 sides). Although not illustrated in FIGS. 1A – 1C, the frame or framed panel structure may further include a support wall extending from the bottom flange to the panel containment structure or to the frame sidewall, as described in more detail below. It should be noted that, throughout this disclosure, the terms "upper portion" and "top lip" may in some cases refer to general positions relative to the bottom flange or the base of the frame, and does not necessarily indicate a position or orientation in the final framed panel structure, which may be oriented in a manner other than horizontal as shown in FIG. 1B (e.g., at an angle, on its side, or even parietally or fully inverted).

FIG. 2A is a plan view schematic to generally illustrate construction of a framed panel structure according to some embodiments. FIG. 2B is a cross-sectional view of FIG. 2A along cutline B—B. A frame precursor structure **201** may be formed from framework material characterized by an average thickness. Frame precursor structure **201** may include a first end **210** and a second end **220** defining a lengthwise dimension. The frame precursor structure **201** may include a first frame section **201-1** designed to fit with or attach to first panel edge **190-1** of panel **190**, a second frame section **201-2** designed to fit with or attach to second panel edge **190-2**, a third frame section **201-3** designed to fit with or attach to third panel edge **190-3**, and even a fourth frame section **201-4** designed to fit with or attach to fourth panel edge **190-4**. Frame precursor structure **201** may include a first corner bend precursor axis **212** between the first and second frame sections and may be designed to bend along the Z axis (the height axis) of the frame sidewall. In a finished framed panel structure, first corner bend precursor axis **212** can correspond to first corner bend **112** (FIG. 1A). Similarly, frame precursor structure **201** may include second and third corner bend precursor axes **214** and **216**, respectively.

Referring to FIG. 2B, the cross-sectional structure correlates to that of FIG. 1B for the finished frame. FIG. 2C is the cross-sectional view as in FIG. 2B but excluding the panel to further illustrate some non-limiting examples of the features of the frame precursor structure, in particular, frame section **201-2**. Here, second frame section **201-2** may be characterized by height **H** and may include a lengthwise fold **202-2** perhaps defining an intersection of a frame sidewall **203-2** with a bottom flange **204-2**. The second frame section may include a series of folds to form a panel containment structure including a lower shelf **205-2**, a pocket wall **206-2**, a top lip **207-2** and perhaps even a pocket region **208-2**. In some embodiments, the bottom

flange may generally represent, or be provided at, the base of the frame section. The panel **190** may be received into a portion of the pocket region and secured in place, optionally with some sealant (not shown). In some embodiments, each frame section of the frame precursor structure may have substantially the same cross-sectional structure as shown for the second frame section **201-2** in FIG. 2B. But in some other embodiments, there may be differences between cross-sectional structures of two or more of frame sections. In the embodiment illustrated in FIGS. 2B and 2C, the lower shelf **205-2** is shown as being formed from, or including multiple layers of, framework material. In some embodiments, any or all of the other frame section features (e.g., the sidewall, bottom flange, pocket wall, upper lip, or the like) may be formed from or include multiple layers of framework material. In some cases, multiple layers may provide increased strength to the frame.

In order to accommodate bending of the frame precursor structure to enclose the panel, the frame precursor structure may include a series of notches (**212N**, **214N**, **216N**) in the top lip, the lower shelf, and even the bottom flange, such notches corresponding to first, second, and third corner bend precursor axes, **212**, **214**, and **216**, respectively. In FIG. 2A, the notches are only visible in the top lip (between top lip **207-1** and top lip **207-2**, between top lip **207-2** and top lip **207-3**, and between top lip **207-3** and top lip **207-4**), but similar notches may also be present in the lower shelf and bottom flange. In some embodiments, the angle of the notch may be about 180° minus the angle of the panel corner being enclosed. Similarly, the ends of the frame precursor structure may also include an angled cut (**210N** and **220N**) in the top lip, the lower shelf, and the bottom flange to accommodate formation of a corner joint.

In FIG. 2D, there is shown a non-limiting example of a side view schematic (with slight elevation) of the frame precursor structure facing the side that can receive the panel. For clarity, not all of the features are labelled, but in combination with the other figures, the identity of each feature is self-evident.

Referring to FIG. 2E, there is a plan view showing a non-limiting example of an intermediate state of assembling the framed panel structure where the frame precursor structure has received the panel edge **190-2** into frame section **201-2** and bends are being formed along the bend precursor axes as other frame sections move closer to their intended final positions around the panel. Note that assembly does not have to start with panel edge **190-2** but may instead start with any panel edge or corner. Forming the corner joint **118** where the two ends

(**210** and **220**) of the frame precursor structure meet may be a final step in this portion of the framed panel structure assembly, but there may be additional steps to further secure or modify the frame (e.g., adding optional support brackets, tightening optional bolts, or the like). In some embodiments, assembling the framed panel structure may include use of an assembly apparatus that holds and manipulates the panel and frame precursor structure(s). With respect to orientation of the components during assembly relative to the assembly apparatus, the plan view of FIG. 2E may represent a view from above, or alternatively a view from below, or even a view from the side, depending on the nature of the assembly apparatus.

In some embodiments, the corner bends and/or corner joints may include features capable of forming interlocking structures. For example, a bottom flange or other portion on one side of the corner may include a locking element that may be received into an opening on the other side of the corner.

Although not illustrated in FIGS. 2A – 2E, one or more frame sections may further include a support wall extending from the bottom flange to the panel containment structure or to the frame sidewall, as described in more detail below.

In some embodiments, the frame precursor structure **201** may be substantially linear (as shown) prior to assembling the framed panel structure. In some embodiments, the frame precursor structure may be received by an assembler already partially bent at one or more corner bend precursor axes. One or more corner bend precursor axes may be pre-scored or include a furrow or features that promote bending along the height access between the frame sections.

The frame and frame precursor structures described in FIGS. 1A-C and 2A-E are non-limiting examples. In some embodiments, rather than using one frame precursor structure, multiple frame precursor structures may be used to enclose a panel. For example, with a rectangular panel, two similar frame precursor structures, each having one corner bend precursor axis may be used to form a framed panel structure that may include two corner joints at opposite corners and two corner bends at opposite corners. Alternatively, a first frame precursor structure may have two corner bend precursor axes and a second frame precursor structure may have no corner bend precursor axes and be used to form a framed panel structure that may include two corner joints at adjacent corners and two corner bends also at adjacent corners. Alternatively, three frame precursor structures may be used where one may have one corner bend precursor axis and the other two may not, whereby a framed panel structure may

include one corner bend and three corner joints. Alternatively, four frame precursor structures may be used wherein none have a corner bend precursor axis and the framed panel structure may include four corner joints.

FIG. 3 is a plan view showing a non-limiting example of assembling a frame using four frame precursor structures according to some embodiments. Each frame precursor structure (each of which may also be referred to herein as a frame section) **301-1**, **301-2**, **301-3**, **301-4** may optionally include any of the features described above, such as a bottom flange, a side wall, and even a panel containment structure that may include a lower shelf, a pocket wall and a top lip. In some cases, one or more frame sections may further include a support wall extending from the bottom flange to the panel containment structure or to the frame sidewall. In this view, only the top lip **307-1**, **307-2**, **307-3**, **307-4** of each frame precursor structure is visible. Each frame precursor structure may have a first end **310-1**, **310-2**, **310-3**, **310-4** and a second end **320-1**, **320-2**, **320-3**, **320-4**. When assembled, a first end of one frame precursor structure may form a corner joint with a second end of an adjacent frame precursor structure. As discussed with respect to FIG. 2E, the plan view of FIG. 2E may represent a view from above, or alternatively a view from below, or even a view from the side, depending on the nature of the assembly apparatus.

As indicated by the arrows, a first frame precursor structure may be designed to fit with or attach to a first panel edge **190-1** of panel **190**, a second frame precursor structure **301-2** may be designed to fit with or attach to a second panel edge **190-2**, a third frame precursor structure **301-3** may be designed to fit with third panel edge **190-3**, and even a fourth frame precursor structure **301-4** may be designed to fit with fourth panel edge **190-4**. There are numerous variations regarding the sequence used to assemble the frame. In some embodiments, all four frame precursor structures are concurrently brought together with their respective panel edges and attached at approximately the same time. In some cases, attachment is sequential and may be in any order. In some embodiments, just two or three frame precursor structures are concurrently brought together with their respective panel edges and the remaining frame precursor structures are attached later or already pre-attached. In some embodiments, two or three of the frame precursor structures may be first attached to each other via a corner joint and then attached to the panel. In some cases, a frame precursor structure may initially be brought together with its respective panel edge at an angle rather than flush or parallel. In some cases,

the choice of assembly sequence may in part be dependent upon the design of the corner joint to be used. In some embodiments, corners joint connection may, for example, be made using clinching, rivets, screws, nuts/bolts, welding, adhesives, or the like. In some cases, corner joint connections may be made using a tab connection assembly or any of the other connection structures and methods discussed in US Provisional Patent Application 63/272,086 filed Oct. 26, 2021.

In some embodiments, a finished frame (whether made from a continuous piece or from multiple frame section pieces) may further include one or more cross bars that may extend from one frame section to an opposite or adjacent frame section. In some embodiments with respect to a rectangular frame, a cross bar may extend between the two longest opposing frame sections. In some cases, a cross bar may connect two opposing frame sections at about their middle areas. Cross bars may act to strengthen the frame. A cross bar may be connected to the frame at the bottom flange, a frame sidewall, or at some other frame feature including, but not limited to, support walls (discussed below). In some embodiments, a cross bar structure may include an upper surface upon which the panel may rest or optionally be adhered to. In some cases, cross bars may be readily attached as part of the panel mounting process (e.g., as discussed in FIGS. 2E and 3). That is, an additional separate step may not be needed in some cases. In some embodiments, the cross bars may be formed of the framework material used for the rest of the frame. In some embodiments, the cross bars may use a different material.

FIG. 4A is a perspective view of a non-limiting example of a frame that includes a cross bar according to some embodiments. For clarity, the framed panel is not shown. In some cases, frame **401** may include a first frame section **401-1**, second frame section **401-2**, third frame section **401-3**, and fourth frame section **401-4**. Cross bar **460** may be connected to opposing frame sections **401-1** and **401-3**. In some embodiments, connection may, for example, be made using clinching, crimping, rivets, screws, nuts/bolts, welding, adhesives, or the like. In some cases, connections may be made using a tab connection assembly or any of the other connection structures and methods discussed in US Provisional Patent Application 63/272,086 filed Oct. 26, 2021.

FIG. 4B is a zoomed in view of area B from FIG. 4A. In some cases, first frame section **401-1** may optionally have a box frame structure as described below. Frame section **401-1** may, for example, include a bottom flange **404-1**, a support wall **432-1** lower shelf **405-1**, top lip

407-1, and frame sidewall (not visible in this view). In some embodiments cross bar **460** may include a cross bar top surface **465** and cross bar sidewall **463**. Cross bar **460** may optionally have a box type of structure including another sidewall (not visible in this figure) opposite cross bar sidewall **463** and a bottom flange or bottom surface (not visible in this figure) opposite cross bar top surface **465**. In some cases, the cross bar top surface **465** may contact the panel and may optionally include an adhesive layer to help secure the panel. In some embodiments, the cross bar top surface **465** may be flush (at the same height) with lower shelf **405-1** of the first frame section. In some embodiments, cross bar **465** may be connected to the first frame section at the frame sidewall, bottom flange, support wall, or any combination.

The framework material should have sufficient strength to support the panel. In some embodiments, the framework material may include a metal such as uncoated steel, coated steel, stainless steel, aluminum, or another metal or metal alloy (coated or uncoated), or the like. In some embodiments, the framework material may be a coated metal such as coated steel or the like that includes an anti-corrosion coating or treatment. For example, coated steel may include metallic-coated steel, organic-coated steel, or tinplate. Some non-limiting examples of metallic coatings for steel may include zinc and zinc alloys (e.g., a Zn-Al alloy), aluminum, and magnesium. Depending on the coating, such metallic coatings may be applied by hot dip galvanization, electro-galvanizing, thermal spray, or the like. Some non-limiting examples of organic coatings may include polyesters or PVDF, which may be applied from a paint or other coatable mixture. Tinplate may be made by coating tin onto the cold-rolled steel, e.g., by electroplating. In some embodiments, the thickness of coated steel for use as a framework material may be in a range of about 0.5 to about 0.6 mm, alternatively about 0.6 to about 0.7 mm, alternatively about 0.7 to about 0.8 mm, alternatively about 0.8 to about 0.9 mm, alternatively about 0.9 to about 1.0 mm, alternatively about 1.0 to about 1.2 mm, alternatively about 1.2 to about 1.4 mm, alternatively about 1.4 to about 1.6 mm, alternatively about 1.6 to about 1.8 mm, alternatively about 1.8 to about 2.0 mm, or any combination or permutation of ranges thereof. When a coated steel framework material may be used to make a frame for a conventional photovoltaic solar panel, in some embodiments, the thickness may be in a range of about 0.7 to about 1.4 mm.

In some embodiments, steel may be a steel other than stainless steel. For some applications, e.g., for photovoltaic solar panels, steel may have a useful combination of

technical and commercial benefits. Steel can have properties that may be applied in the material selection, fabrication, and long-term durability that are useful to the form and function of the frame or frame precursor structure product. During preproduction, steel may be readily coated with anti-corrosion coatings employing multiple chemistries that offer corrosion resistance which can be beneficial to the durability of the frames. Steel may be painted with clear or specific colors that may optionally allow identification of a specific module selection of various categories. Because painting or anti-corrosion coatings may be applied in high-speed manufacturing formats, the cost and durability are more effective than most other metals. Steel may optionally be both painted and have anti-corrosion coatings, allowing for multiple benefits to the branding, module identification, and long-term maintenance over non-steel module frames.

Steel is a highly durable material that may be significantly deformed while retaining its toughness and resistance to structural failure. The properties of toughness while being deformed may be referred to as ductility. Due to the ductility of steel, it may be shaped starting from a thin sheet of material, e.g., wrapped around a coil, which may be fed directly into a punching station that may employ a variety of methods to cut or partially cut or create grooves in the face of the steel sheet. Following this process, the steel which has been modified in the punching station may be fed into a linear and non-linear set of rollers which can deform the steel sheet into a new profile, of which many variations are possible. Due to the ductility of steel, this process may be performed at high speed, with production speeds from less than about 0.1 meters/second to over about 4.0 meters/second. Steel's compatibility with this high-speed forming process may provide significant manufacturing cost advantages. Due to steel's ductility, it may be bent into simple or complex shapes that will retain their relative shape or position for the life of the product. In some embodiments, steel that has been shaped into simple or complex forms may also be designed to yield or partially yield at specific locations or along a predetermined path as part of intended installation or operational parameters.

Steel has electrical properties which may allow it to act as a code-approved path of intended electricity, such as to create an electrical ground or electrical bonding. Due to the properties of steel and the potential anti-corrosion or paint coatings available, the electrical ground or electrical bonding may still occur without the need for additional hardware or devices. When steel module frames are attached directly to a steel structure, most electrical

codes allow for this connection to be considered a competent electrical ground or electrical bond. This means that the framed panel structures may connect directly to a steel substructure, and may be considered to have achieved sufficient electrical ground or electrical bond sufficient to meet code, with or without addition of hardware, as part of the module-to-substructure attachment.

Steel's magnetic properties may allow for special features and benefits through the use of magnetic steel frames. The magnetic properties of steel may allow for simple attachments of appurtenances utilizing few or no added hardware. Steel's magnetic properties may allow for sensory devices to collect useful data during the manufacture of a frame precursor structure or data regarding a panel installation. Steel's magnetic properties may allow for robot sensors to be used to assist in the proper installation or deinstallation of panel modules. Steel's magnetic properties may allow the easy attachment or pre-attachment of hardware of various sorts to the module frame to facilitate installation of additional equipment.

In some cases, the frame precursor structure may be fabricated from an elongated sheet of the framework material that is bendable and cuttable. The elongated sheet may be cut, for example, using a water cutter, a laser, a punch, a saw, or the like, depending on the framework material. The cuts may be used to form some of the various features described herein such as notches, holes, furrows or other features. After at least some of the cuts have been made, the elongated sheet may be folded to form at least a portion of the frame precursor structure. Such folding may include, but is not limited to, roll forming. In some embodiments, the cutting and folding processes may be applied to a coated steel-based framework material.

FIG. 5 is block diagram showing a non-limiting example of a manufacturing process line for making frame precursor structures according to some embodiments. Manufacturing process line **500** may include a framework material station **510** having framework material that may be fed into the next station. In some embodiments, the framework material may be in the form of sheets that are pre-cut to the final desired length. In some embodiments, the framework material may be fed continuously to the next station. For example, framework material station **510** may include a coil **512** of coated steel **514**. The coated steel **514** may be supplied to punching station **520**. For example, the punching station **520** may pull the coated steel **514** from the coil. In some embodiments, certain cutting and/or punching processes may be performed at punching station **520** to cut and/or remove predetermined sections of the framework material

to make a patterned framework material. In some embodiments, the framework material may be cut to a desired length at the punching station, if such cut has not yet been performed. In some embodiments, the process may be controlled to high tolerances. Punching station **520** may include a microprocessor **525** and machine software and/or firmware that may control the cutting. Punching station **520** may include one or more sensors **526** that provide data to the microprocessor which may be used to monitor the punching processes or identify defects. The microprocessor **525** may be in electronic communication with another microprocessor or with an external computer for sending or receiving data or instructions. Such electronic communication may be through cables or wireless methods. In some embodiments, the coil of framework material may already be partially or fully pre-punched or pre-cut. In some cases, a coil of pre-punched or pre-cut framework material may bypass the punching station.

After the punching station **520**, the patterned framework material, e.g., coated steel, may be received by a roll forming station **530**. The steel may be shaped in a linear fashion using multiple rollers that provide a graduated bending process to form the steel into the desired shape (shaped framework material). The design of the rollers, order of the rollers, and tolerances may be highly precise, and may result in a fully (or nearly fully) shaped and punched frame precursor structure. Roll forming station **530** may include a microprocessor **535** and machine software and/or firmware that may control the roll forming. Roll forming station **530** may include one or more sensors **536** that provide data to the microprocessor which may be used to monitor the bending and folding processes or identify defects. The microprocessor **535** may be in electronic communication with another microprocessor or with an external computer for sending or receiving data or instructions. Such electronic communication may be through cables or wireless methods. In some embodiments, the framework material may be cut to a desired length at the roll forming station, if such cut has not yet been performed. In some embodiments, the roll forming station may include an adhesive applicator tool to apply an appropriate adhesive to a predetermined portion of the framework material while shaping framework material, e.g., to help the shaped framework material to maintain its shape.

After the roll forming station **530**, the shaped framework material, e.g., coated steel, may be received by a post forming station **540**. Some non-limiting examples of post forming processes may include cutting the frame precursor structures to length, buffing/deburring, cleaning, or passing the frame precursor structures through straightening rollers or dies that may

ensure product accuracy. Post forming station **540** may include a microprocessor **545** and machine software and/or firmware that may control one or more post forming processes. Post forming station **540** may include one or more sensors **546** that provide data to the microprocessor which may be used to monitor the post forming processes or identify defects or out-of-tolerance parts. These data may be fed back to roll forming station **530** for active adjustment of roll forming rollers or adjustment rollers. Post forming station **540** may include a cleaning section. The microprocessor **545** may be in electronic communication with another microprocessor or with an external computer for sending or receiving data or instructions. Such electronic communication may be through cables or wireless methods.

After the post forming station **540**, finished (or nearly finished) frame precursor structures **560** are received by a finished product station **550**. The frame precursor structures may be loaded into transportation containers and prepared for delivery, e.g., to a solar panel module production facility.

In some embodiments, the framework material may proceed in a generally linear (forward) direction from one station to the next. In some embodiments, the direction of framework material may be temporarily reversed within a station, for example, to repeat a particular step. In some embodiments, there may be multiple punching stations, roll forming stations, and/or post forming stations.

For any of the aforementioned stations, the microprocessor(s) may provide control signals to electro-mechanical motors that may be responsible for moving the intermediate products along the manufacturing line. Depending upon the process to be performed on the intermediate products, software/firmware running on the microprocessor(s) may dictate various factors/parameters of production. For merely some non-limiting examples, a microprocessor may dictate the speed and/or direction of the intermediate products traversing a given station. In some embodiments, a microprocessor may dictate when and/or how the intermediate products are to be shaped, punched, cut or the like in order to affect the desired intermediate/final products. In some embodiments, a microprocessor may receive signals from one or more sensors for monitoring manufacturing progress, identifying defects or out-of-tolerance parts, or measuring some other useful property of intermediate products as they are made. For example, an optical or imaging sensor(s) may provide data that allows a microprocessor to assess manufacturing status and/or how well a particular production step was

performed. In some embodiments, if quality is below standard, a microprocessor may send a status alert signal to a system operator and/or to another microprocessor. Other sensors may also be useful to monitor manufacturing status and/or quality control metrics. In addition to optical and imaging sensors, non-limiting examples of potentially useful sensors or their components may include laser-based sensors (including, but not limited, to laser position sensors), vision systems (including, but not limited to vision measurement and shape vision systems), contact sensors (including, but not limited to contact position sensors), vibration sensors, thermal sensors, conductivity sensors, roughness sensors, profilometers, ultrasonic sensors, stress sensors, and the like.

In some embodiments, the frame or framed panel structure may be attached to a support structure that may hold the frame or framed panel structure in a predetermined position. Such support structures and systems may take many forms, but some non-limiting examples may include racking, rail mounts, pole mounts, tracking mounts, or non-tracking mounts, or the like. In combination with a support structure, a frame or framed panel structure may be attached to its intended target, including but not limited to, to a building (e.g., a roof, a wall, an awning or the like), to the ground, to a shade structure or carport, or to a moving or stationary vehicle. In some embodiments, a frame or framed panel structure may be attached directly to its intended target without an intermediate support structure. In such case, the target itself may act as the support structure.

To provide robust support and strength to the framed panel such as a solar panel, it may be useful for the frame to include one or more connection features, for example, when forming a corner joint between frame precursor structures or sections. For the purposes of describing various connection features and technology below, the terms “frame precursor structure” and “frame sections” may be used interchangeably unless otherwise noted. In some cases, the frame may also include additional strengthening features such as cross bars that may extend from one frame section to an opposite or adjacent frame section. These additional strengthening features may also benefit from the use of one or more connection features. Similarly, in some embodiments, certain connection features may be used to attach a framed panel structure to a support structure such as racking.

In some embodiments, the frame or frame sections illustrated in FIGS. 1 – 3 may benefit from additional structural support features to improve the strength of the frame in some way to

address various forces it may experience when used in a framed panel structure. For example, such additional support may enable the frame to hold larger panels (e.g., PV laminates), withstand greater environmental and/or handling forces (wind, snow, mounting, clamping, bending, torsional stresses or the like), or increase PV module lifetime by reducing the number or intensity or of stress points, or improving their distribution. In some cases, structural support features may enable the use of framework materials that are thinner, easier to handle, or less expensive.

In some embodiments a useful structural support feature may include a support wall extending (i) between the bottom flange and the frame sidewall, (ii) between the bottom flange and the lower shelf, or (iii) both (i) and (ii). In some cases, a frame or frame section including a support wall, bottom flange, sidewall, and lower shelf, may be advantageously produced from a single piece of framework material. In some cases, using a single piece of framework material for these features may simplify manufacturing thereby reducing costs and increasing throughput and yield. Such single piece manufacturing may also increase the lifetime of the frame by avoiding the many failure-prone attachments points that would be needed if these features were assembled from separate parts.

There are many embodiments of useful frame sections that include a support wall. FIG. 6A is a perspective view of a cutaway portion of a non-limiting example of a frame section including a support wall according to some embodiments. The height **H** and lengthwise **L** axes are also shown for reference. FIG. 6B is a cross-sectional view of the frame section from FIG. 6A, but labelled in a modified manner to clarify that any of the features may include multiple layers of framework material. Frame section **601** may include a framework material that has been cut and folded into a desired shape. Frame section **601** may include a bottom flange **604** provided at the base of the frame section, which in some embodiments may include multiple layers of framework material such as bottom flange layers **604'** and **604''**. A frame sidewall **603** may be provided at an outer portion of the frame section and characterized by a height extending from the bottom flange. In some embodiments, a lengthwise fold **602** may define an intersection of the frame sidewall **603** and the bottom flange **604**, e.g., with bottom flange layer **604'**. A panel containment structure may be provided at an upper portion of the frame sidewall. The panel containment structure may include at least a lower shelf **605**, and may also include a pocket wall **606**, a top lip **607**, and perhaps even a pocket region **608** for containing the panel.

In some embodiments, some or all of the lower shelf **605** may include multiple layers of framework material, such as lower shelf layers **605'**, **605''**, **605'''**. In some embodiments, two or more lower shelf layers may be formed from a fold in the framework material at the upper portion of the frame sidewall. In some embodiments, the top lip may be formed of multiple layers of framework material, such as top lip layer **607'** and top lip layer **607''** which may be formed from a top lip fold **637** to form a multilayered rounded top lip edge. A support wall **632** may be provided at an inner portion of the frame section (inner relative to the frame sidewall). In some embodiments, the support wall **632** may extend between the bottom flange and the lower shelf. In some embodiments, the frame section may include a reversing flange fold **639** such that a portion **604'**of the bottom flange may include a double layer of framework material. In some embodiments, another lengthwise fold **631** may define an intersection of the support wall **632** with the bottom flange structure, e.g., with portion 6**04'.** In some cases, a lengthwise fold **633** may define an intersection of the support wall with the lower shelf **605**.

FIG. 6C is a plan view of a non-limiting example of a portion of framework material **640** prior to any cutting, punching, or folding operations used to make the frame section **601**. The lengthwise dimension of the framework material is illustrated as are a first edge **E1** and second edge **E2**, which are also labelled in FIGS. 6A and 6B. In some embodiments, such as shown in FIG. 6A and 6B, **E1** may correspond to the end of top lip layer **607''** and **E2** may correspond to the end of lower shelf layer **605'**.

FIG. 6D is a cross-sectional view of a non-limiting example of a framed panel structure according to some embodiments. Framed panel structure **600** may include various frame sections as previously discussed, e.g., frame section **601-2** and opposing frame section **601-4**. In some embodiments, each frame section may include a frame sidewall **603-2**, **603-4**, a bottom flange **604-2**, **604-4**, a lower shelf **605-2**, **605-4**, a pocket wall **606-2**, **606-4**, a top lip **607-2**, **607-4**, and a support wall **632-2**, **632-4**. The panel **690** may be received into a portion of each pocket region (formed by the lower shelf, the pocket wall, and the top lip) and secured in place, optionally with a sealant that may have adhesive properties (not shown). The frame sidewall of a frame section may be characterized as provided at an outer portion of the frame section whereas the support wall of the same frame section may be characterized as provided at an inner portion of the frame section. By "outer portion", in some embodiments it is meant that, relative to the support wall position, the frame sidewall may be generally provided further from the

center of the panel. By "inner portion", in some embodiments it is meant that, relative to the frame sidewall position, the support wall may be generally provided closer to the center of the panel. That is, "outer portion" and "inner portion" are relative terms with respect to the frame sidewall and support wall, and do not necessarily mean the outermost part or innermost part of a frame section (although that may be the case in some embodiments).

Frames or frame precursor structures having a frame section like FIG. 6A or 6B may sometimes be referred to herein as a "box frame" where the bottom flange, frame sidewall, lower shelf and support wall collectively form in cross-section an enclosed structure, in this case, one having four sides. However, the term "box frame" may apply to any frame section that in cross section forms any enclosed shape. In some embodiments, the enclosed shape may involve at least the bottom flange, the frame sidewall, and the support wall, and have three or more apparent sides in cross section.

As mentioned, there are numerous alternative embodiments of box frames besides those shown in FIGS. 6A – 6B. FIGS. 7A – 7AA are cross-sectional views of some non-limiting examples of frame sections according to some embodiments. For clarity, these figures are generally not labelled with part numbers, but the identity of their various frame features are self-evident from the other figures and discussion herein. Box frames, including but not limited to the box frames illustrated herein, may have one or more of the following advantages: improved load distribution; improved strength for use with top clamps when mounting to racking; improved torsional stiffness; improved flexural stiffness; improved manufacturability; or some other advantage. As noted elsewhere, wherever layers of framework material meet, an attachment feature may optionally be provided to bond or otherwise hold the layers together. In some cases, a particularly useful attachment feature location may be highlighted in the figure by a star (*). Some non-limiting examples of attachment features may include clinching, crimping, rivets, screws, nuts/bolts, welding, adhesives, or the like. In some cases, connections between layers may be made using a tab connection assembly or any of the other connection structures and methods discussed in US Provisional Patent Application 63/272,086 filed Oct. 26, 2021.

Wire management features

In some embodiments, a frame, frame section, or frame precursor structure, e.g., any of those described herein or similar structures, may further include one or more wire management

(WM) features formed at least in part from the same piece of framework material used to make the frame, frame section, or frame precursor structure. In some cases, a WM feature may include or be characterized as a deformable shape that may be cut, punched, or otherwise formed in the framework material. A WM feature may be formed, for example, at an appropriate station in a manufacturing line such as described with respect to FIG. 5. In some cases, the WM feature comes at no additional cost since it is simply utilizing framework material already purchased, thereby saving overall cost by reducing the need for separate wire management technology such as zip ties.

The WM feature may be designed to be deformed (bent, folded, crushed, or the like) into a shape that can manage electrical wiring in some way. In some cases, managing electrical wiring may include guiding wires along a predetermined path or channel. In some non-limiting examples, the WM feature may form a loop or cooperate with one or more other frame feature surfaces to form a channel. The In some cases, managing electrical wiring may include holding the wires in place so that they do not slip. In some non-limiting examples, the WM feature may pinch the wire or press the wire against one or more other frame feature surfaces.

FIG. 8A is a perspective view of a non-limiting example of a portion of a frame section having a WM feature according to some embodiments. The figure includes a frame sidewall **803**, bottom flange **804**, and WM feature **851** provided in the bottom flange. Near the end of WM feature **851**, there may be a gap or hole **854** that may aid in prying out the WM feature (manually or with a tool). For clarity other frame features are not shown. FIG. 8B is a perspective view of a non-limiting example of a portion of a frame section where the WM feature engages wiring according to some embodiments. FIG. 8C is a cross sectional view of FIG. 8B. In some cases, FIGS. 8B and 8C may represent the frame section after assembly into a framed panel structure, but for clarity, neither the panel nor other frame features are shown. Referring to FIGS. 8B and 8C, WM feature **851'** has been bent upwards from the bottom flange **804** and over towards frame sidewall **803** to engage wiring **861**. Note that the term "wiring" is not limiting and may refer to any number of electrically conductive structures, wires, cables, wire bundles, or the like, that are generally electrically insulated and are not necessarily circular in cross section. In some cases, WM feature **851'** may press wiring **861** against one or both of the bottom flange **804** and the frame sidewall **803** to hold the wiring firmly in place. Not shown,

in some embodiments, the WM feature **851'** may also be partly twisted so that a flat face of the feature is against the wiring.

The concepts of FIGS 8A – 8C are not limited to WM features provided in a bottom flange adjacent a frame sidewall. Referring back to the various figures above, a WM feature may be provided in any frame feature. That is, one or more WM features described anywhere herein may be provided as part of a frame sidewall, a lower shelf, a support wall, a bottom flange, a pocket wall, a top lip, or a frame crossbar, or any combination. The WM feature may be provided parallel to the lengthwise direction of the frame section or frame edge, or alternatively it may be provided orthogonal to the lengthwise direction of the frame section or frame edge, or alternatively at some other angle. The WM feature may have a shape other than an elongated tab so long as it is capable of managing the wiring in some way.

Note that wire management may be desired within the framed panel structure or outside of it. Referring to FIG. 9 there is shown cross-sectional view of a non-limiting example of a framed panel structure according to some embodiments. Framed panel structure **900** may, for example, be as described in FIG. 6D and so the various features are not labelled for clarity. A framed panel structure region **970** has been added over the figure as a dashed line. Wiring within region **970** may be referred to as "internal to the frame". Some non-limiting examples of wiring **961*i*** internal to the frame are shown. Wiring outside of region **970** may be referred to as "external to the frame". Some non-limiting examples of wiring **961*e*** external to the frame are shown. WM features may be designed to manage wiring internal to the frame, external to the frame, or both.

FIG. 10A is a perspective view of a non-limiting example of a portion of a frame section having a WM feature according to some embodiments. The figure includes a first frame feature **10-a** and an abutting second feature **10-b**. A WM feature **1051** may be provided in the first frame feature **10-a**. In some embodiments, frame feature **10-a** and abutting second feature **10-b** may respectively correspond to a frame sidewall and bottom flange, or alternatively a support wall and bottom flange, or alternatively a bottom flange and a frame sidewall, or alternatively a bottom flange and a support wall, or alternatively a frame sidewall and a lower shelf, or alternatively a support wall and a lower shelf, or alternatively a lower shelf and a frame sidewall, or alternatively a lower shelf and a support wall. In some embodiments, the abutting second feature **10-b** may not necessarily be a frame feature and may instead correspond to part

of the racking or support structure to which a framed panel structure is mounted. FIG. 10B is a perspective view of a non-limiting example of a portion of a frame section where the WM feature engages wiring according to some embodiments. FIG. 10C is a cross sectional view of FIG. 10B. In some cases, FIGS. 10B and 10C may represent the frame section after assembly into a framed panel structure, but for clarity, neither the panel nor other frame features are shown. Referring to FIGS. 10B and 10C, WM feature **1051'** has been bent over from the first frame feature **10-a** to engage wiring **1061**. In some cases, WM feature **1051'** may press wiring **1061** against both the first frame feature **10-a** and the abutting second feature **10-b.** Referring to FIG. 10C, the angle made between the bent WM feature **1051'** and the plane of the first frame feature **10-a** may in some cases be less than 90°. The edges of the WM feature may optionally be rounded or coined so that it does not cut into the wiring. In some embodiments, as shown in FIG. 10D which is similar to FIG. 10B, the WM feature may include a pry-point **1063** (indent, slot, or the like) to aid when using a tool to bend it into position. In some embodiments, as shown in FIG. 10E which is similar to FIG. 10D, the WM feature may include additional bends so that it wraps or partially wraps around the wiring.

FIG. 11A is a perspective view of a non-limiting example of a portion of a frame section having a WM feature according to some embodiments. The figure includes a first frame feature **11-a** and an abutting second feature **11-b**. A WM feature **1151** may be provided in the first frame feature **11-a**. FIG. 11B is similar to FIG. 11A but face on with respect to first frame feature **11-a**. In some cases, FIG. 11A may be considered analogous to the embodiments of FIG. 10A, but here, WM feature **1151** may include bent edges **1152** that are folded or bent out of the general plane of the rest of the WM feature. In FIG. 11B, the bent edges may be bent backward below the plane of the figure. The first frame feature **11-a** may further include an access cutout **1155** in the framework material, e.g., to allow access to a pry-out tool such as needle nose pliers or any other appropriate tool. The particular shape of access cutout **1155** may depend in part upon the intended pry-out tool and may also take into consideration any effects such a cutout has on the strength of the frame.

In some embodiments, frame feature **11-a** and abutting second feature **11-b** may respectively correspond to a frame sidewall and bottom flange, or alternatively a support wall and bottom flange, or alternatively a bottom flange and a frame sidewall, or alternatively a bottom flange and a support wall, or alternatively a frame sidewall and a lower shelf, or

alternatively a support wall and a lower shelf, or alternatively a lower shelf and a frame sidewall, or alternatively a lower shelf and a support wall. In some embodiments, the abutting second feature **11-b** may not necessarily be a frame feature and may instead correspond to part of the racking or support structure to which a framed panel structure is mounted. FIG. 11C is a perspective view of a non-limiting example of a portion of a frame section where the WM feature engages wiring according to some embodiments. FIG. 11D is a cross sectional view of FIG. 11C. In some cases, FIGS. 11C and 11D may represent the frame section after assembly into a framed panel structure, but for clarity, neither the panel nor other frame features are shown. Referring to FIGS. 11C and 11D, WM feature **1151'** has been bent over from the first frame feature **11-a** to engage wiring **1161**. In some cases, WM feature **1151'** may press wiring **1161** against both the first frame feature **11-a** and the abutting second feature **11-b.** Referring to FIG. 11D, the angle made between the bent WM feature **1151'** and the plane of the first frame feature **11-a** may in some cases be less than 90°. In some embodiments, the bent edges **1152** of the WM feature may be directed away from the wiring to avoid the possibility of the WM feature edge cutting into the wiring.

In some embodiments, a WM feature may be provided in a frame feature formed from two or more layers of framework material. The WM feature may be punched or cut into just one of the layers or alternatively into both layers. FIG. 12A is a perspective view of a frame section where a WM feature engages wiring according to some embodiments. FIG. 12B is a cross-sectional view of FIG. 12B. In some cases, FIGS. 12A and 12B may represent a frame section after assembly into a framed panel structure, but for clarity the panel is not shown. Frame section **1201** may be a box frame which may include various features as described previously. For clarity, just the bottom flange **1204** and support wall **1232** are labeled, but the other frame features are self-evident from the previous discussions. Bottom flange **1204** may include a WM feature **1251'** that has been bent into position to secure wiring **1261** in a manner similar to that discussed with reference to FIGS. 8B and 8C. A portion of bottom flange **1204** includes a first bottom flange layer **1204'** and a second bottom flange layer **1204''**. In some embodiments, the WM feature **1251'** may be provided in the second bottom flange layer. In some cases, the first bottom flange layer **1204'** may include a hole or other opening **1254** in registration with the WM feature. The hole may provide an access point for a tool or finger to

push the WM feature upwards out of the plane of the bottom flange. The hole may optionally be smaller in size than the WM feature.

Although not shown, both layers of the bottom flange may optionally include one or more WM features. Further, as discussed above, the concepts of FIGS. 12A and 12B may be applied to other frame features and they are not limited solely to the bottom flange in combination with the support wall.

In some embodiments, a frame feature may include multiple WM features. For example, FIG. 13A is a perspective view of a non-limiting example of multiple WM features according to some embodiments. In FIG. 13A, a frame feature **13-a** may include a first WM feature **1351-1** and a second WM feature **1351-2**. In some cases, these WM features may act independently on different wiring or different sections of the same wiring. In some cases, the WM features may operate cooperatively to form a single WM feature, e.g., by linking the two ends of **1351-1** and **1351-2** to form a loop or twisted structure (neither are shown). In some embodiments, linking may include a crimp or some other attachment feature. In some embodiments, frame feature **13-a** may represent a frame sidewall, a bottom flange, a support wall, a lower shelf, a pocket wall, or a top lip. FIG. 13B is like FIG. 13A but showing the multiple WM features in a different orientation.

In some embodiments, the WM feature(s) may include one or more interlocking elements. For example, FIG. 14A is a perspective view of a non-limiting example of WM features having interlocking elements according to some embodiments. In FIG. 14A, a frame feature **14-a** may include a first WM feature **1451-1** and a second WM feature **1451-2**. In some embodiments, one or both WM features may include an interlocking element, e.g., notch **1453-1** and **1453-2**. FIG. 14B illustrates the WM features with interlocking elements engaged to form an interlocked WM feature **1451'** which in some cases may wrap around wiring (not shown). In some cases, using multiple WM features cooperatively may allow larger wire bundles to be managed. In some embodiments, one or more WM features may include multiple notches to accommodate wiring of various sizes. In some embodiments, frame feature **14-a** may represent a frame sidewall, a bottom flange, a support wall, a lower shelf, a pocket wall, or a top lip.

Numerous other options for interlocking elements may be used besides the notches shown in FIGS. 14A and 14B. For example, FIG. 15A is a perspective view of a non-limiting example of WM features having interlocking elements according to some embodiments. In FIG.

15A, a frame feature **15-a** may include a first WM feature **1551-1** and a second WM feature **1551-2**. In some embodiments, the WM features may include an interlocking element, e.g., a slot **1553-1** in the first WM feature, and an insertable tab **1553-2** as part of the second WM feature. FIG. 15B illustrates the WM features with interlocking elements engaged to form an interlocked WM feature **1551'** which in some cases may wrap around wiring (not shown). The tab may slide through the slot and snap in place, or alternatively the tab may be bent backwards over a portion of the first WM feature to lock the pieces in place. In some embodiments, frame feature **15-a** may represent a frame sidewall, a bottom flange, a support wall, a lower shelf, a pocket wall, or a top lip.

In some embodiments, a WM feature may include an interlocking element that cooperates with another interlocking element within a frame feature. For example, FIG. 16A is a perspective view of a non-limiting example of a frame feature and a WM feature having interlocking elements according to some embodiments. In FIG. 16A, a frame feature **16-a** may include a WM feature **1651** and a hole or slot **1654**. The end of the WM feature **1651** and the slot **1654** may act as interlocking elements. FIGS. 16B and 16C illustrate the WM feature with engaged with the slot to form an interlocked WM feature **1651'** which in some cases may wrap around wiring (not shown). In some cases, the end of the WM feature may slide through the slot and snap in place, or alternatively may be bent backward over a portion of the frame feature **16-a** to form a bent tab **1653** that locks the pieces in place. In some embodiments, frame feature **16-a** may represent a frame sidewall, a bottom flange, a support wall, a lower shelf, a pocket wall, or a top lip. In some embodiments, the WM feature may be provided on one frame feature and the hole or slot may be provided on a different frame feature, e.g., an adjacent or abutting frame feature.

In some embodiments, a WM feature may be provided so that it is already partially bent prior to assembly of the framed panel structure in order to make it easier to use after assembly. In some embodiments a WM feature may be offset from the frame feature it is provided in, e.g., as shown in FIG. 17. Such an offset may be provided prior to assembly of the framed panel structure in order to make it easier to use after assembly. Note that FIG. 17 is not labelled, but the features are self-evident from the preceding discussion.

In some embodiments a WM feature may be cut or punched so that the edges may be dissimilar in length so as to promote bending at an angle. For example, FIG. 18A is a

perspective view of a portion of a frame section having a WM feature according to some embodiments. In some cases, the dissimilar lengths may promote a bending angle that may be about 90° relative to the lengthwise WM feature direction prior to bending. In some cases, the WM feature may include small notches near the bend points of the WM feature which also may facilitate bending in the proper manner. FIG. 18B shows the WM feature engaging wiring after bending it in place. Note that FIGS. 18A and 18B are not labelled, but the features are self-evident from the preceding discussion.

In some embodiments, a WM feature may include a furrow, scribe, or other feature that may help promote bending at predetermined locations. In some embodiments, a WM feature may have a curved shape to prevent (or reduce the likelihood of) edges of WM feature from directly touching the wiring it is securing. For example, FIG. 19 illustrates a side view of wiring **1961** in contact with a curved WM feature **1951** (other frame features are not shown for clarity). In some embodiments, such curvature may be provided as part of a punching process that may include a curved die. In some embodiments, the edges of the WM features may themselves be coined or rounded to reduce the likelihood of damage to wiring and/or cuts to persons using the frames. FIG. 20 is a side view of a portion of a WM feature **2051** showing rounded edges 2052. During punching, the punch side may have a slightly rounded edge so the punch direction may aid in the rounding. The rounding may be increased in the punch design and the punch-to-die clearance. The shape of the punch and die can also aid in the rounding of the edges.

Although described herein with respect to their utility in making frames for solar panels, the methods, equipment, and devices of the present application may be used to manufacture many other products in many other fields. In some cases, such other products may be those formed at least in part from a generally flat starting material including, but not limited to, sheet metal (coated or uncoated).

It should be noted that various parts and frame features, including but not limited to, frame sidewalls and bottom flanges, have generally be represented in their respective figures as being straight or flat, but in some embodiments, one or more of these features (or other features shown as being straight or flat) may instead be non-straight or non-flat. For example, one or more of these features may include one or more curves or additional bends and still effectively perform their intended function.

Note also that in any of the figures herein, folds that may be represented as having sharp corners may be replaced with rounded corners. In some embodiments, a corner formed by a fold may be characterized by a bending radius.

In some embodiments, in areas where a portion of framework material may come into contact with another material including, but not limited to, another portion of framework material, a bolt, a washer, a support structure, or the like, such areas may optionally include an anti-corrosion coating or an additional anti-corrosion coating treatment including, but not limited to, those already discussed.

In some embodiments, in areas where multiple layers of framework material are formed, such areas may optionally include a bonding or attachment feature to hold the layers together. Some non-limiting examples of attachment features may include a crimp, a clinch, an interlocking element between the layers, double-sided adhesive tape, an adhesive, a weld, a braze, a solder, or the like. In some embodiments, an anticorrosion coating may also have adhesive properties and act as an attachment feature.

Still further embodiments herein include the following enumerated embodiments. The term "including" (and its variations, "includes", "include") in these enumerated embodiments encompasses its normal meaning in addition to "comprising" ("comprises", "comprise") and/or "consisting of" ("consists of", "consist of") and/or "consisting essentially of" ("consists essentially of", consist essentially of").

Enumerated Embodiments

Enumerated embodiment 1. A frame for at least partially enclosing or supporting a panel, the frame including at least a first frame section characterized by a first end and a second end defining a lengthwise dimension corresponding to an edge of the panel, the first frame section including:

a) a frame sidewall provided at an outer portion of the frame section, the frame sidewall characterized by a height extending from a base portion of the frame section;

b) a frame support wall provided at an outer portion of the frame section, the frame support wall characterized by a height extending from a base portion of the frame section;

c) a panel containment structure provided at an upper portion of the frame sidewall, the panel containment structure including a lower shelf; and

d) one or more wire management features,

wherein features (a) – (d) are formed at least in part from a single piece of framework material.

Enumerated embodiment 2. The frame according to any of embodiments 1 – 3, wherein at least a portion of the frame sidewall, the lower shelf, or both the frame sidewall and lower shelf, includes at least two layers of framework material.

Enumerated embodiment 3. The frame of embodiment 1 or 2, wherein the frame sidewall includes at least one wire management feature.

Enumerated embodiment 4. The frame according to any of embodiments 1 – 3, wherein the lower shelf includes at least one wire management feature.

Enumerated embodiment 5. The frame according to any of embodiments 1 – 4, further including a bottom flange provided at the base portion of the first frame section, wherein (i) the frame sidewall extends from the bottom flange, and (ii) the bottom flange is formed at least in part from the single piece of framework material.

Enumerated embodiment 6. The frame of embodiment 5, further including a lengthwise fold defining an intersection of the frame sidewall with the bottom flange.

Enumerated embodiment 7. The frame of embodiment 5 or 6, wherein at least a portion of the bottom flange includes at least two layers of framework material.

Enumerated embodiment 8. The frame according to any of embodiments 5 – 7, wherein the bottom flange includes at least one wire management feature.

Enumerated embodiment 9. The frame according to any of embodiments 5 – 8, further including a support wall provided at an inner portion of the first frame section, the support wall extending (i) between the bottom flange and the frame sidewall, (ii) between the bottom flange and the lower shelf, or (iii) both (i) and (ii), wherein the support wall is formed at least in part from the single piece of framework material.

Enumerated embodiment 10. The frame of embodiment 9, wherein at least a portion of the support wall includes at least two layers of framework material.

Enumerated embodiment 11. The frame of embodiment 9 or 10, wherein the support wall includes at least one wire management feature.

Enumerated embodiment 12. The frame according to any of embodiments 1 – 11, wherein the panel containment structure further includes a pocket wall extending from the lower shelf, wherein the pocket wall is formed at least in part from the single piece of framework material.

Enumerated embodiment 13. The frame of embodiment 12, wherein at least a portion of the pocket wall includes at least two layers of framework material.

Enumerated embodiment 14. The frame of embodiment 12 or 13, wherein the pocket wall includes at least one wire management feature.

Enumerated embodiment 15. The frame according to any of embodiments 12 – 14, wherein the panel containment structure further includes a top lip intersecting an upper portion of the pocket wall, thereby forming a pocket region for receiving the panel, the pocket region defined by the lower shelf, the pocket wall, and the top lip, wherein the top lip is formed at least in part from the single piece of framework material.

Enumerated embodiment 16. The frame of embodiment 15, wherein at least a portion of the top lip includes at least two layers of framework material.

Enumerated embodiment 17. The frame of embodiment 15 or 16, wherein the top lip includes at least one wire management feature.

Enumerated embodiment 18. The frame according to any of embodiments 1 – 17, wherein at least one wire management feature is operable at least in part to manage wiring external to the frame.

Enumerated embodiment 19. The frame of embodiment 18, wherein the at least one wire management feature for managing wiring external to the frame is provided as part of the bottom flange or frame sidewall.

Enumerated embodiment 20. The frame according to any of embodiments 1 – 19, wherein at least one wire management feature is operable at least in part to manage wiring internal to the frame.

Enumerated embodiment 21. The frame of embodiment 20, wherein the at least one wire management feature for managing wiring internal to the frame is provided as part of the frame sidewall, lower shelf, bottom flange, or support wall.

Enumerated embodiment 22. The frame according to any of embodiments 1 – 21, wherein at least one wire management feature includes bent edges.

Enumerated embodiment 23. The frame according to any of embodiments 1 – 22, wherein at least one wire management feature includes a curved shape.

Enumerated embodiment 24. The frame according to any of embodiments 1 – 23, wherein one or more wire management features include an interlocking element.

Enumerated embodiment 25. The frame according to any of embodiments 1 – 24, wherein a wire management feature includes an interlocking element that cooperates with an interlocking element formed in the same frame feature which includes the wire management feature or with an interlocking element formed in another frame feature that abuts the frame feature including the wire management feature.

Enumerated embodiment 26. A framed panel structure including a frame according to any of embodiments 1 – 25, wherein: i) at least one the wire management feature is pressed against wiring in order to hold it in place against the frame or against a support structure; ii) at least one of the wire management feature forms a channel that guides wiring; or iii) both i) and ii).

Enumerated embodiment 27. The framed panel structure of embodiment 26, wherein the panel includes a solar panel.

Enumerated embodiment 28. An array of two or more framed solar panel structures according to embodiment 27 including more wire management features than zip ties.

Enumerated embodiment 29. The array of embodiment 28, wherein a combined energy output of the framed solar panel structures is at least 1 megawatt.

As can be easily understood from the foregoing, the basic concepts of the various embodiments of the present application(s) may be embodied in a variety of ways. It involves frame, frame precursor structure, frame section, framed panel structure and/or wire management techniques as well as devices to accomplish the appropriate frame, frame precursor structure, frame section, framed panel structure, and/or wire management. In this application, the frame, frame precursor structure, frame section, framed panel structure and/or wire management technology techniques are disclosed as part of the results shown to be achieved by the various devices described and as steps which are inherent to utilization. They are simply the natural result of utilizing the devices as intended and described. In addition, while some devices are disclosed, it should be understood that these not only accomplish certain

methods but also can be varied in a number of ways. Importantly, as to all of the foregoing, all of these facets should be understood to be encompassed by this disclosure.

The discussion included in this provisional application is intended to serve as a basic description. The reader should be aware that the specific discussion may not explicitly describe all embodiments possible; many alternatives are implicit. It also may not fully explain the generic nature of the various embodiments of the present application(s) and may not explicitly show how each feature or element can actually be representative of a broader function or of a great variety of alternative or equivalent elements. As one example, terms of degree, terms of approximation, and/or relative terms may be used. These may include terms such as the words: substantially, about, only, and the like. These words and types of words are to be understood in a dictionary sense as terms that encompass an ample or considerable amount, quantity, size, etc. as well as terms that encompass largely but not wholly that which is specified. Further, for this application if or when used, terms of degree, terms of approximation, and/or relative terms should be understood as also encompassing more precise and even quantitative values that include various levels of precision and the possibility of claims that address a number of quantitative options and alternatives. For example, to the extent ultimately used, the existence or non-existence of a substance or condition in a particular input, output, or at a particular stage can be specified as substantially only *x* or substantially free of *x*, as a value of about *x*, or such other similar language. Using percentage values as one example, these types of terms should be understood as encompassing the options of percentage values that include 99.5%, 99%, 97%, 95%, 92% or even 90% of the specified value or relative condition; correspondingly for values at the other end of the spectrum (e.g., substantially free of *x*, these should be understood as encompassing the options of percentage values that include not more than 0.5%, 1%, 3%, 5%, 8% or even 10% of the specified value or relative condition, all whether by volume or by weight as either may be specified. In context, these should be understood by a person of ordinary skill as being disclosed and included whether in an absolute value sense or in valuing one set of or substance as compared to the value of a second set of or substance. Again, these are implicitly included in this disclosure and should (and, it is believed, would) be understood to a person of ordinary skill in this field. Where the application is described in device-oriented terminology, each element of the device implicitly performs a function. Apparatus claims may not only be included for the device described, but also method or process claims may be included to address

the functions of the embodiments and that each element performs. Neither the description nor the terminology is intended to limit the scope of the claims that will be included in any subsequent patent application. As used herein and in the appended claims, the singular forms "a", "an", and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a method" includes a plurality of such methods and reference to "the anode" includes reference to one or more anodes and equivalents thereof known to those skilled in the art, and so forth. Terms like "overlaying", "over" or the like may be direct contact, indirect contact, above, upon, cover, or the like.

It should also be understood that a variety of changes may be made without departing from the essence of the various embodiments of the present application(s). Such changes are also implicitly included in the description. They still fall within the scope of the various embodiments of the present application(s). A broad disclosure encompassing both the explicit embodiment(s) shown, the great variety of implicit alternative embodiments, and the broad methods or processes and the like are encompassed by this disclosure and may be relied upon when drafting the claims for any subsequent patent application. It should be understood that such language changes and broader or more detailed claiming may be accomplished at a later date (such as by any required deadline) or in the event the applicant subsequently seeks a patent filing based on this filing. With this understanding, the reader should be aware that this disclosure is to be understood to support any subsequently filed patent application that may seek examination of as broad a base of claims as deemed within the applicant's right and may be designed to yield a patent covering numerous aspects of embodiments of the present application(s) both independently and as an overall system.

Further, each of the various elements of embodiments of the present application(s) and claims may also be achieved in a variety of manners. Additionally, when used or implied, an element is to be understood as encompassing individual as well as plural structures that may or may not be physically connected. This disclosure should be understood to encompass each such variation, be it a variation of an embodiment of any apparatus embodiment, a method or process embodiment, or even merely a variation of any element of these. Particularly, it should be understood that as the disclosure relates to elements of the various embodiments of the present application(s), the words for each element may be expressed by equivalent apparatus terms or method terms -- even if only the function or result is the same. Such equivalent, broader, or

even more generic terms should be considered to be encompassed in the description of each element or action. Such terms can be substituted where desired to make explicit the implicitly broad coverage to which embodiments of the present application(s) are entitled. As but one example, it should be understood that all actions may be expressed as a means for taking that action or as an element which causes that action. Similarly, each physical element disclosed should be understood to encompass a disclosure of the action which that physical element facilitates. Regarding this last aspect, as but one example, the disclosure of a "fold" should be understood to encompass disclosure of the act of "folding" -- whether explicitly discussed or not -- and, conversely, were there effectively disclosure of the act of "folding", such a disclosure should be understood to encompass disclosure of a "fold" and even a "means for folding." Such changes and alternative terms are to be understood to be explicitly included in the description. Further, each such means (whether explicitly so described or not) should be understood as encompassing all elements that can perform the given function, and all descriptions of elements that perform a described function should be understood as a non-limiting example of means for performing that function. As other non-limiting examples, it should be understood that claim elements can also be expressed as any of: components that are configured to, or configured and arranged to, achieve a particular result, use, purpose, situation, function, or operation, or as components that are capable of achieving a particular result, use, purpose, situation, function, or operation. All should be understood as within the scope of this disclosure and written description.

Any patents, publications, or other references mentioned in this present application for patent are hereby incorporated by reference. Any priority case(s) claimed by this present application is hereby appended and hereby incorporated by reference. In addition, as to each term used it should be understood that unless its utilization in this present application is inconsistent with a broadly supporting interpretation, common dictionary definitions should be understood as incorporated for each term and all definitions, alternative terms, and synonyms such as contained in the Random House Webster's Unabridged Dictionary, second edition are hereby incorporated by reference. Finally, all references listed in the list of References To Be Incorporated By Reference In Accordance With The Provisional Patent Application or other information statement filed with the application are hereby appended and hereby incorporated by reference, however, as to each of the above, to the extent that such information or statements

incorporated by reference might be considered inconsistent with the patenting of the various embodiments of present application(s) such statements are expressly not to be considered as made by the applicant(s).

Thus, the applicant(s) should be understood to have support and make claims to embodiments including at least: i) each of the frame, frame precursor structure, frame section, framed panel structure, and/or wire management technologies as herein disclosed and described, ii) the related methods disclosed and described, iii) similar, equivalent, and even implicit variations of each of these devices and methods, iv) those alternative designs which accomplish each of the functions shown as are disclosed and described, v) those alternative designs and methods which accomplish each of the functions shown as are implicit to accomplish that which is disclosed and described, vi) each feature, component, and step shown as separate and independent applications, vii) the applications enhanced by the various systems or components disclosed, viii) the resulting products produced by such processes, methods, systems or components, ix) each system, method, and element shown or described as now applied to any specific field or devices mentioned, x) methods and apparatuses substantially as described hereinbefore and with reference to any of the accompanying examples, xi) an apparatus for performing the methods described herein comprising means for performing the steps, xii) the various combinations and permutations of each of the elements disclosed, xiii) each potentially dependent claim or concept as a dependency on each and every one of the independent claims or concepts presented, and xiv) all applications described herein.

In addition and as to computer aspects and each aspect amenable to programming or other electronic automation, it should be understood that in characterizing these and all other aspects of the various embodiments of the present application(s) – whether characterized as a device, a capability, an element, or otherwise, because all of these can be implemented via software, hardware, or even firmware structures as set up for a general purpose computer, a programmed chip or chipset, an ASIC, application specific controller, subroutine, or other known programmable or circuit specific structure -- it should be understood that all such aspects are at least defined by structures including, as person of ordinary skill in the art would well recognize: hardware circuitry, firmware, programmed application specific components, and even a general purpose computer programmed to accomplish the identified aspect. For such items implemented by programmable features, the applicant(s) should be understood to have

support to claim and make a statement of application to at least: xv) processes performed with the aid of or on a computer, machine, or computing machine as described throughout the above discussion, xvi) a programmable apparatus as described throughout the above discussion, xvii) a computer readable memory encoded with data to direct a computer comprising means or elements which function as described throughout the above discussion, xviii) a computer, machine, or computing machine configured as herein disclosed and described, xix) individual or combined subroutines and programs as herein disclosed and described, xx) a carrier medium carrying computer readable code for control of a computer to carry out separately each and every individual and combined method described herein or in any claim, xxi) a computer program to perform separately each and every individual and combined method disclosed, xxii) a computer program containing all and each combination of means for performing each and every individual and combined step disclosed, xxiii) a storage medium storing each computer program disclosed, xxiv) a signal carrying a computer program disclosed, xxv) a processor executing instructions that act to achieve the steps and activities detailed, xxvi) circuitry configurations (including configurations of transistors, gates, and the like) that act to sequence and/or cause actions as detailed, xxvii) computer readable medium(s) storing instructions to execute the steps and cause activities detailed, xxviii) the related methods disclosed and described, xxix) similar, equivalent, and even implicit variations of each of these systems and methods, xxx) those alternative designs which accomplish each of the functions shown as are disclosed and described, xxxi) those alternative designs and methods which accomplish each of the functions shown as are implicit to accomplish that which is disclosed and described, xxxii) each feature, component, and step shown as separate and independent applications, and xxxiii) the various combinations of each of the above and of any aspect, all without limiting other aspects in addition. In addition, the applicant(s) should be understood to have support to claim and make a statement of application that may include claims directed to any of the enumerated embodiments and any permutation or combination thereof.

With regard to claims whether now or later presented for examination, it should be understood that for practical reasons and so as to avoid great expansion of the examination burden, the applicant may at any time present only initial claims or perhaps only initial claims with only initial dependencies. The office and any third persons interested in potential scope of this or subsequent applications should understand that broader claims may be presented at a

later date in this case, in a case claiming the benefit of this case, or in any continuation in spite of any preliminary amendments, other amendments, claim language, or arguments presented, thus throughout the pendency of any case there is no intention to disclaim or surrender any potential subject matter. It should be understood that if or when broader claims are presented, such may require that any relevant prior art that may have been considered at any prior time may need to be re-visited since it is possible that to the extent any amendments, claim language, or arguments presented in this or any subsequent application are considered as made to avoid such prior art, such reasons may be eliminated by later presented claims or the like. Both the examiner and any person otherwise interested in existing or later potential coverage, or considering if there has at any time been any possibility of an indication of disclaimer or surrender of potential coverage, should be aware that no such surrender or disclaimer is ever intended or ever exists in this or any subsequent application. Limitations such as arose in *Hakim v. Cannon Avent Group, PLC*, 479 F.3d 1313 (Fed. Cir 2007), or the like are expressly not intended in this or any subsequent related matter. In addition, support should be understood to exist to the degree required under new matter laws -- including but not limited to European Patent Convention Article 123(2) and United States Patent Law 35 USC 132 or other such laws-- to permit the addition of any of the various dependencies or other elements presented under one independent claim or concept as dependencies or elements under any other independent claim or concept. In drafting any claims at any time whether in this present application or in any subsequent application, it should also be understood that the applicant has intended to capture as full and broad a scope of coverage as legally available. To the extent that insubstantial substitutes are made, to the extent that the applicant did not in fact draft any claim so as to literally encompass any particular embodiment, and to the extent otherwise applicable, the applicant should not be understood to have in any way intended to or actually relinquished such coverage as the applicant simply may not have been able to anticipate all eventualities; one skilled in the art, should not be reasonably expected to have drafted a claim that would have literally encompassed such alternative embodiments.

Further, if or when used, the use of the transitional phrase “comprising” is used to maintain the “open-end” claims herein, according to traditional claim interpretation. Thus, unless the context requires otherwise, it should be understood that the term “comprise” or variations such as “comprises” or “comprising”, are intended to imply the inclusion of a stated

element or step or group of elements or steps but not the exclusion of any other element or step or group of elements or steps. Such terms should be interpreted in their most expansive form so as to afford the applicant the broadest coverage legally permissible. The use of the phrase, "or any other claim" is used to provide support for any claim to be dependent on any other claim, such as another dependent claim, another independent claim, a previously listed claim, a subsequently listed claim, and the like. As one clarifying example, if a claim were dependent "on claim 20 or any other claim" or the like, it could be re-drafted as dependent on claim 1, claim 15, or even claim 25 (if such were to exist) if desired and still fall with the disclosure. It should be understood that this phrase also provides support for any combination of elements in the claims and even incorporates any desired proper antecedent basis for certain claim combinations such as with combinations of method, apparatus, process, and the like claims.

Finally, any claims set forth at any time are hereby incorporated by reference as part of this description of various embodiments of the present application, and the applicant expressly reserves the right to use all of or a portion of such incorporated content of such claims as additional description to support any of or all of the claims or any element or component thereof, and the applicant further expressly reserves the right to move any portion of or all of the incorporated content of such claims or any element or component thereof from the description into the claims or vice-versa as desired to define the matter for which protection is sought by this present application or by any subsequent continuation, division, or continuation-in-part application thereof, or to obtain any benefit of, reduction in fees pursuant to, or to comply with the patent laws, rules, or regulations of any country or treaty, and such content incorporated by reference shall survive during the entire pendency of this present application including any subsequent continuation, division, or continuation-in-part application thereof or any reissue or extension thereon.

CLAIMS

We claim:

1. A frame for at least partially enclosing or supporting a panel, the frame comprising at least a first frame section characterized by a first end and a second end defining a lengthwise dimension corresponding to an edge of the panel, the first frame section comprising:

a) a frame sidewall provided at an outer portion of the frame section, the frame sidewall characterized by a height extending from a base portion of the frame section;

b) a support wall provided at an inner portion of the first frame section characterized by a height extending from a base portion of the frame section;

c) a panel containment structure provided at an upper portion of the frame sidewall, the panel containment structure comprising a lower shelf; and

d) one or more wire management features,

wherein features (a) – (d) are formed at least in part from a single piece of framework material.

2. The frame according to any of claims 1 – 3, wherein at least a portion of the frame sidewall, the lower shelf, or both the frame sidewall and lower shelf, comprises at least two layers of framework material.

3. The frame of claim 1 or 2, wherein the frame sidewall comprises at least one wire management feature.

4. The frame according to any of claims 1 – 3, wherein the lower shelf comprises at least one wire management feature.

5. The frame according to any of claims 1 – 4, further comprising a bottom flange provided at the base portion of the first frame section, wherein (i) the frame sidewall extends from the bottom flange, and (ii) the bottom flange is formed at least in part from the single piece of framework material.

6. The frame of claim 5, further comprising a lengthwise fold defining an intersection of the frame sidewall with the bottom flange.

7. The frame of claim 5 or 6, wherein at least a portion of the bottom flange comprises at least two layers of framework material.

8. The frame according to any of claims 5 – 7, wherein the bottom flange comprises at least one wire management feature.

9. The frame according to any of claims 5 – 8, further comprising a support wall provided at an inner portion of the first frame section, the support wall extending (i) between the bottom flange and the frame sidewall, (ii) between the bottom flange and the lower shelf, or (iii) both (i) and (ii), wherein the support wall is formed at least in part from the single piece of framework material.

10. The frame of claim 9, wherein at least a portion of the support wall comprises at least two layers of framework material.

11. The frame of claim 9 or 10, wherein the support wall comprises at least one wire management feature.

12. The frame according to any of claims 1 – 11, wherein the panel containment structure further comprises a pocket wall extending from the lower shelf, wherein the pocket wall is formed at least in part from the single piece of framework material.

13. The frame of claim 12, wherein at least a portion of the pocket wall comprises at least two layers of framework material.

14. The frame of claim 12 or 13, wherein the pocket wall comprises at least one wire management feature.

15. The frame according to any of claims 12 – 14, wherein the panel containment structure further comprises a top lip intersecting an upper portion of the pocket wall, thereby forming a pocket region for receiving the panel, the pocket region defined by the lower shelf, the pocket wall, and the top lip, wherein the top lip is formed at least in part from the single piece of framework material.

16. The frame of claim 15, wherein at least a portion of the top lip comprises at least two layers of framework material.

17. The frame of claim 15 or 16, wherein the top lip comprises at least one wire management feature.

18. The frame according to any of claims 1 – 17, wherein at least one wire management feature is operable at least in part to manage wiring external to the frame.

19. The frame of claim 18, wherein the at least one wire management feature for managing wiring external to the frame is provided as part of the bottom flange or frame sidewall.

20. The frame according to any of claims 1 – 19, wherein at least one wire management feature is operable at least in part to manage wiring internal to the frame.

21. The frame of claim 20, wherein the at least one wire management feature for managing wiring internal to the frame is provided as part of the frame sidewall, lower shelf, bottom flange, or support wall.

22. The frame according to any of claims 1 – 21, wherein at least one wire management feature comprises bent edges.

23. The frame according to any of claims 1 – 22, wherein at least one wire management feature comprises a curved shape.

24. The frame according to any of claims 1 – 23, wherein one or more wire management features comprise an interlocking element.

25. The frame according to any of claims 1 – 24, wherein a wire management feature comprises an interlocking element that cooperates with an interlocking element formed in the same frame feature which comprises the wire management feature or with an interlocking element formed in another frame feature that abuts the frame feature comprising the wire management feature.

26. A framed panel structure comprising a frame according to any of claims 1 – 25, wherein: i) at least one the wire management feature is pressed against wiring in order to hold it in place against the frame or against a support structure; ii) at least one of the wire management feature forms a channel that guides wiring; or iii) both i) and ii).

27. The framed panel structure of claim 26, wherein the panel comprises a solar panel.

28. An array of two or more framed solar panel structures according to claim 27 comprising more wire management features than zip ties.

29. The array of claim 28, wherein a combined energy output of the framed solar panel structures is at least 1 megawatt.

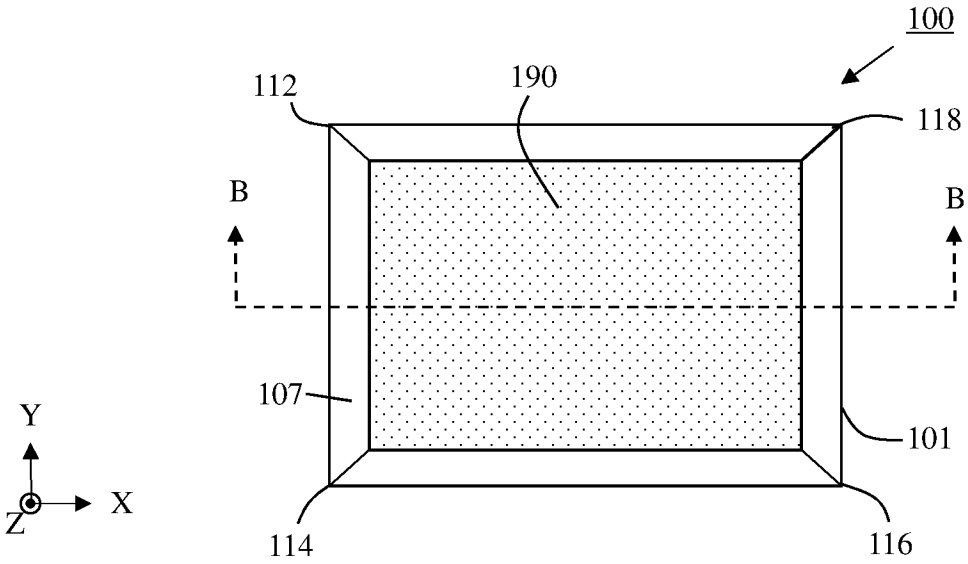


FIG. 1A

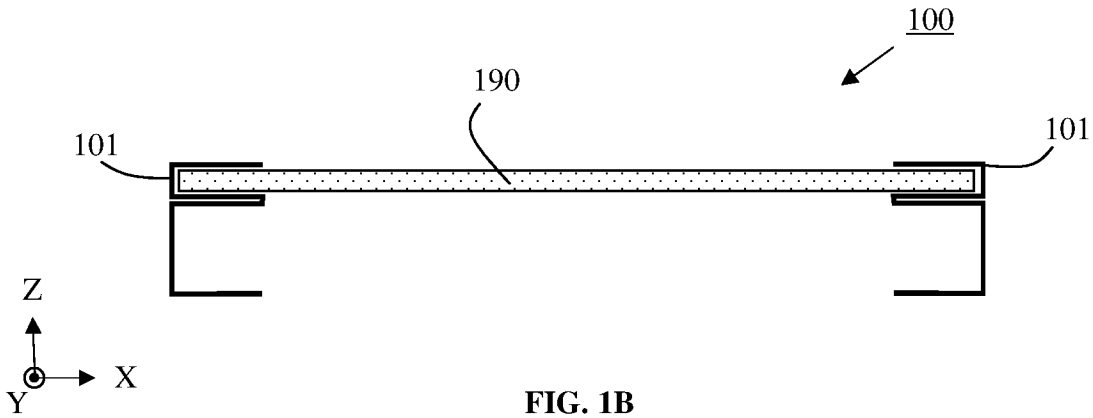


FIG. 1B

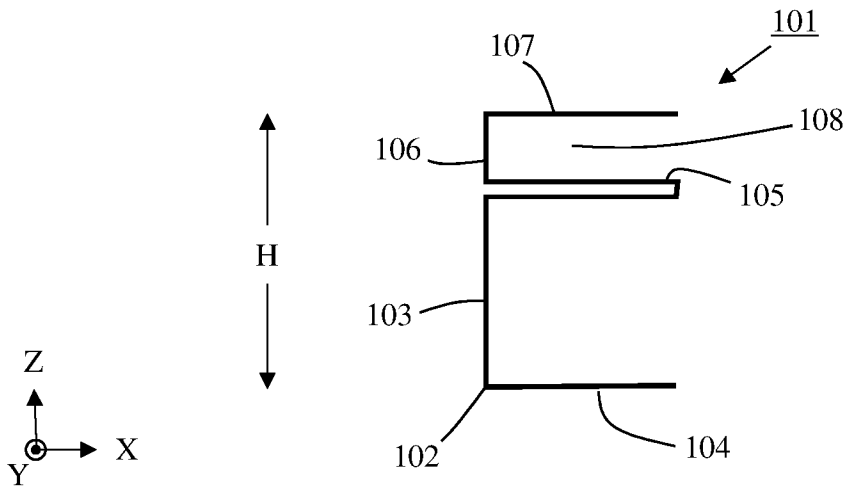


FIG. 1C

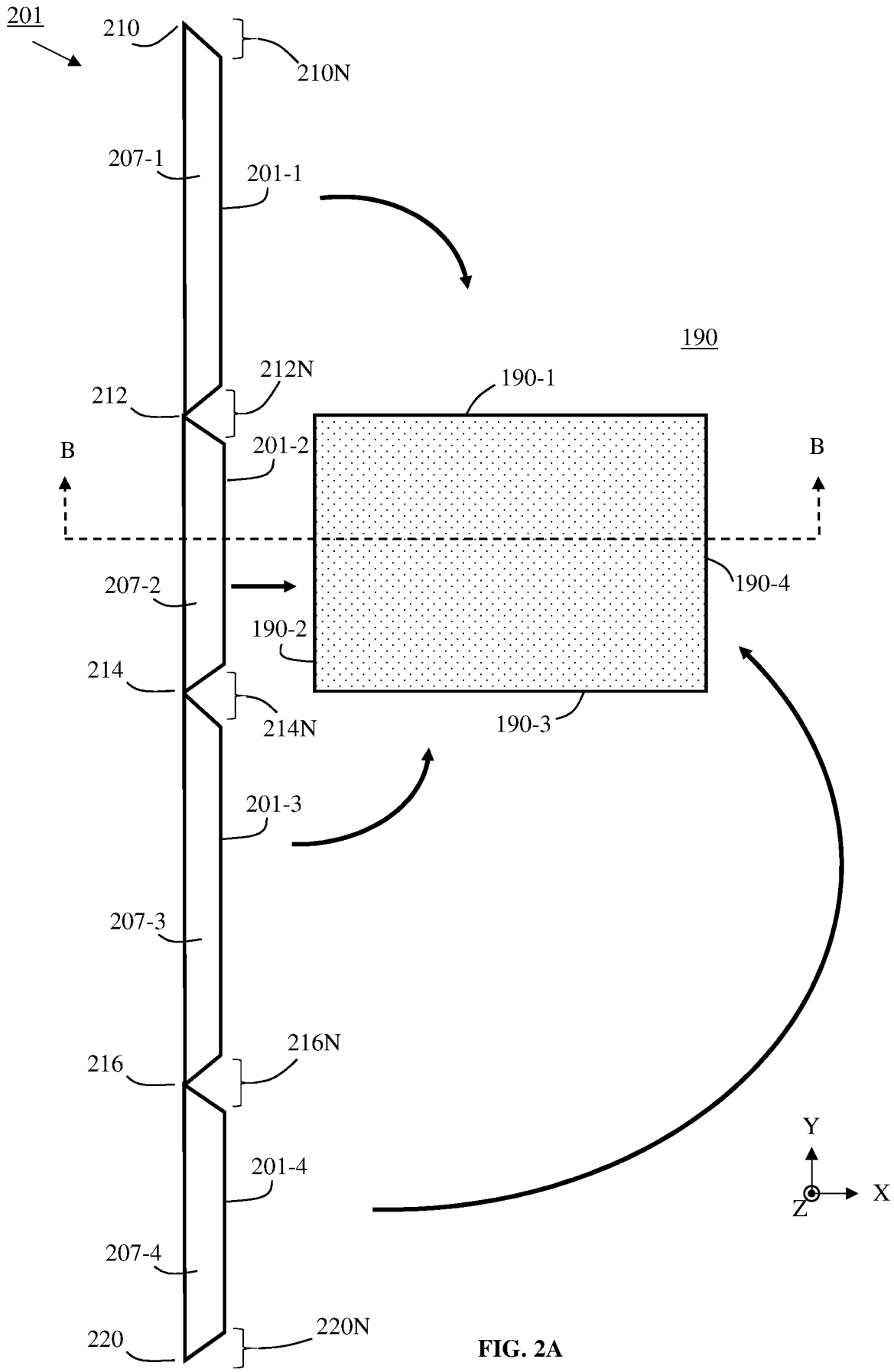

201
210
210N
207-1
201-1
190
212N
190-1
212
201-2
B
B
207-2
190-4
190-2
214
214N
190-3
201-3
207-3
216N
216
201-4
Y
X
Z
207-4
220
220N

FIG. 2A

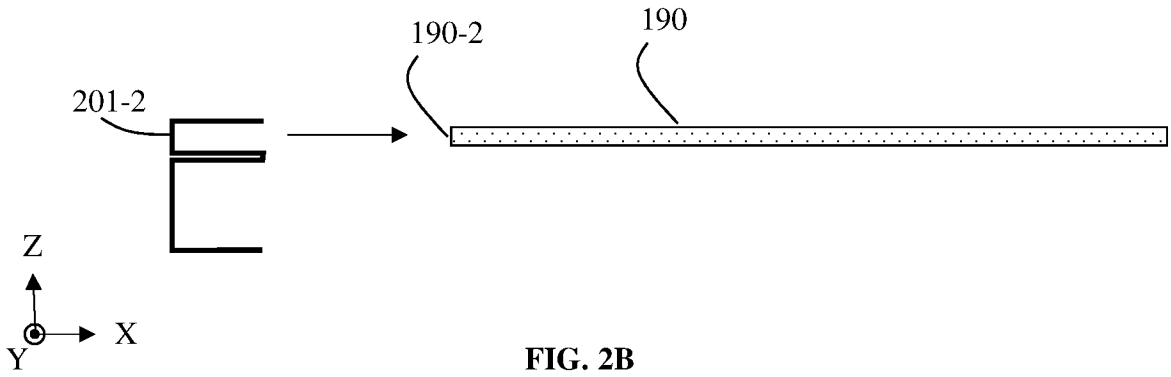

190-2
190
201-2
Z
X
Y

FIG. 2B

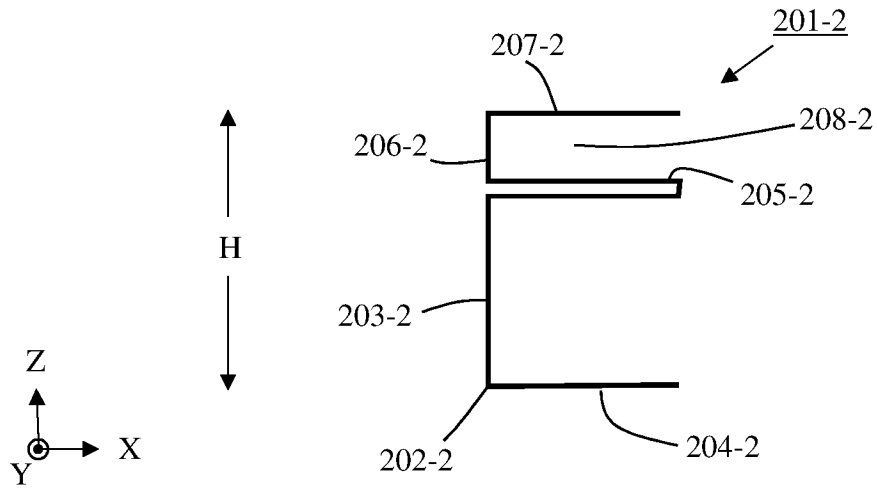

201-2
207-2
208-2
206-2
205-2
H
203-2
Z
X
Y
202-2
204-2

FIG. 2C

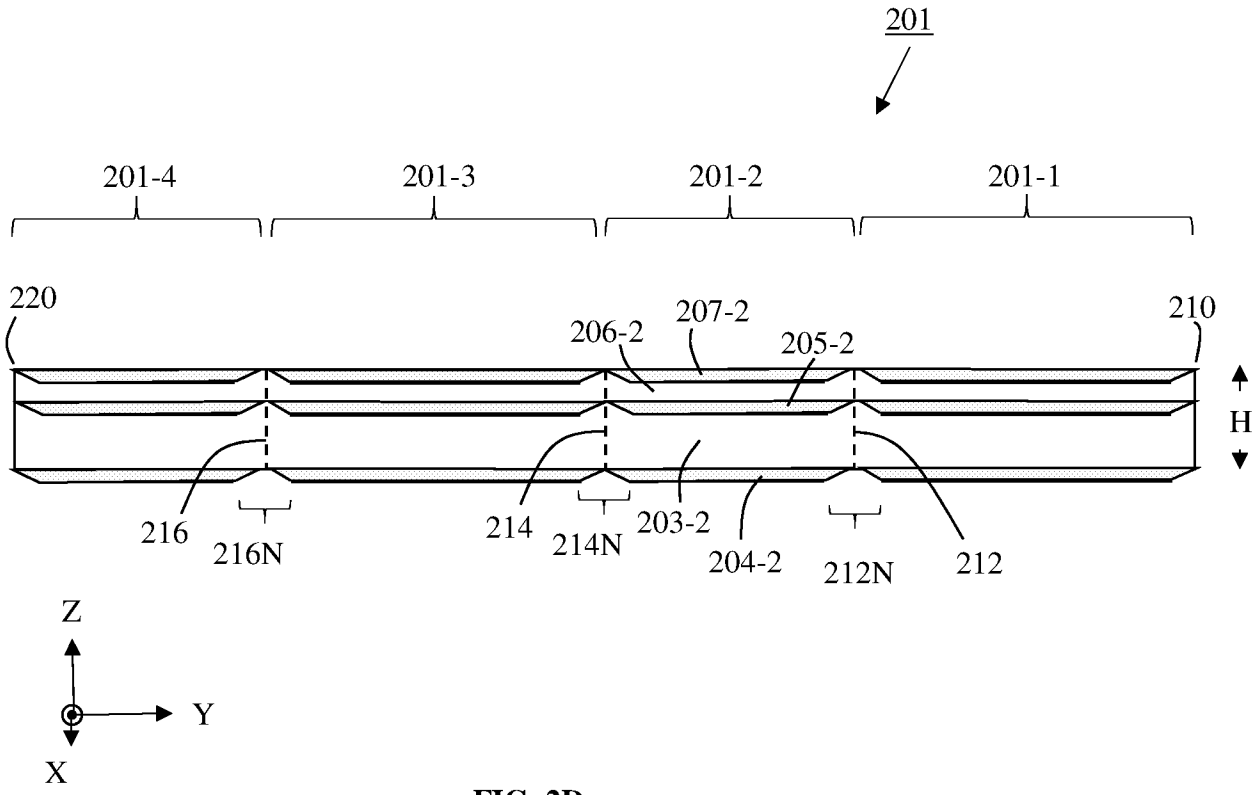

201
201-4
201-3
201-2
201-1
220
206-2
207-2
205-2
210
H
216
216N
214
214N
203-2
204-2
212N
212
Z
Y
X

FIG. 2D

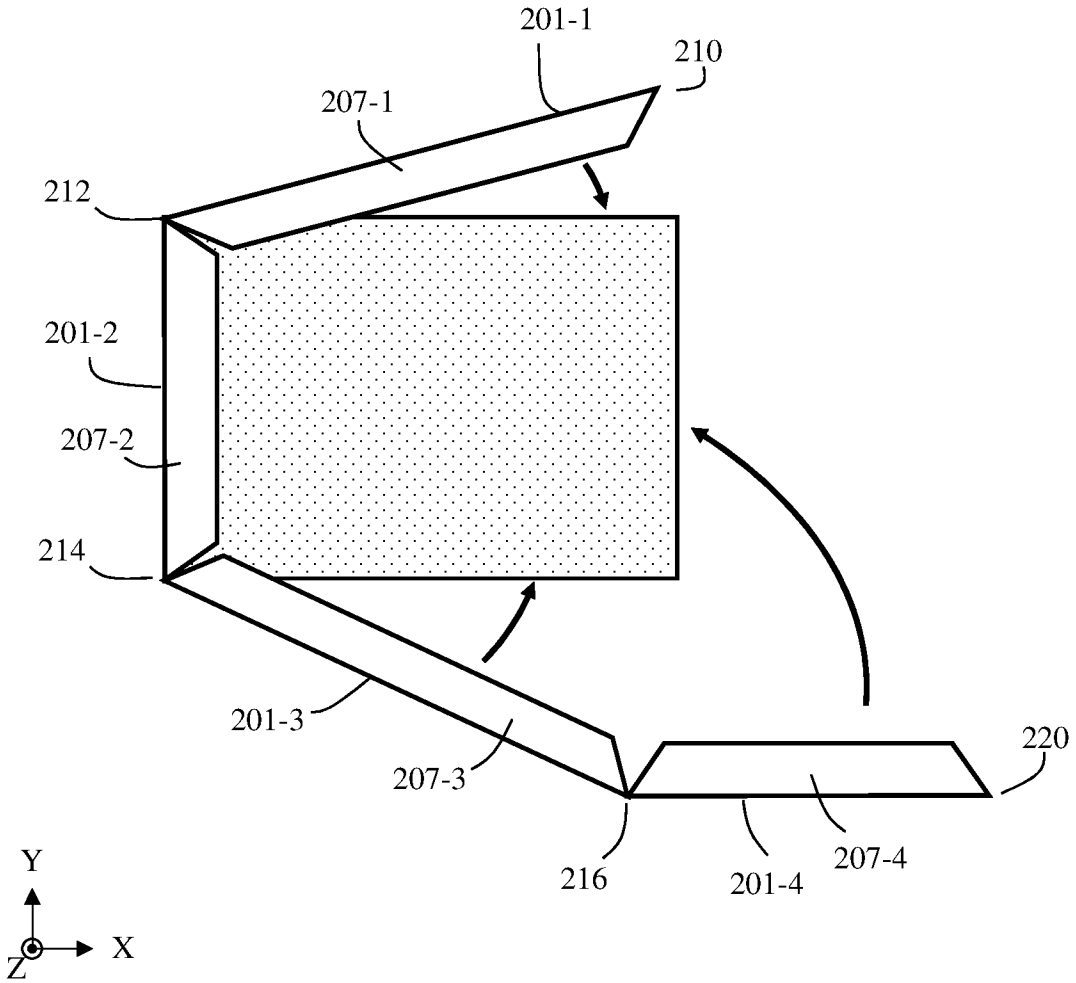

201-1
210
207-1
212
201-2
207-2
214
201-3
207-3
220
216
201-4
207-4
Y
X
Z

FIG. 2E

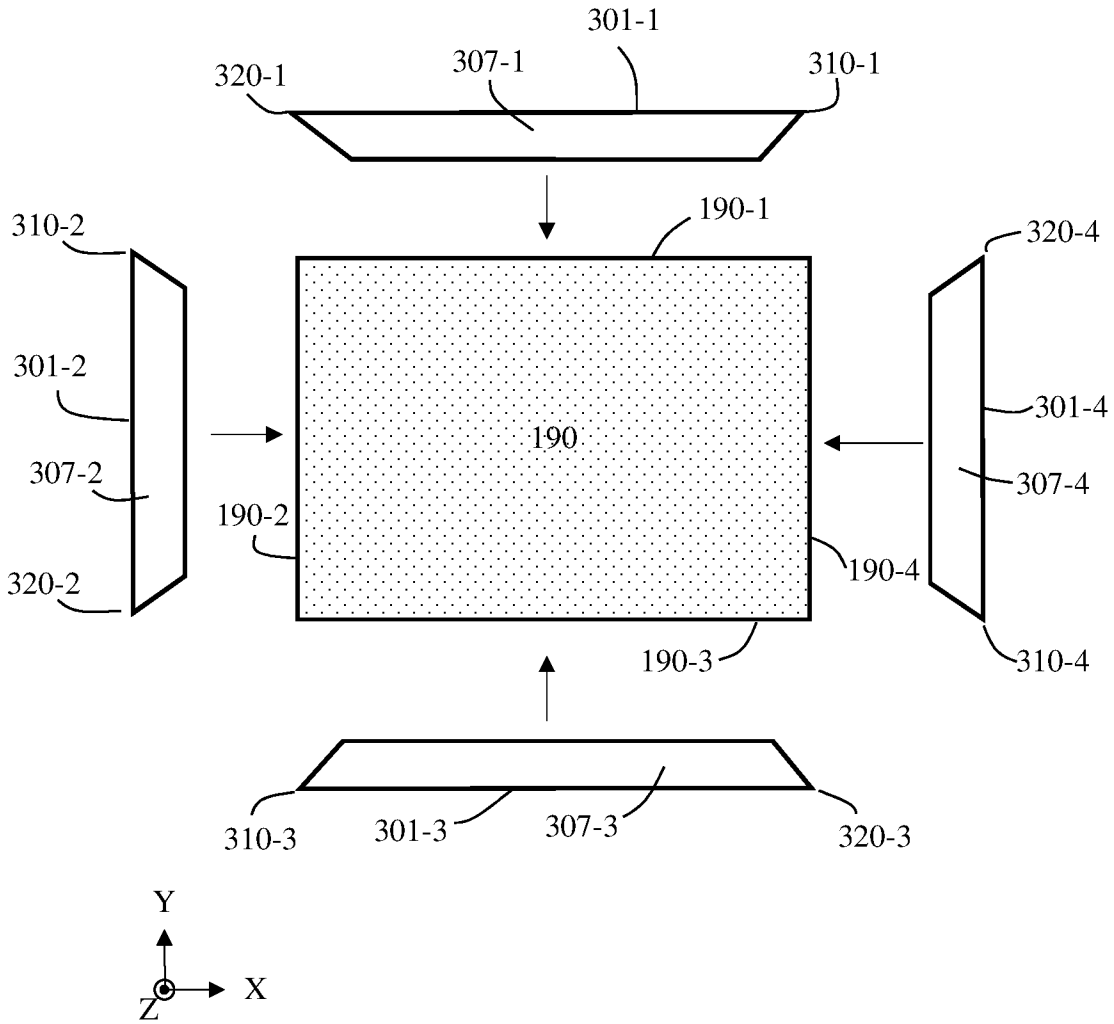

301-1
320-1
307-1
310-1
190-1
310-2
320-4
301-2
301-4
190
307-2
307-4
190-2
190-4
320-2
190-3
310-4
310-3
301-3
307-3
320-3
Y
X
Z

FIG. 3

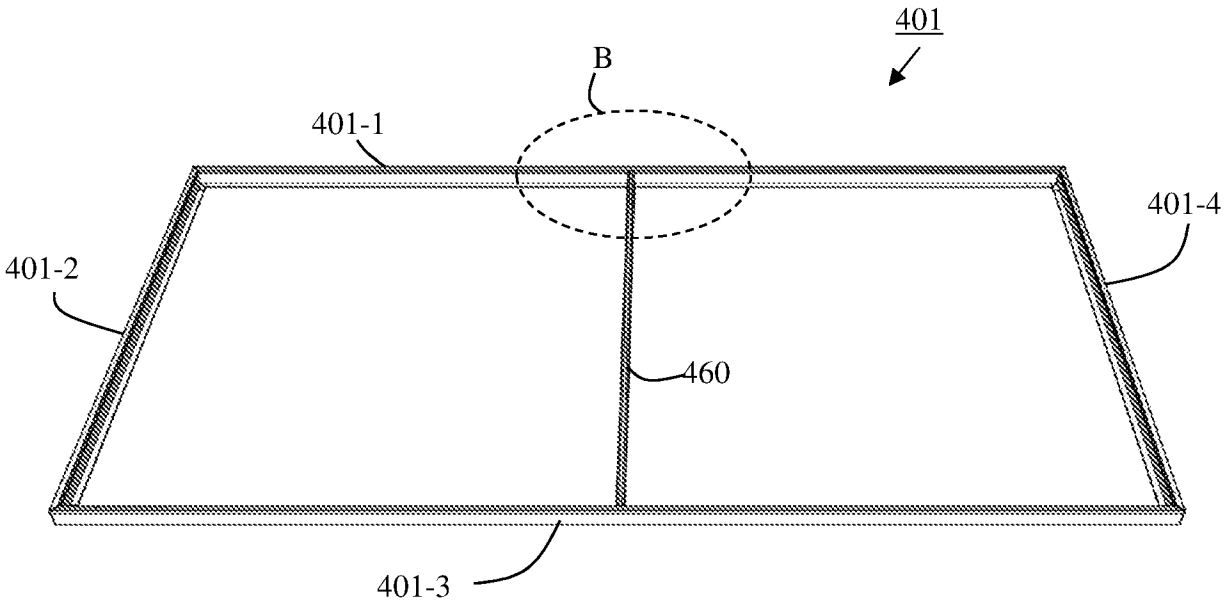

401
B
401-1
401-4
401-2
460
401-3

FIG. 4A

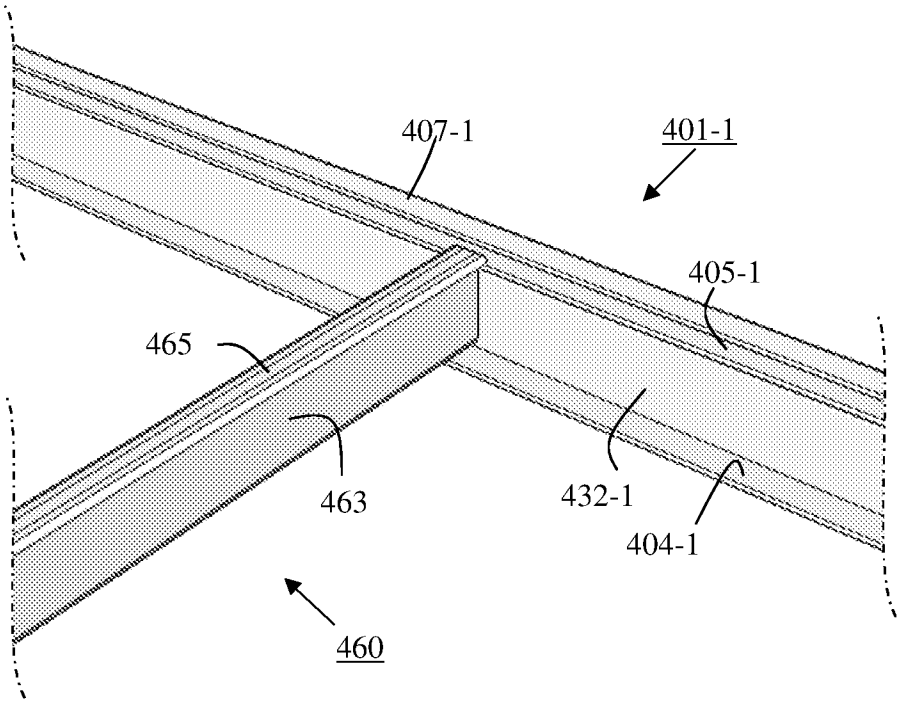

407-1
401-1
405-1
465
463
432-1
404-1
460

FIG. 4B

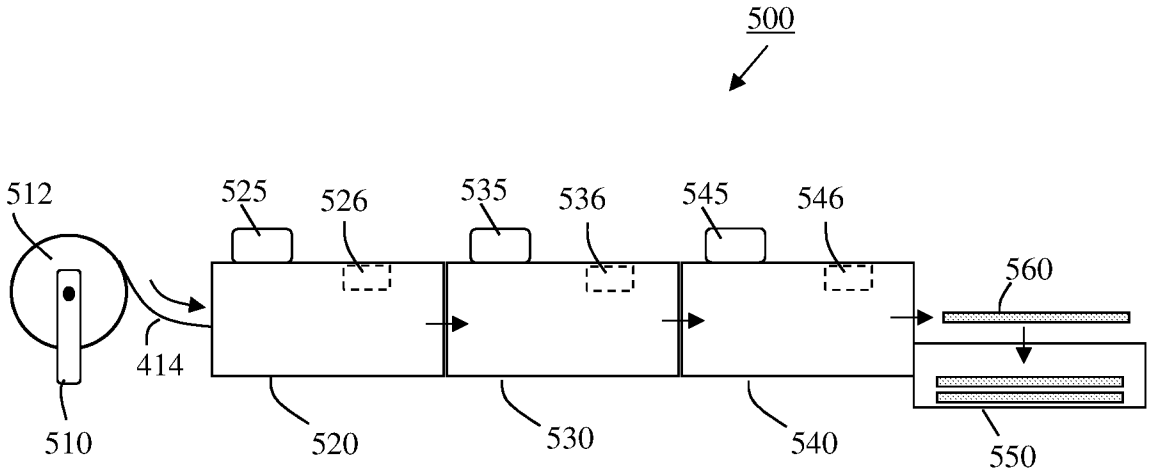


FIG. 5

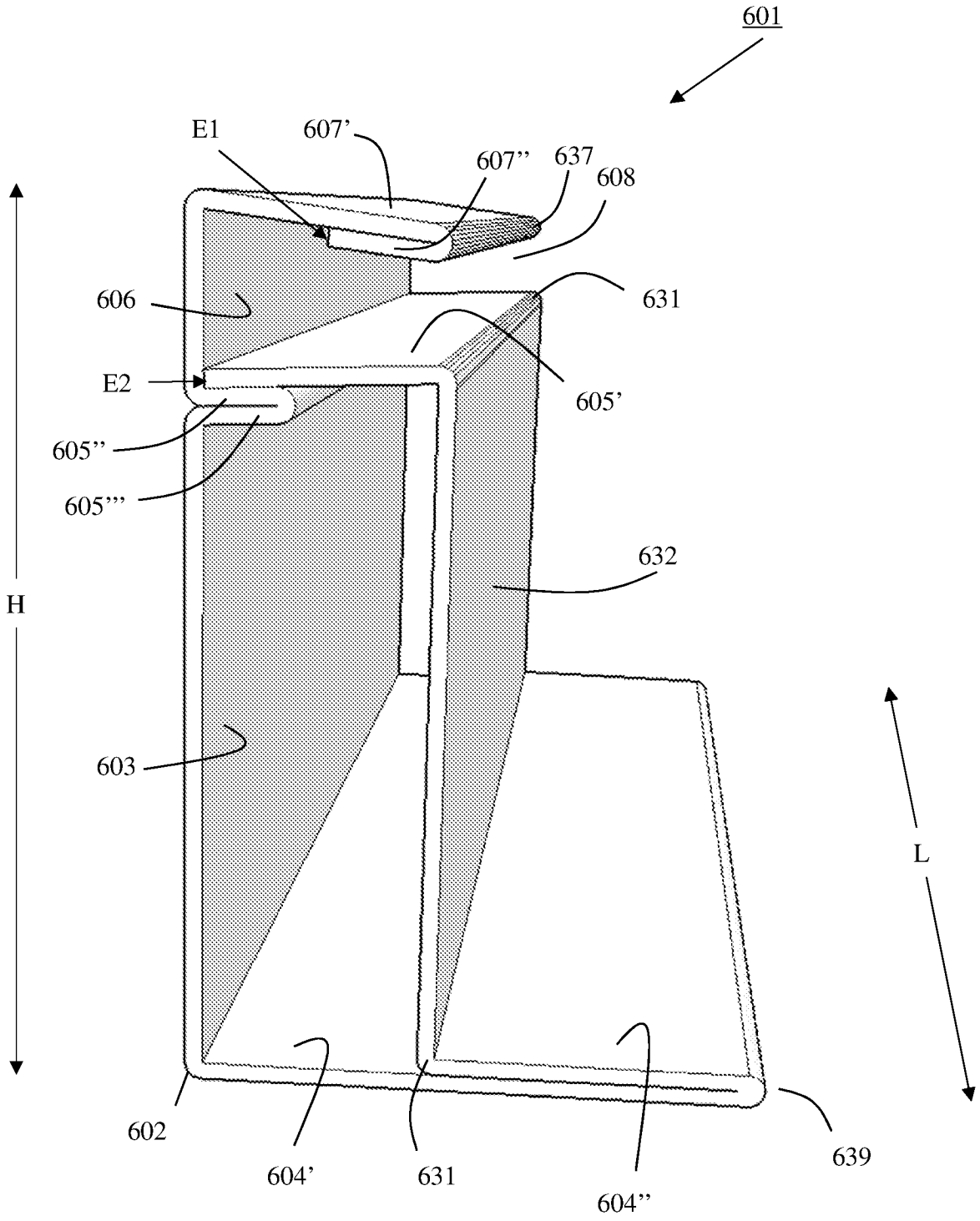

601
E1
607'
607''
637
608
606
631
E2
605'
605''
605'''
632
H
603
L
602
604'
631
604''
639

FIG. 6A

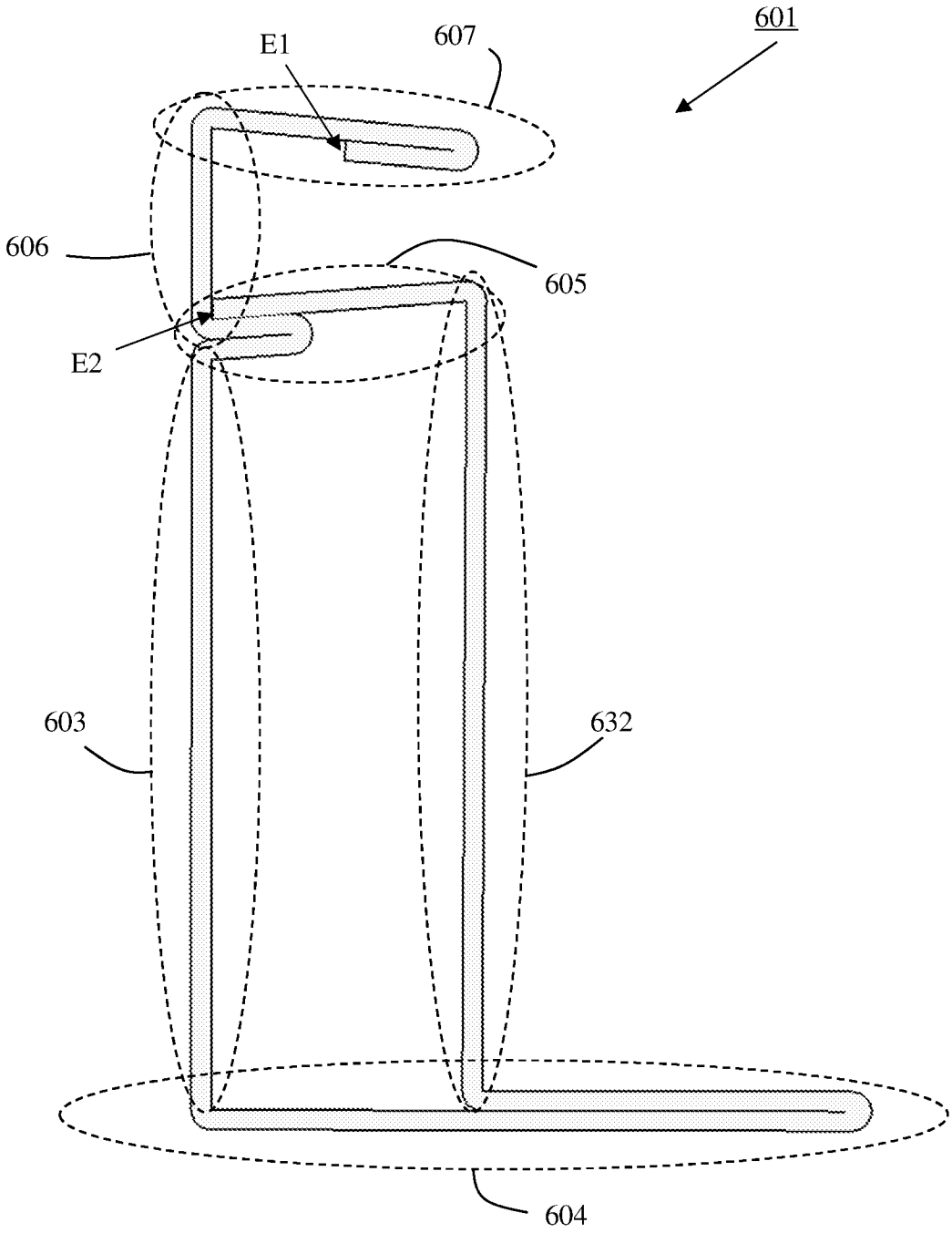


FIG. 6B

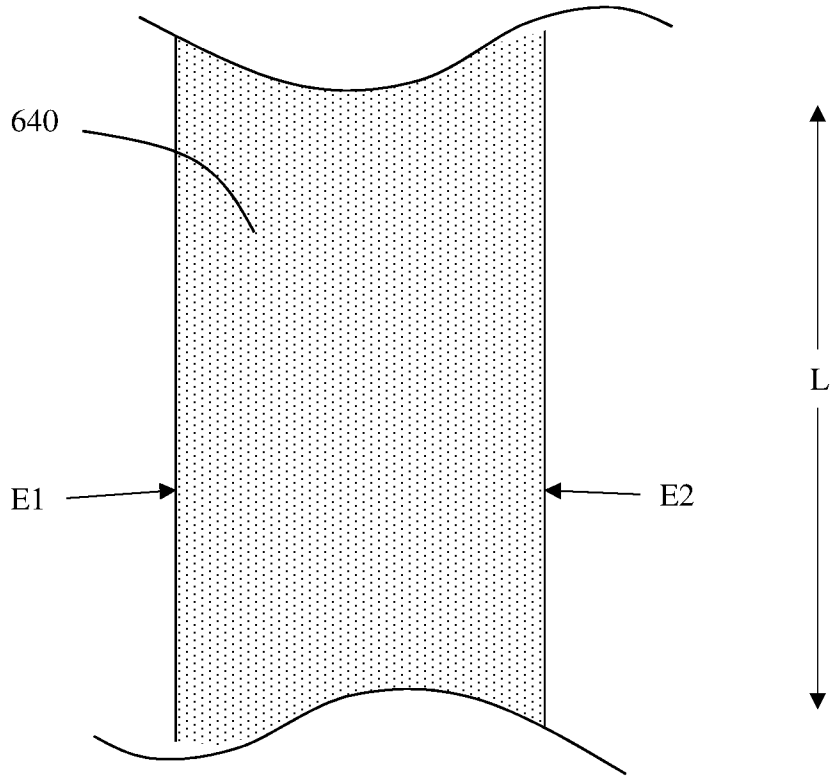
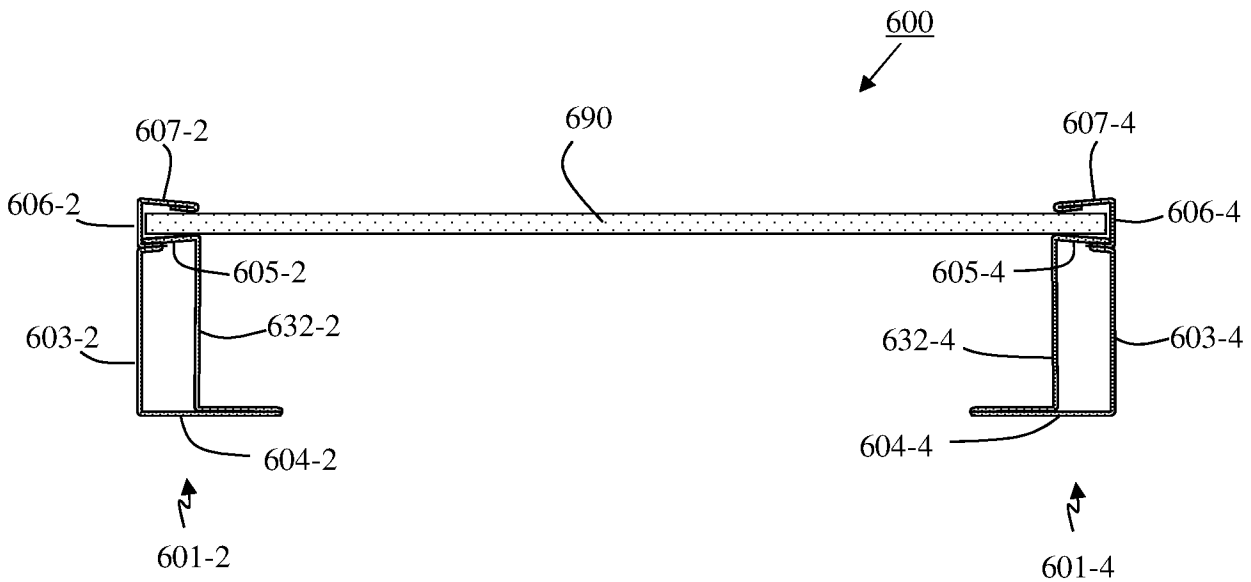

640
L
E1
E2

FIG. 6C


600
607-2
690
607-4
606-2
606-4
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605-4
603-2
632-2
632-4
603-4
604-2
604-4
601-2
601-4

FIG. 6D

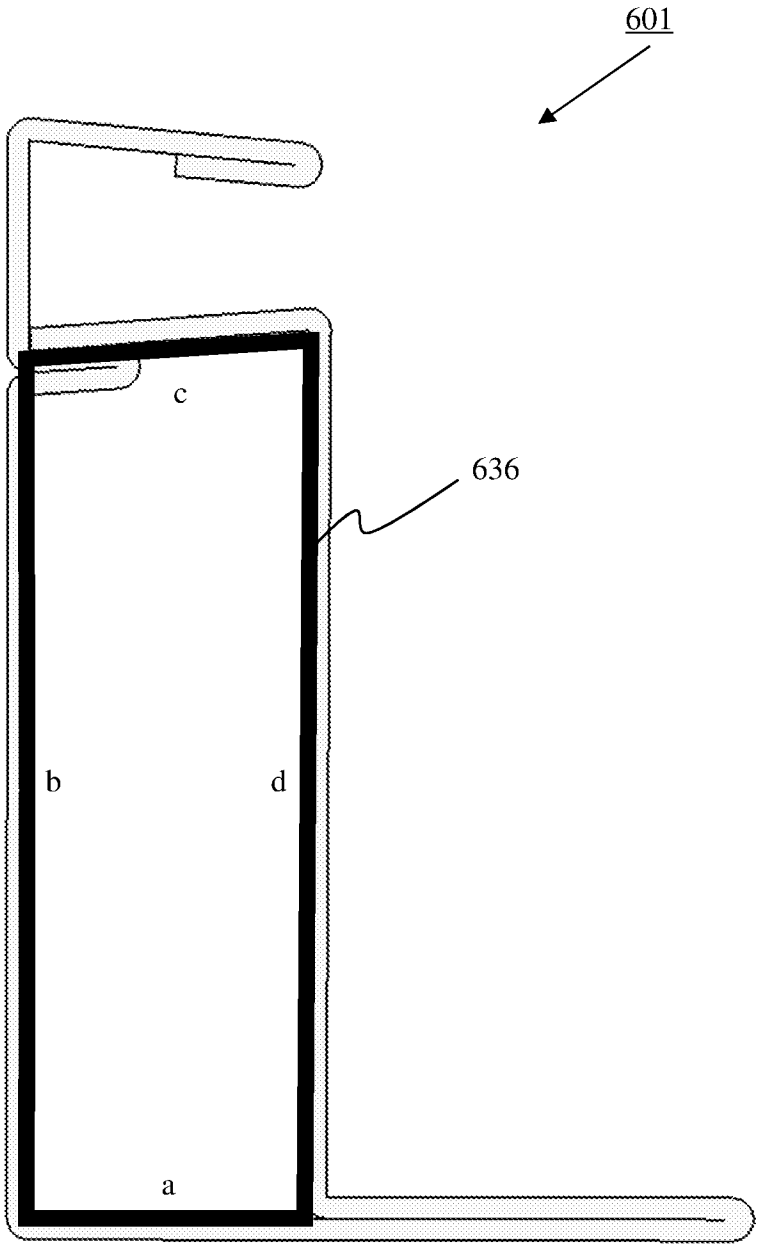

FIG. 6E

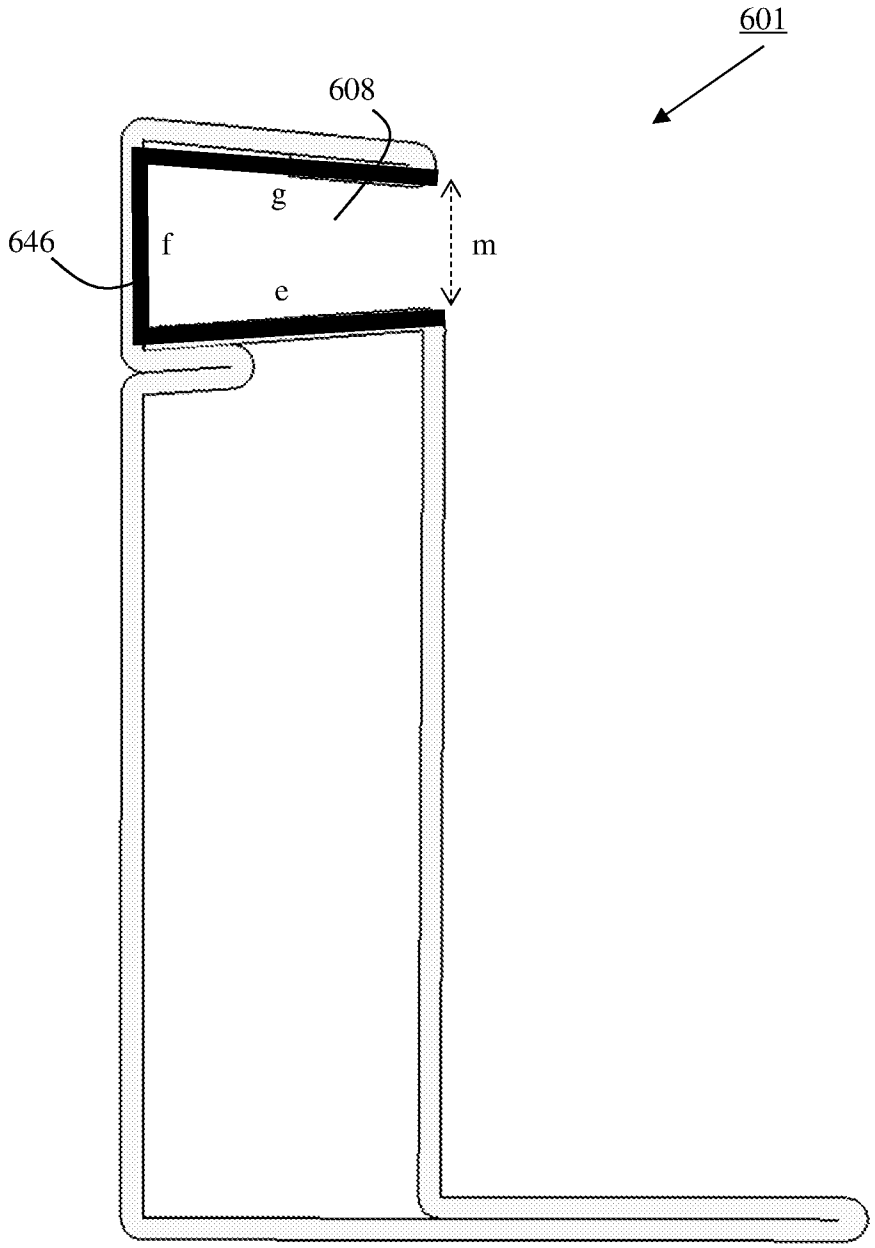

FIG. 6F

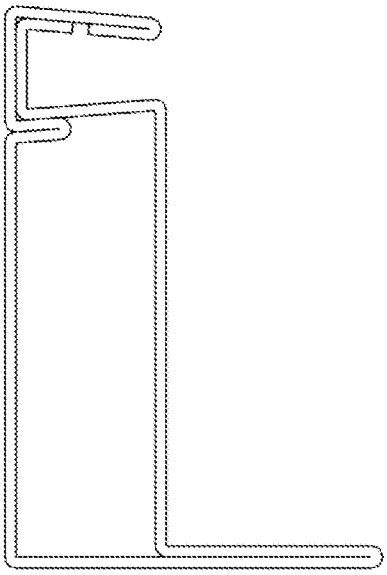

FIG. 7A

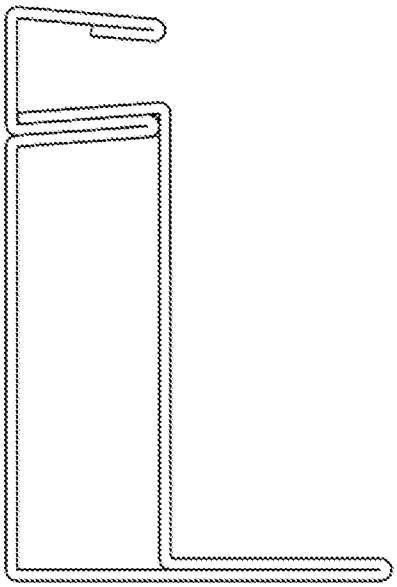

FIG. 7B

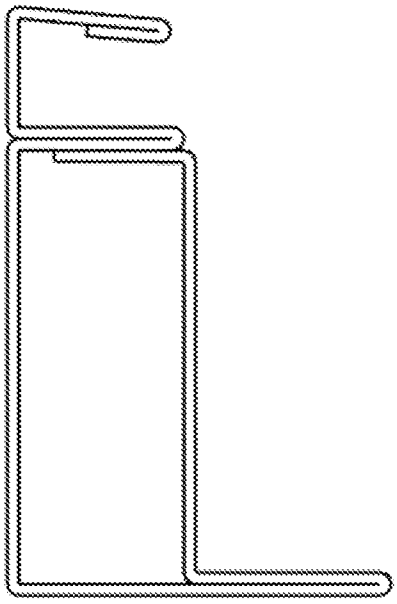

FIG. 7C

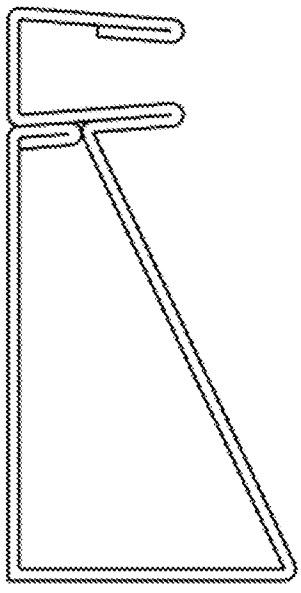

FIG. 7D

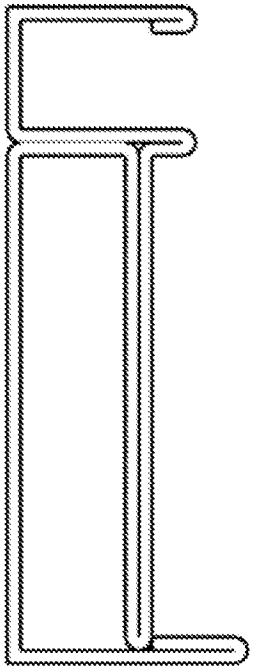

FIG. 7E

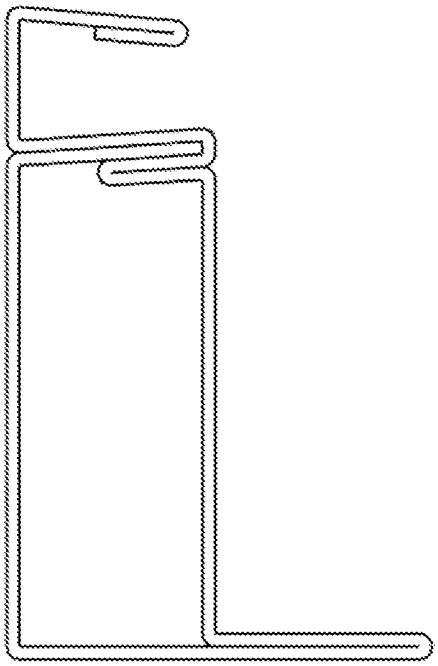

FIG. 7F

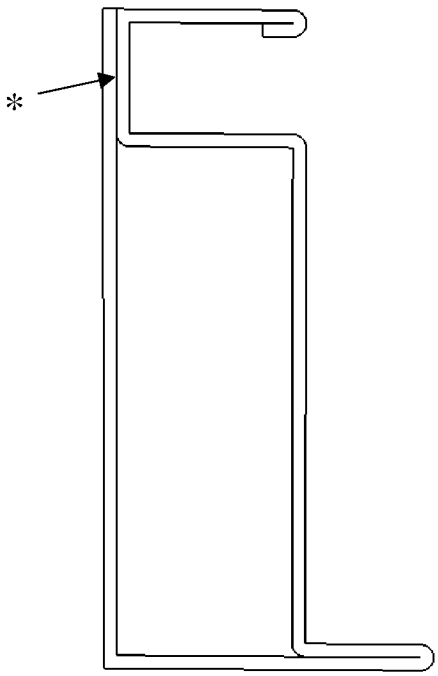

FIG. 7G

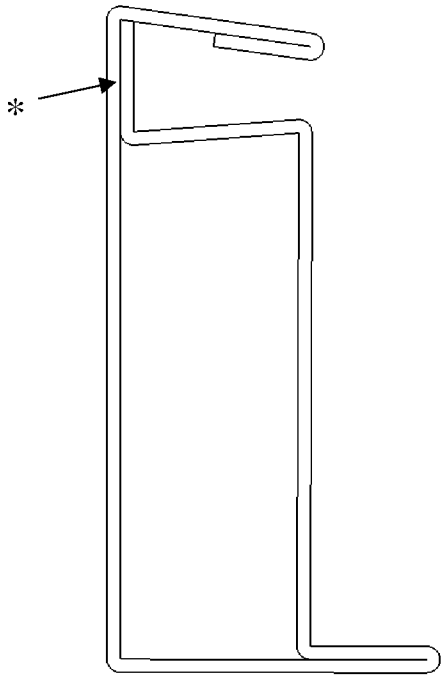

FIG. 7H

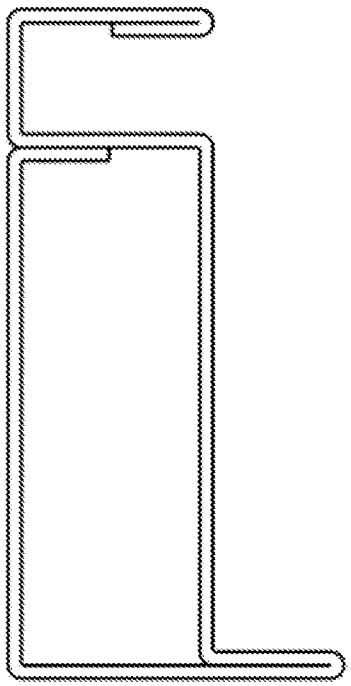

FIG. 7I

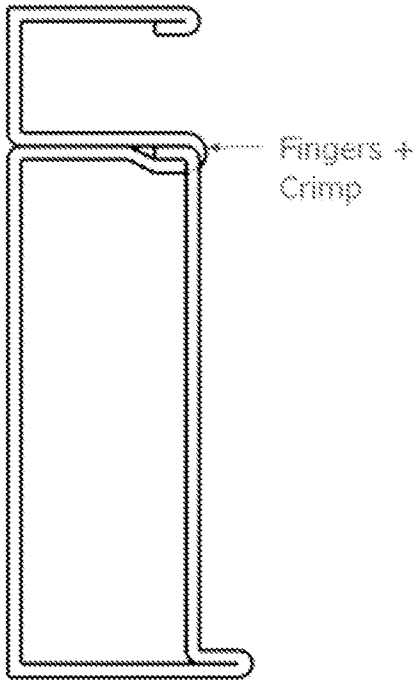

FIG. 7J

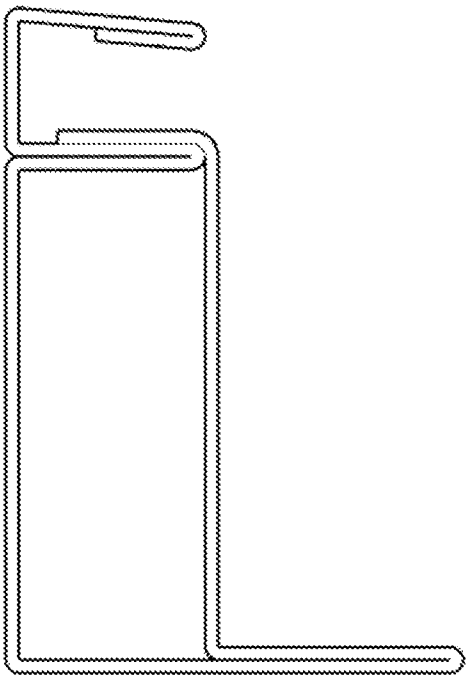

FIG. 7K

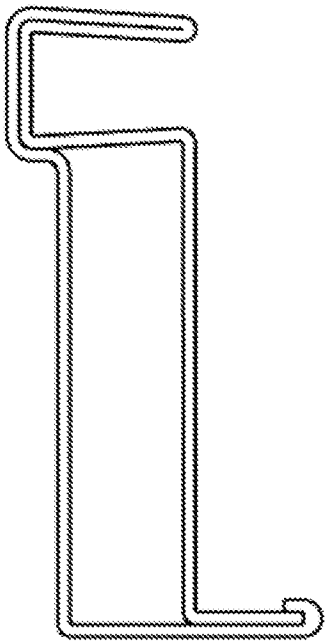

FIG. 7L

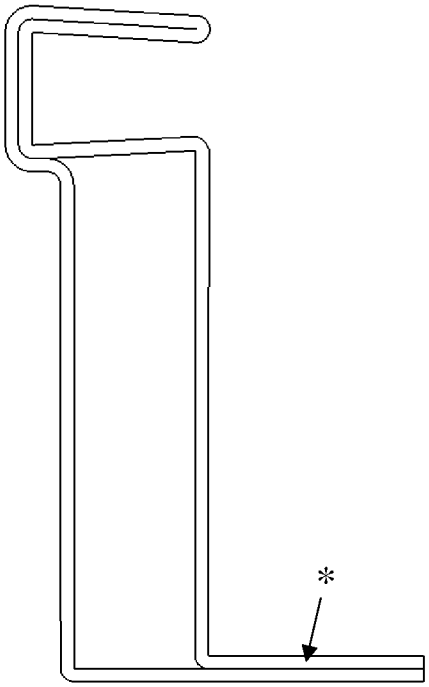

FIG. 7M

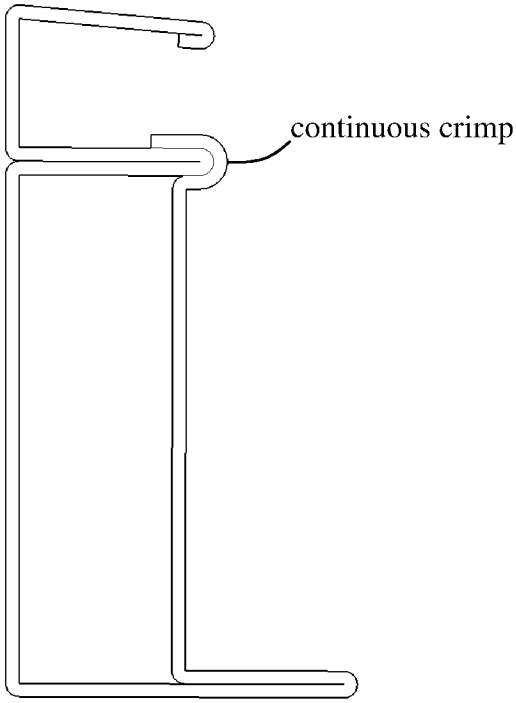

FIG. 7N

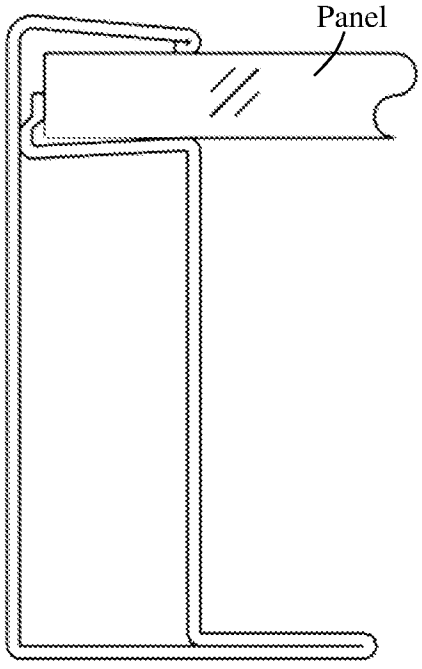

FIG. 7O

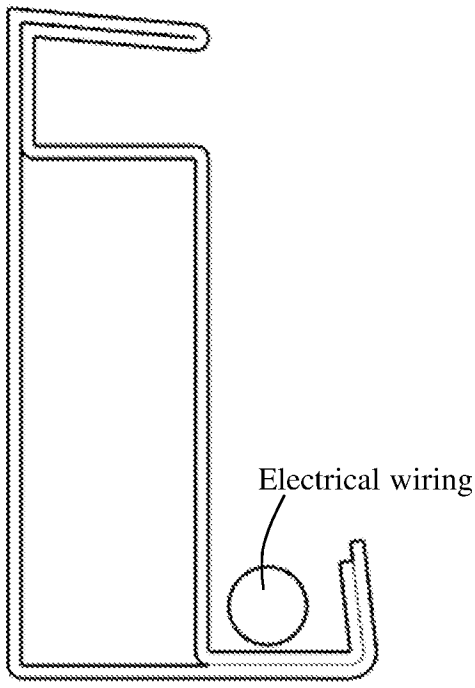

FIG. 7P

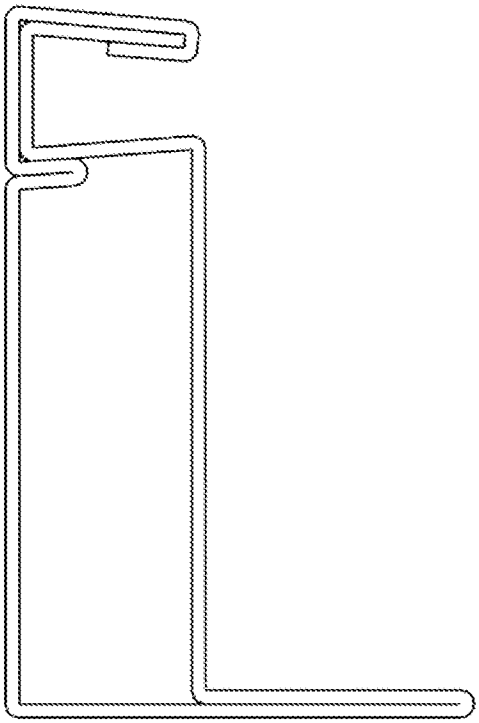

FIG. 7Q

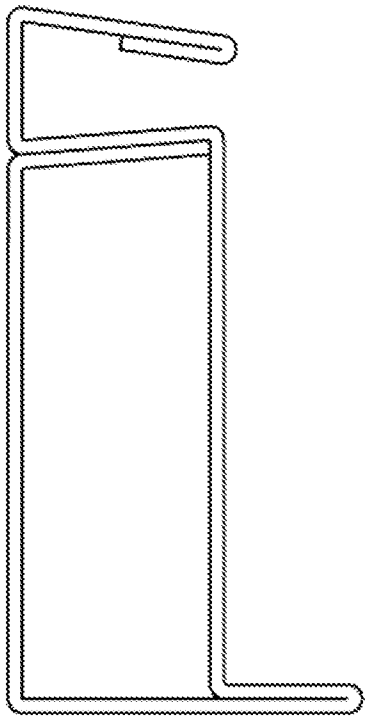

FIG. 7R

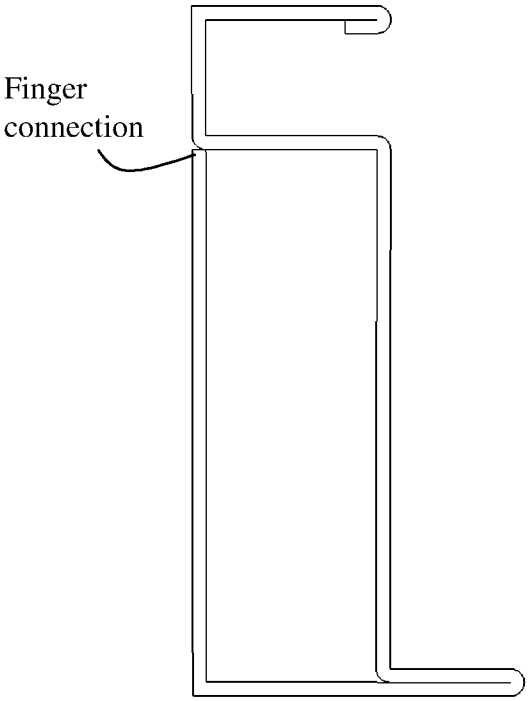

FIG. 7S

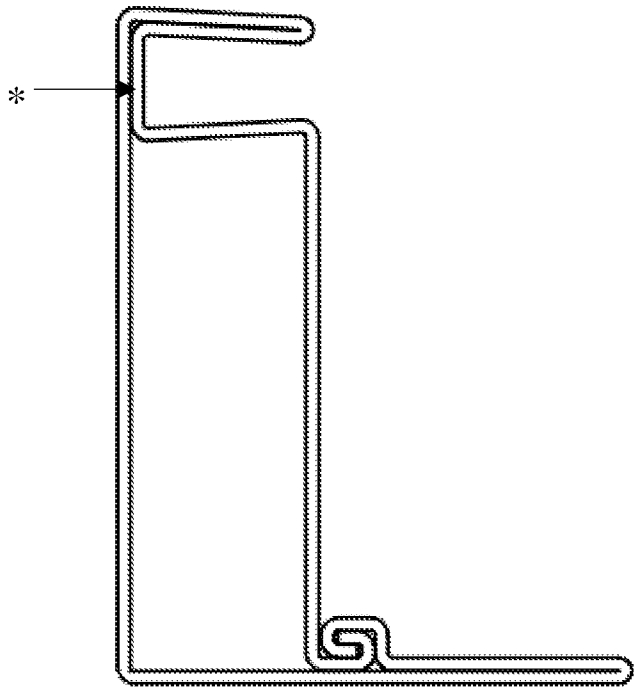

FIG. 7T

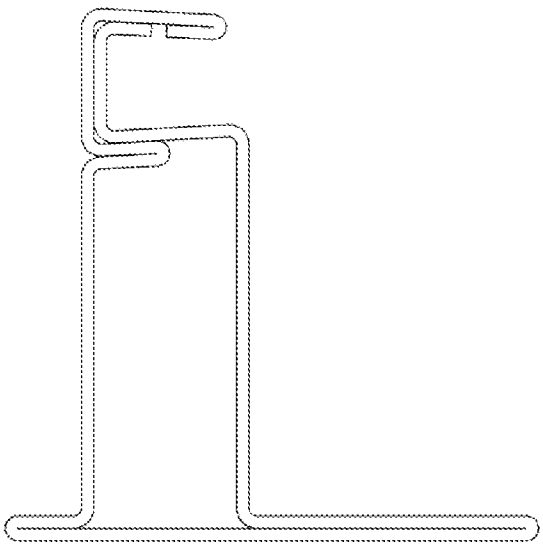

FIG. 7U

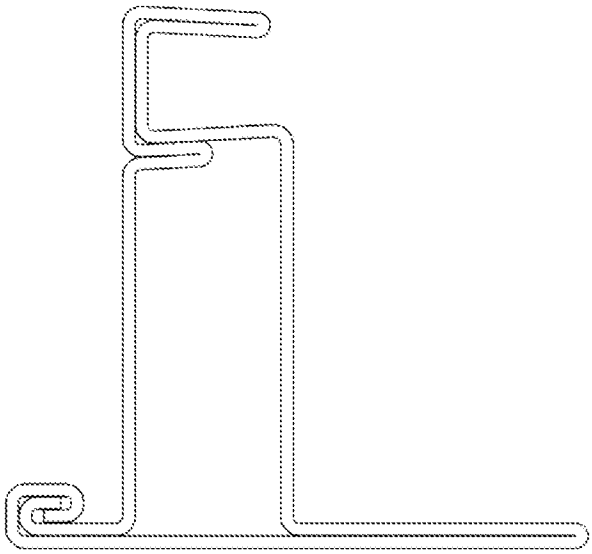

FIG. 7V

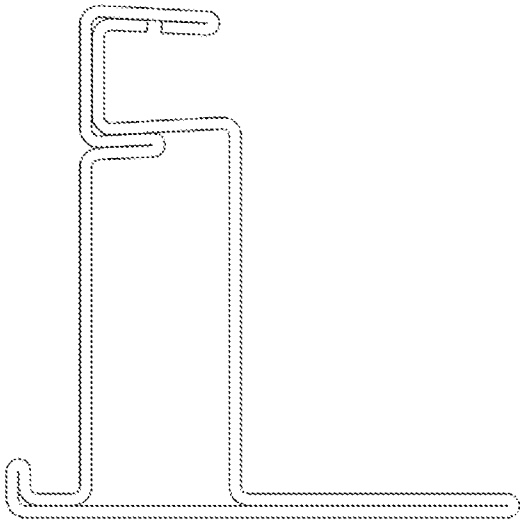

FIG. 7W

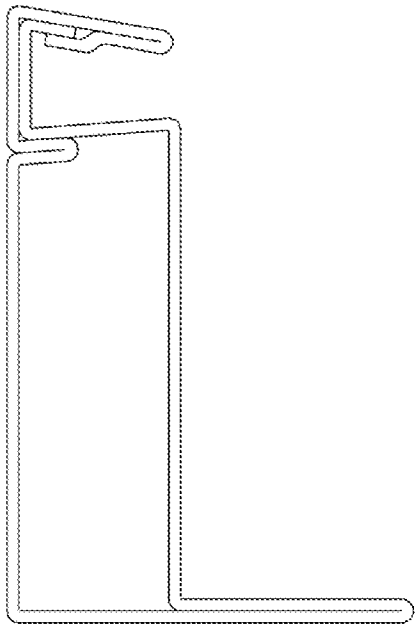

FIG. 7X

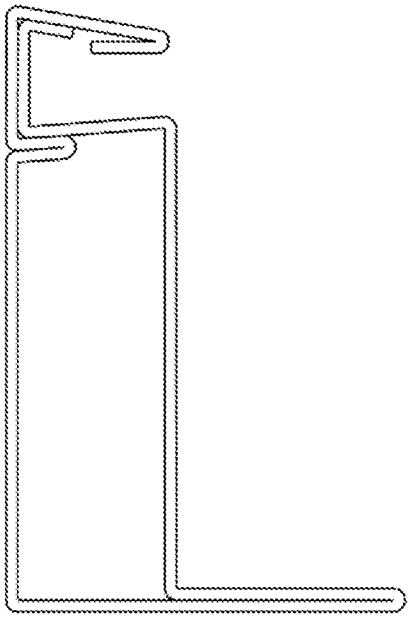

FIG. 7Y

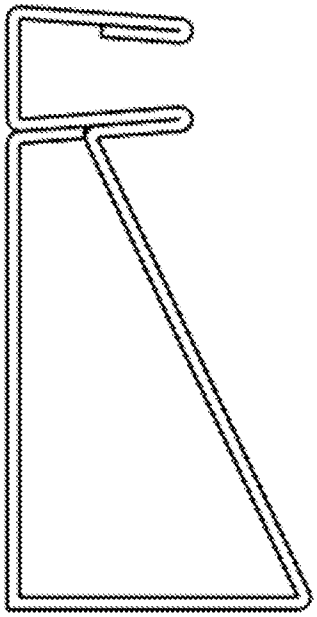

FIG. 7Z

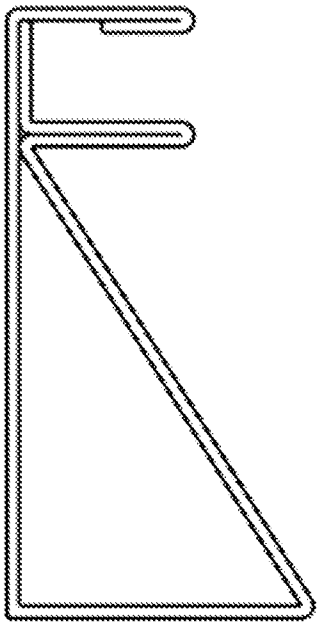

FIG. 7AA

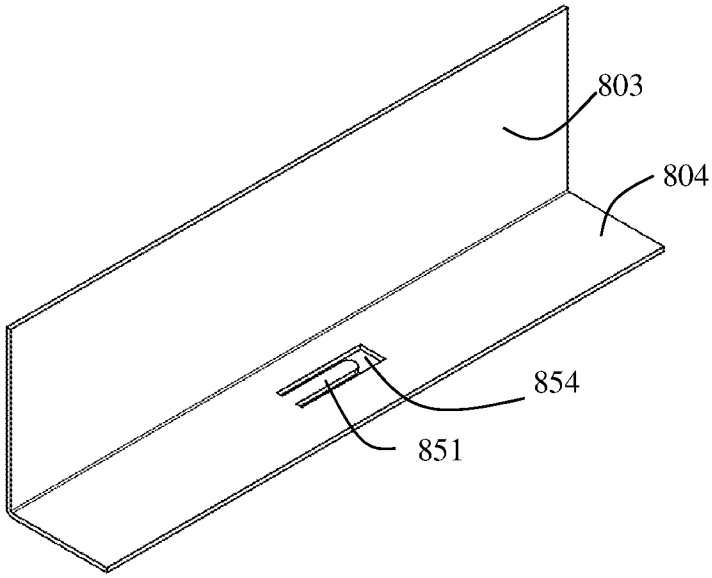

FIG. 8A

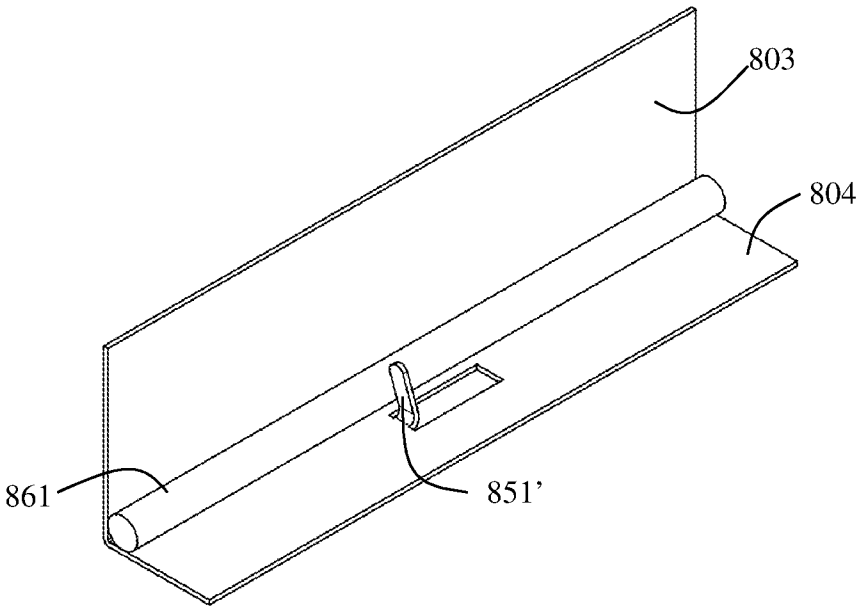

FIG. 8B

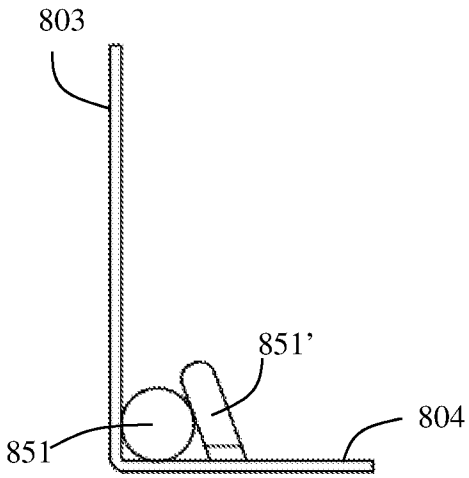

FIG. 8C

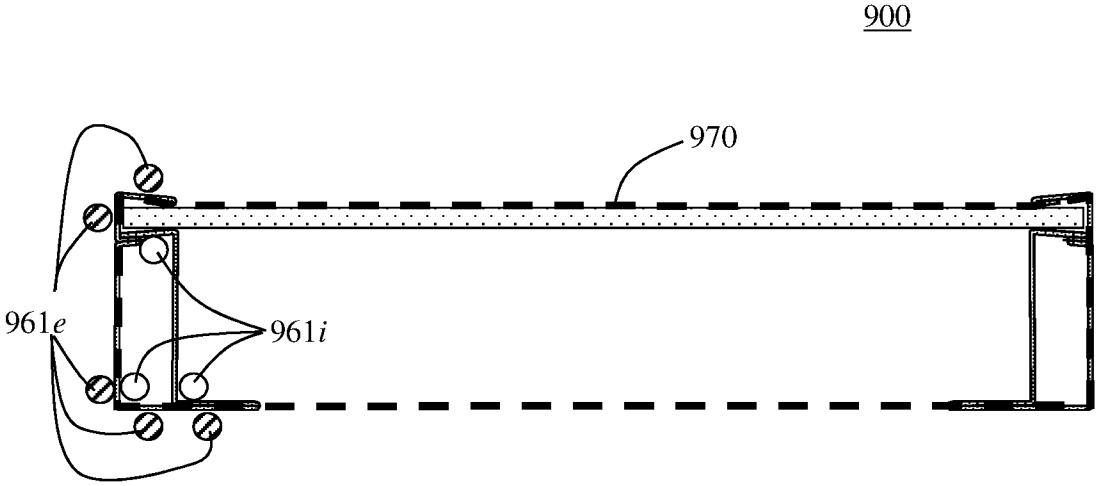

FIG. 9

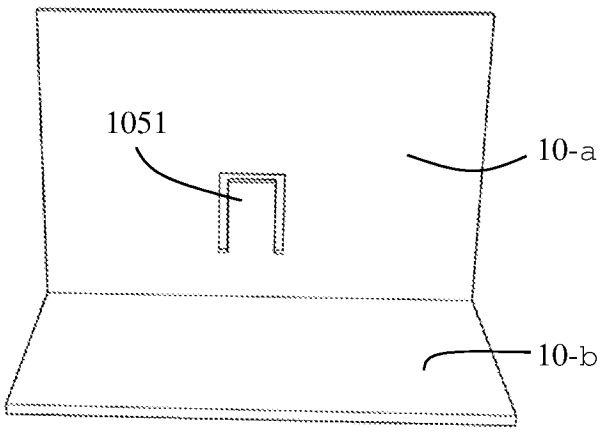

FIG. 10A

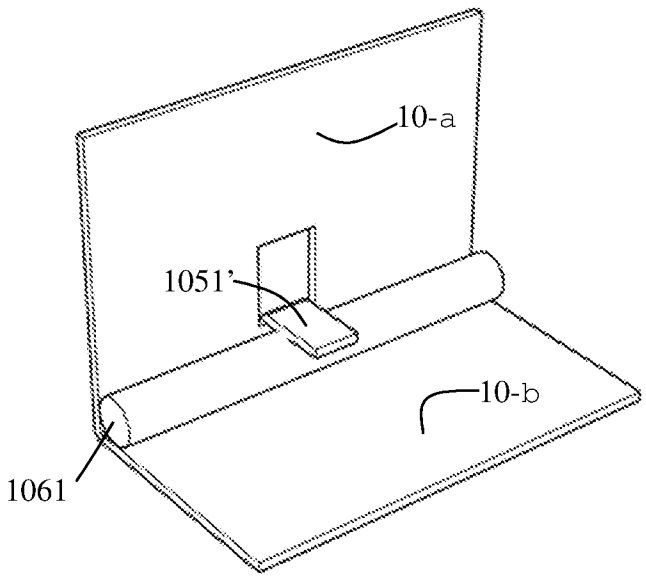

FIG. 10B

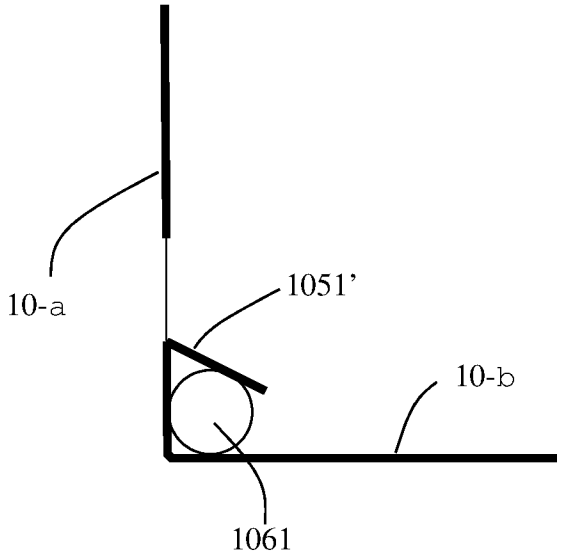

FIG. 10C

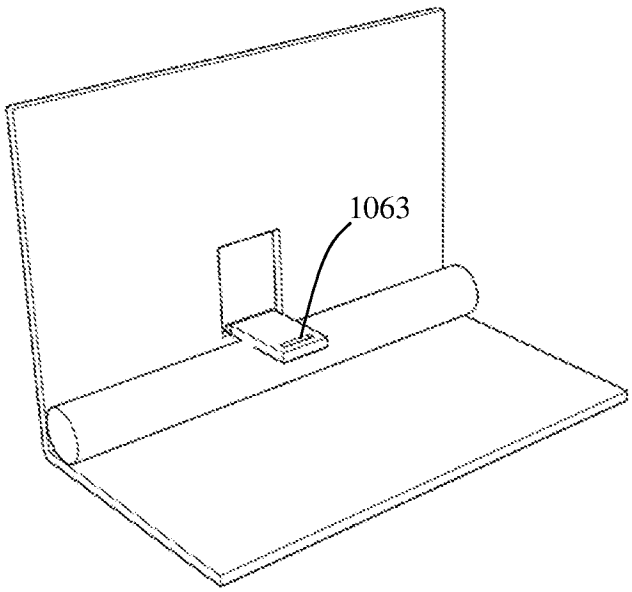

FIG. 10D

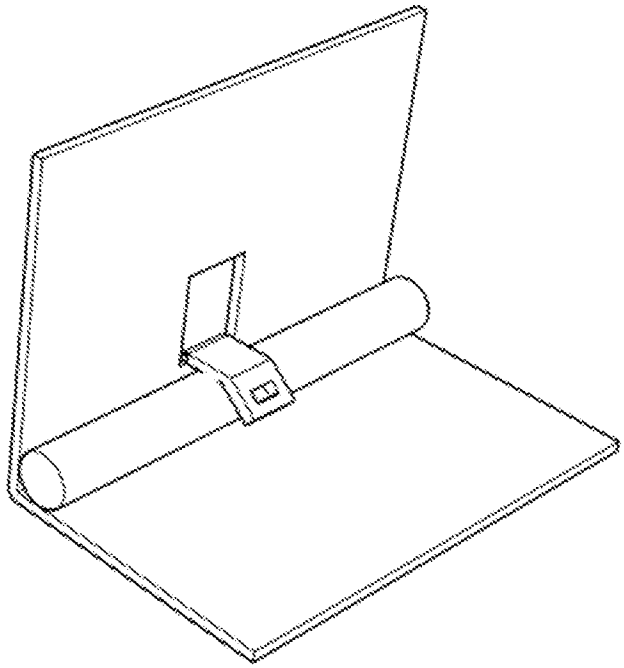

FIG. 10E

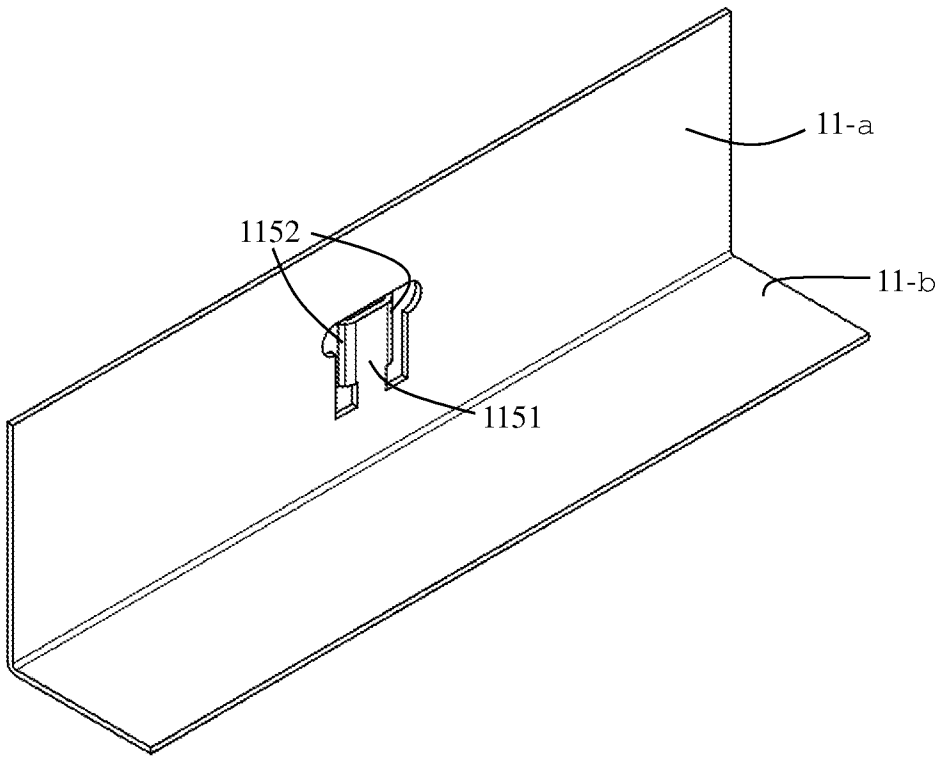

FIG. 11A

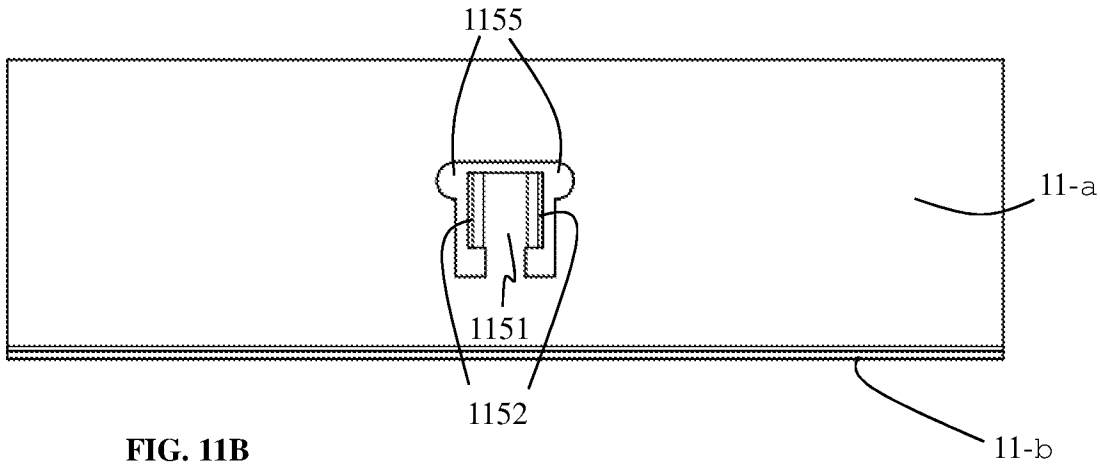

FIG. 11B

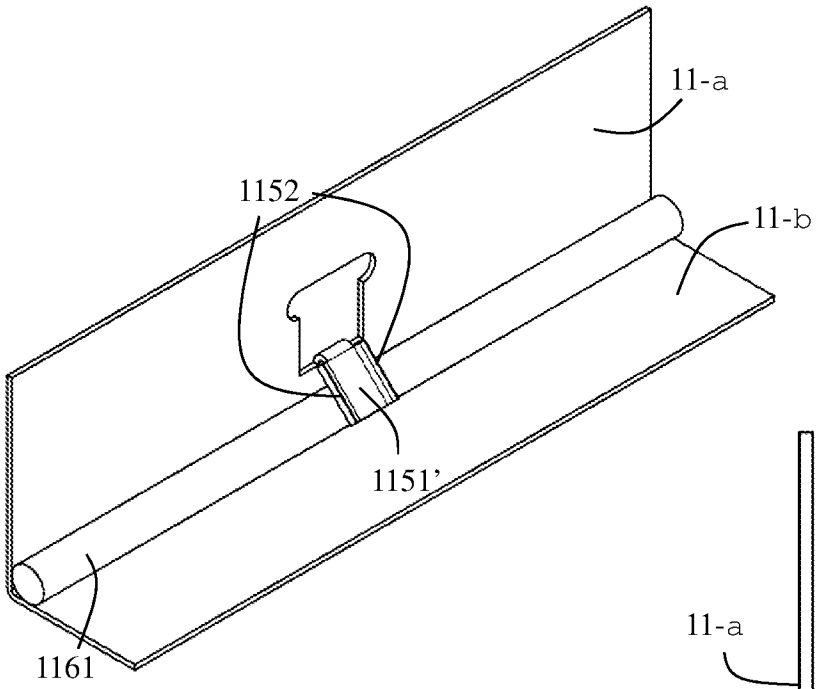

FIG. 11C

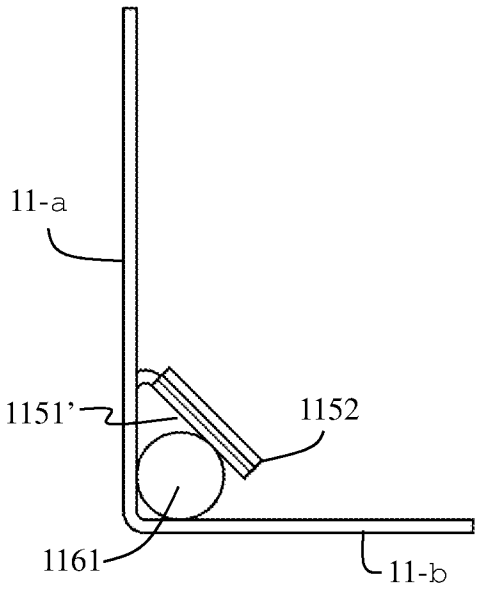

FIG. 11D

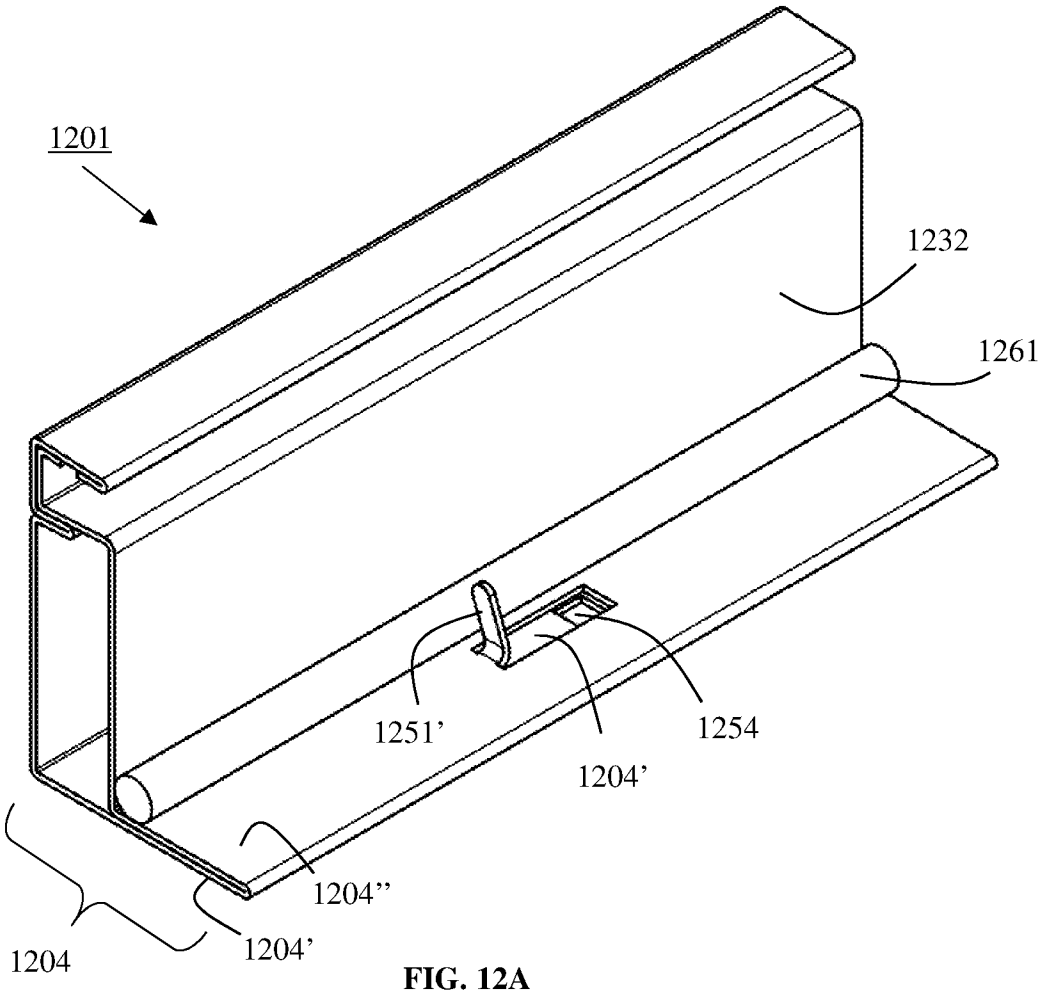

FIG. 12A

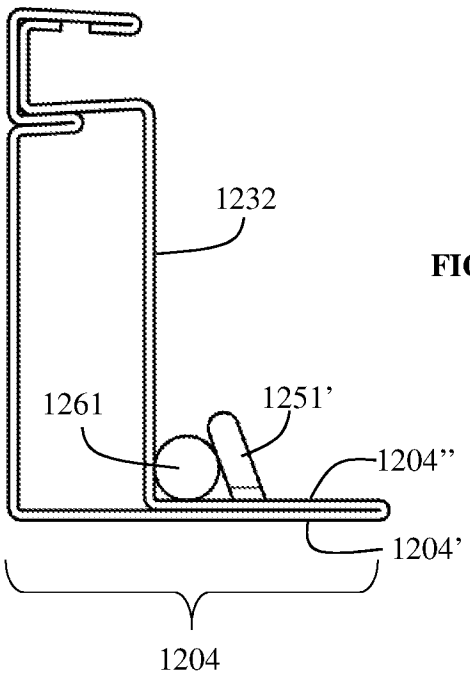

FIG. 12B

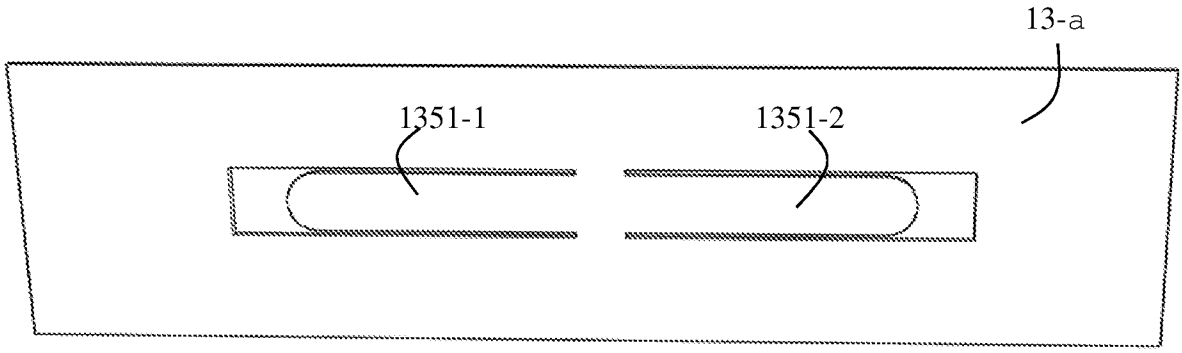

FIG. 13A

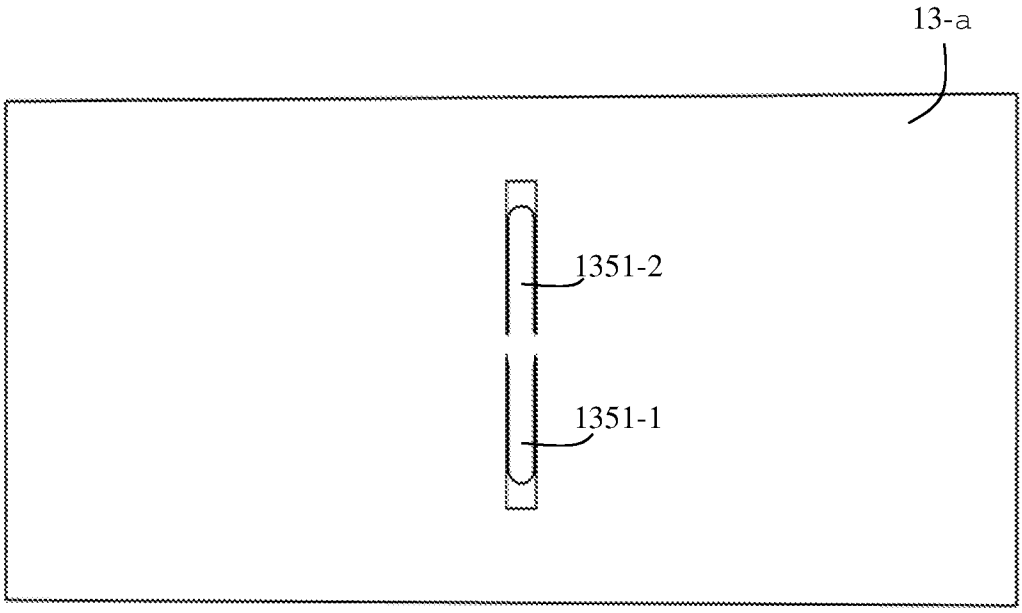

FIG. 13B

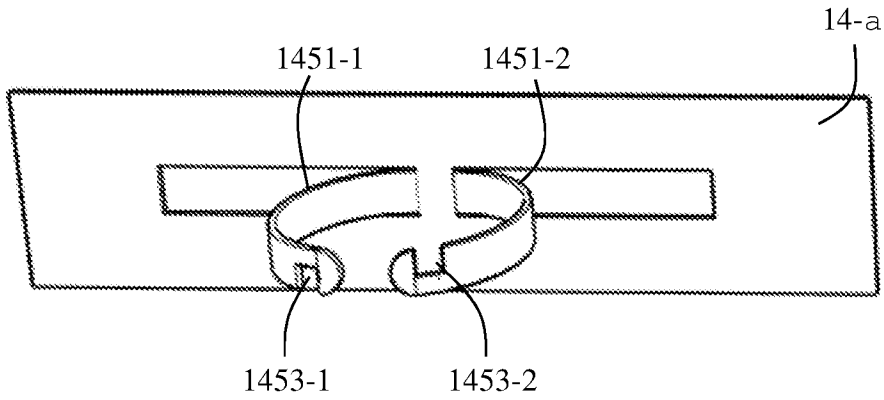

FIG. 14A

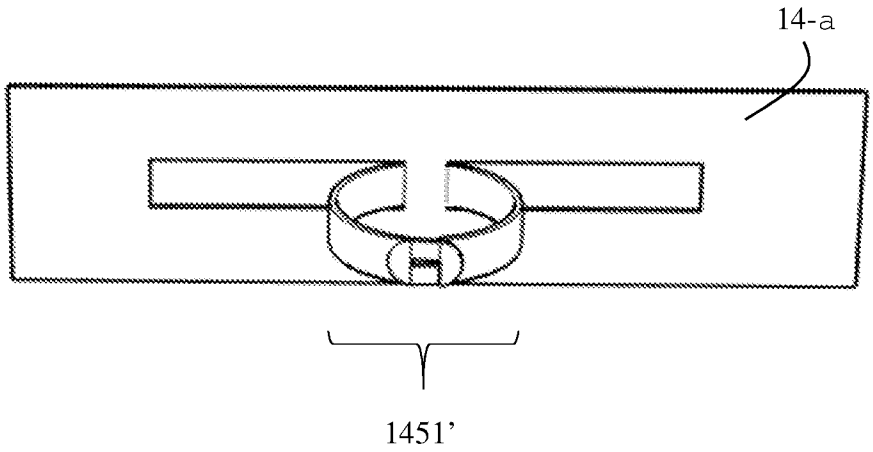

FIG. 14B

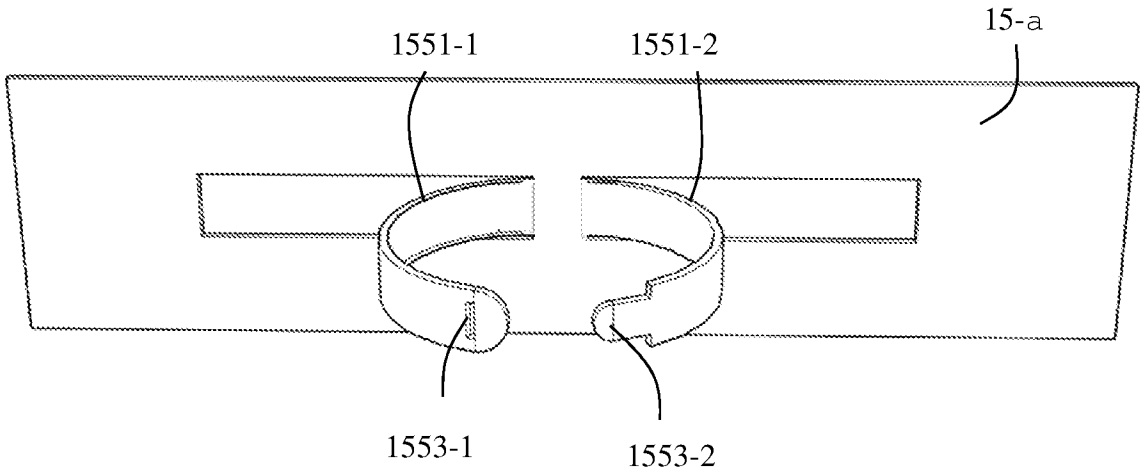

FIG. 15A

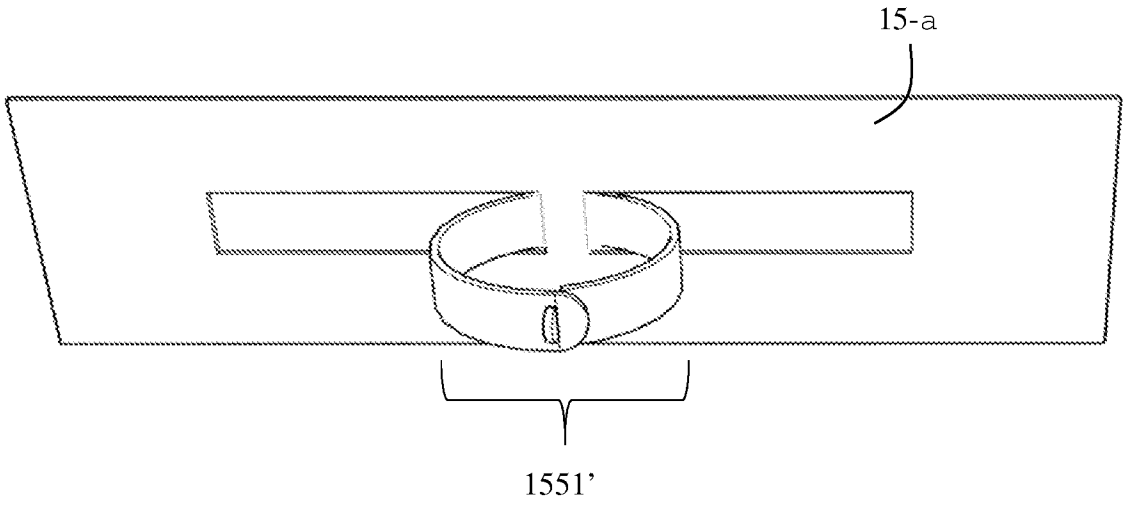

FIG. 15B

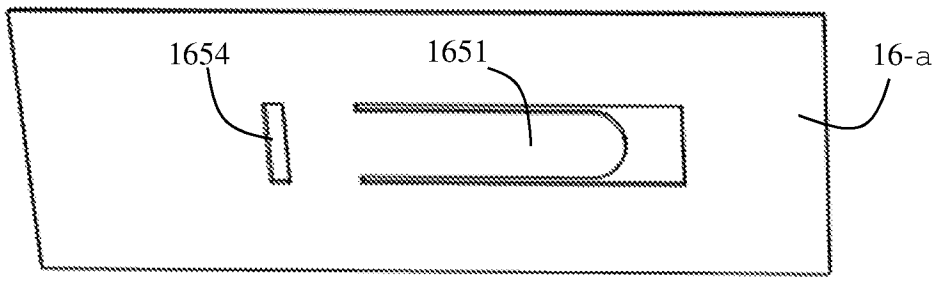

FIG. 16A

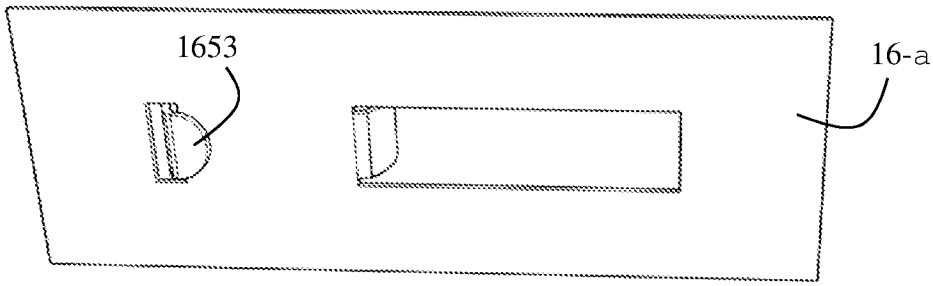

FIG. 16B

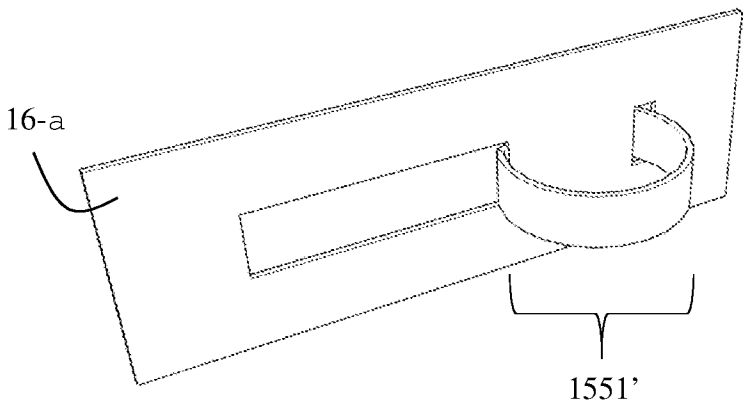

FIG. 16C

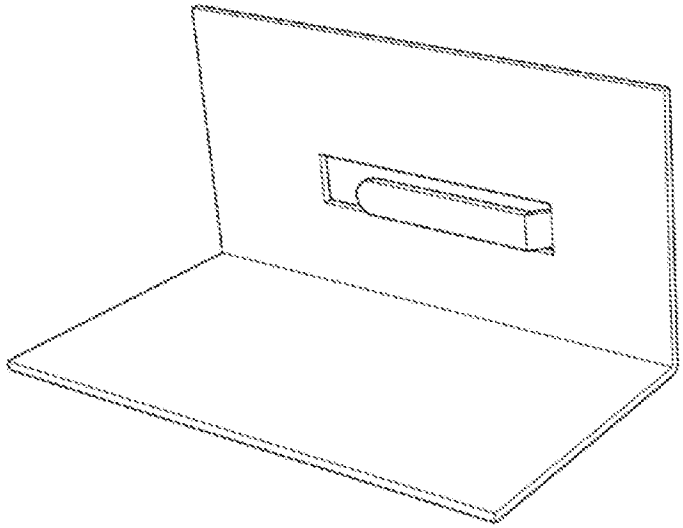

FIG. 17

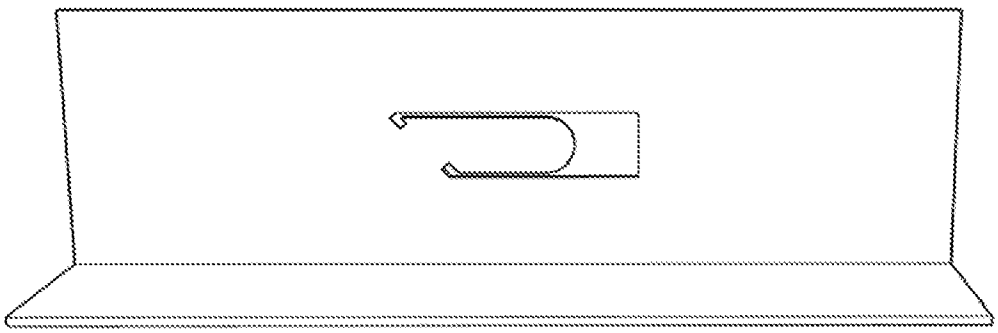

FIG. 18A

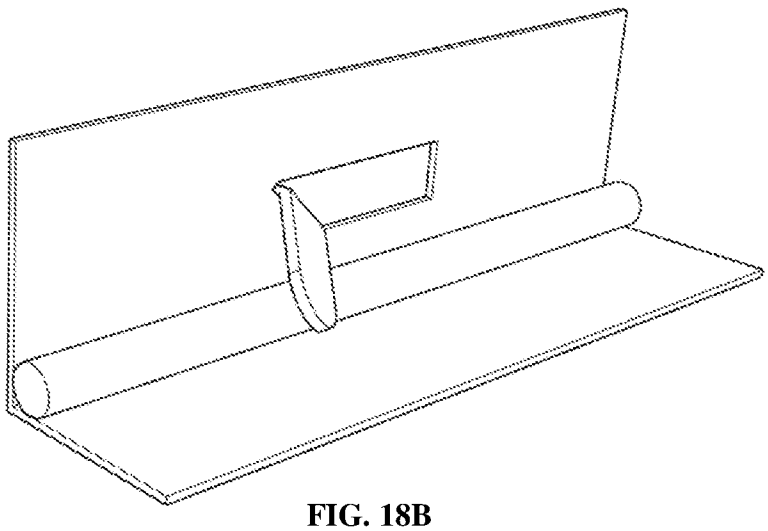

FIG. 18B

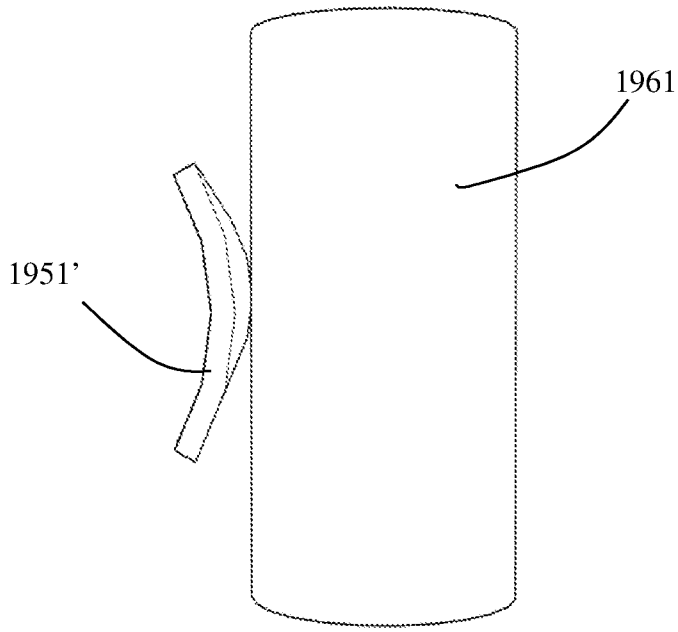

FIG. 19

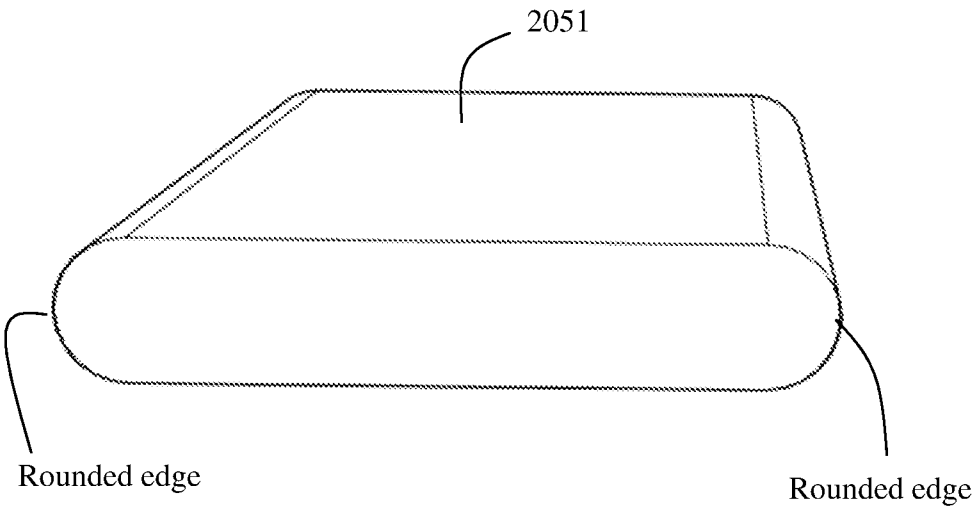

FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2022/052598

A. CLASSIFICATION OF SUBJECT MATTER

H02S 30/10(2014.01)i; **H02S 40/22**(2014.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H02S 30/10(2014.01); E04B 1/38(2006.01); E04D 13/18(2006.01); F16S 3/08(2006.01); H01L 31/042(2006.01); H02S 20/23(2014.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: frame, panel, support-wall, wire-management

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2020-252091 A1 (ORIGAMI SOLAR) 17 December 2020 (2020-12-17) Page 17; claims 3-12; and figures 40-57.	1
Y	US 2010-0162641 A1 (JEAN-PIERRE REYAL et al.) 01 July 2010 (2010-07-01) Figure 7.	1
A	KR 10-2306817 B1 (DAONTECHNICS INC.) 29 September 2021 (2021-09-29) The entire document.	1
A	KR 10-2159900 B1 (LEE, SUN CHAN) 24 September 2020 (2020-09-24) The entire document.	1
A	JP 2006-278672 A (KYOCERA CORP.) 12 October 2006 (2006-10-12) The entire document.	1

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 April 2023	**25 April 2023**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2022/052598

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☑ Claims Nos.: **6, 10, 13, 16, 19, 21, 27-29**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

Claims 6, 10, 13, 16, 19, 21, 27-29 are not clear because they refer to multiple dependent claims, which do not comply with PCT Rule 6.4(a).

3. ☑ Claims Nos.: **2-5, 7-9, 11, 12, 14, 15, 17, 18, 20, 22-26**
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2022/052598

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2020-252091 A1	17 December 2020	CN 114375543 A	19 April 2022
		EP 3981071 A1	13 April 2022
		US 2022-0302872 A1	22 September 2022
US 2010-0162641 A1	01 July 2010	CN 101702954 A	05 May 2010
		CN 101702954 B	18 April 2012
		EP 2140500 A1	06 January 2010
		EP 2140500 B1	04 April 2018
		JP 2010-525194 A	22 July 2010
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		KR 10-2010-0023807 A	04 March 2010
		US 8549800 B2	08 October 2013
		WO 2008-145903 A1	04 December 2008
KR 10-2306817 B1	29 September 2021	None	
KR 10-2159900 B1	24 September 2020	None	
JP 2006-278672 A	12 October 2006	None	