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Romesburg

(54) STRUCTURAL INSULATED MONOLITHIC PHOTOVOLTAIC SOLAR-POWER ROOF AND METHOD OF USE THEREOF

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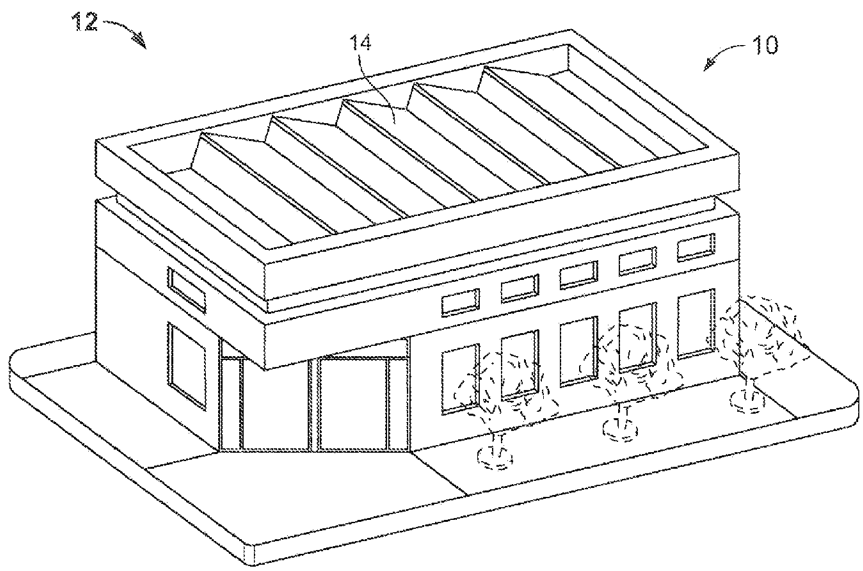
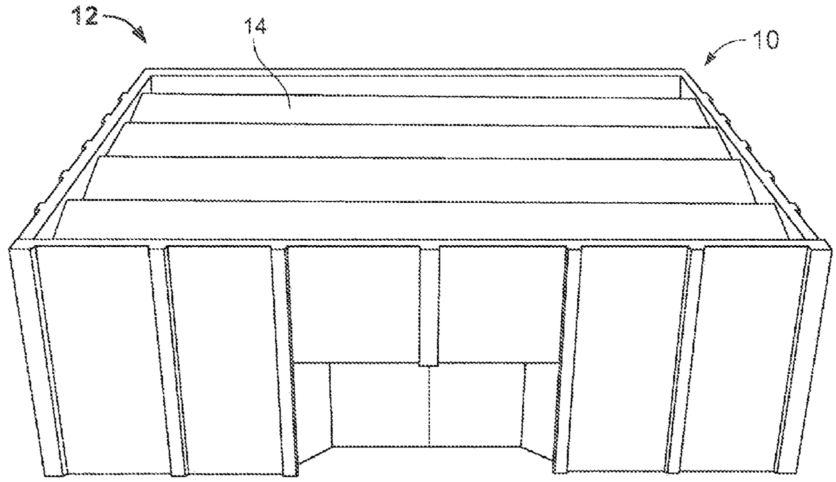
(52) **U.S. Cl.** **52/173.3**; 52/745.06; 165/53

(57) **ABSTRACT**

A photovoltaic roof structure is provided. The monolithic roof structure comprises a plurality of composite panels, photovoltaic modules and connectors, wherein the respective composite panels are comprised of an outer skin, an inner skin, and an insulation layer between the outer and inner skins, the photovoltaic modules are incorporated into the outer skin, and the connectors physically and electrically couple the composite panels to one another to form the roof structure.





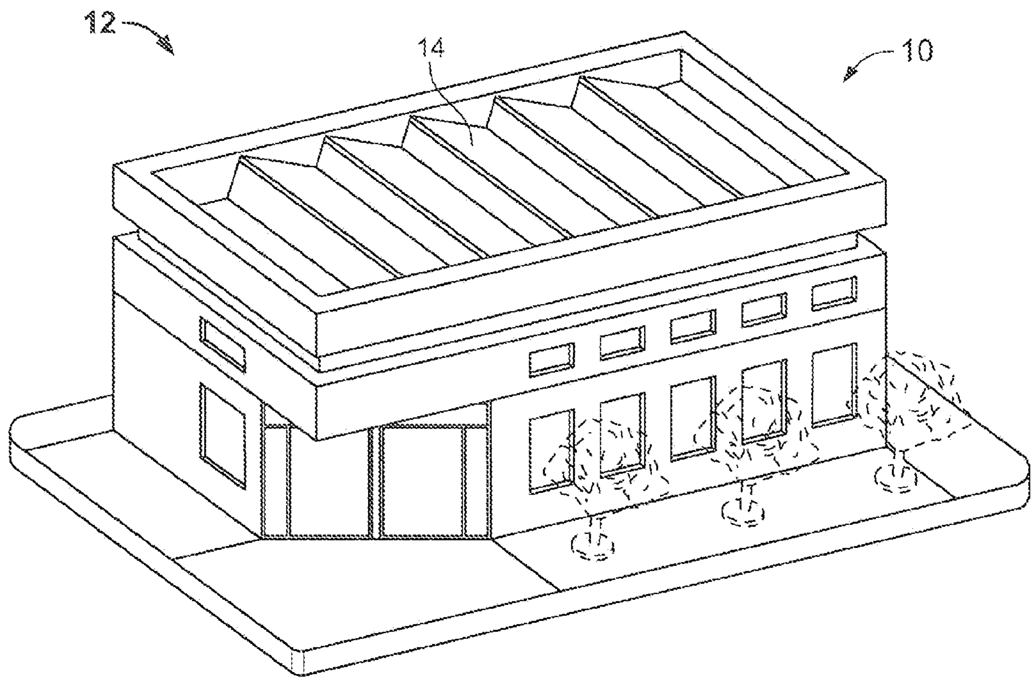


FIG. 1A

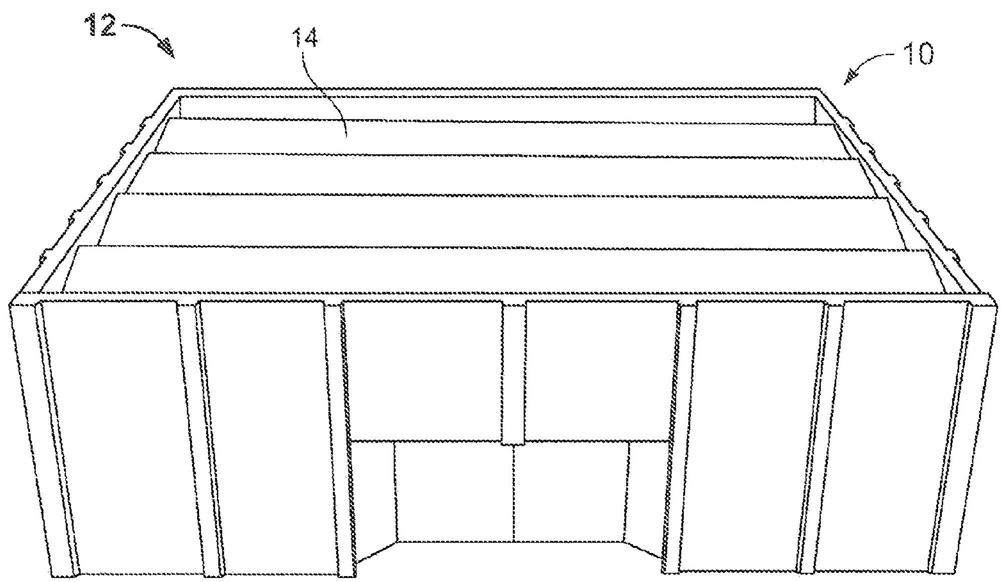


FIG. 1B

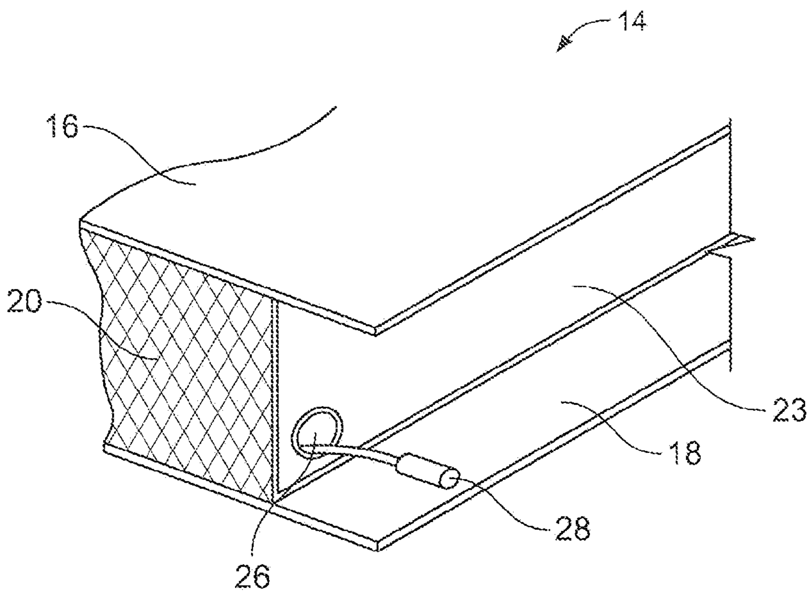


FIG. 2

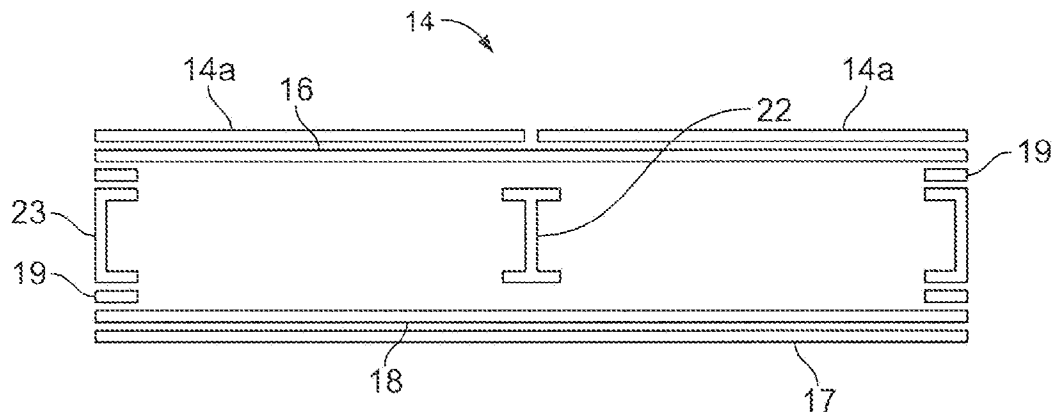


FIG. 3A

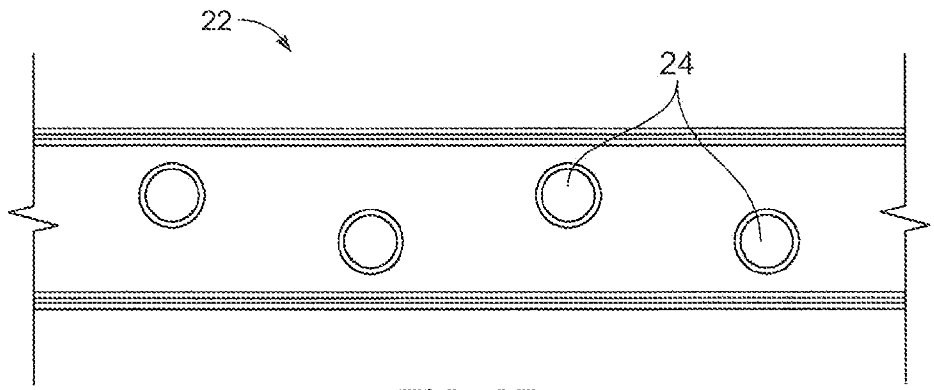


FIG. 3B

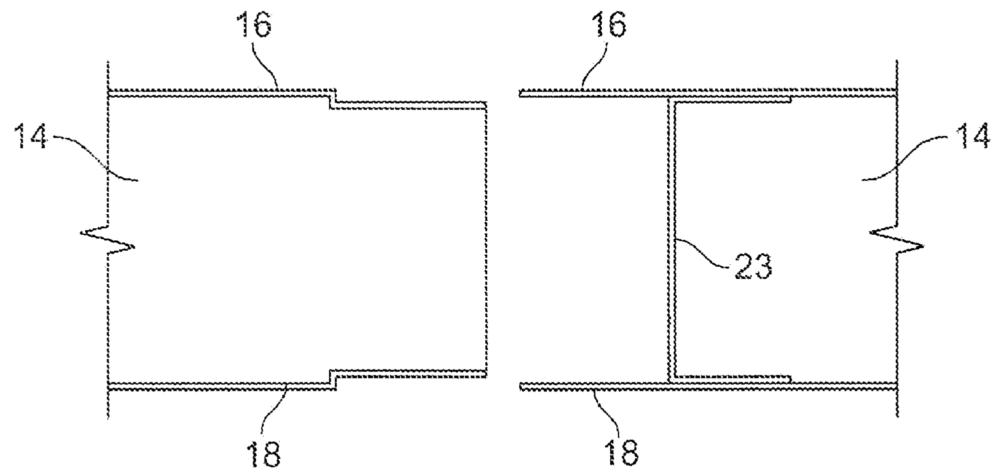


FIG. 4

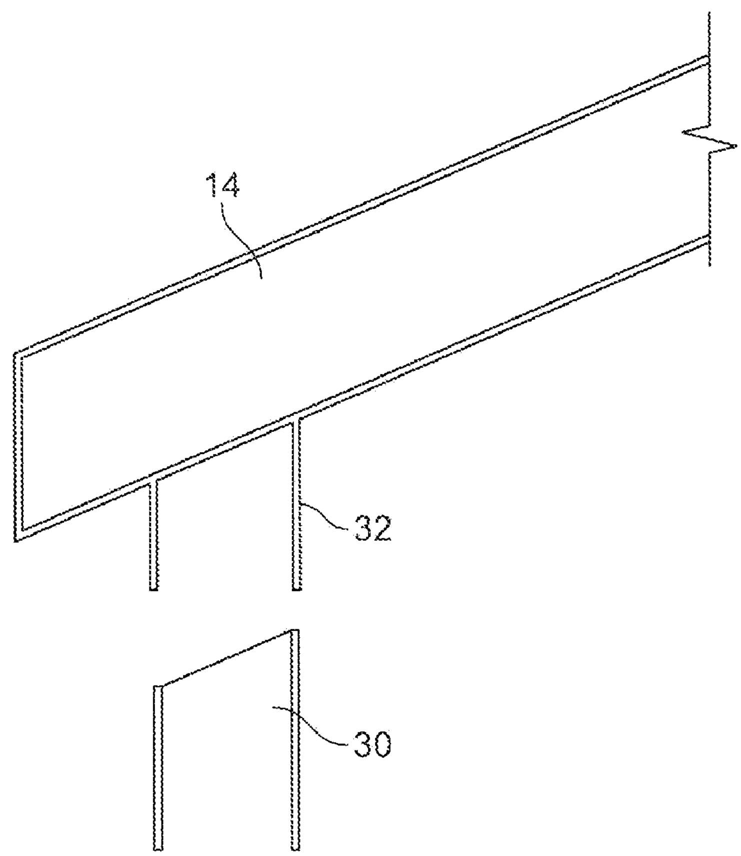


FIG. 5A

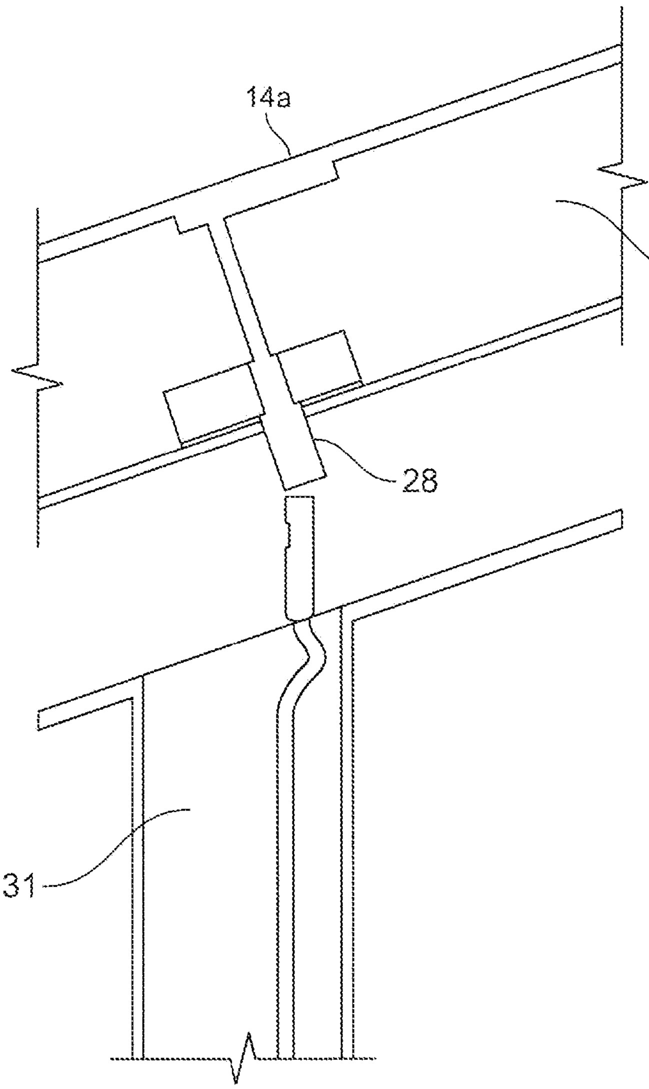

14a
14
28
31

FIG. 5B

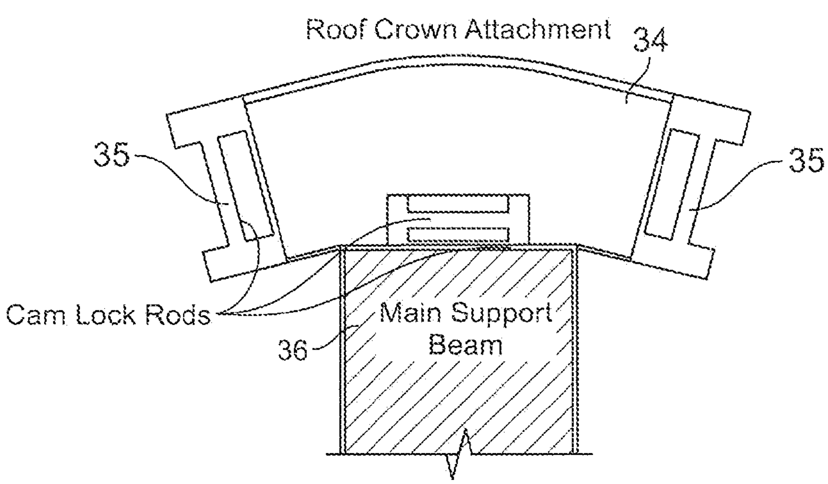

Roof Crown Attachment
34
35
35
Cam Lock Rods
36
Main Support Beam

FIG. 5C

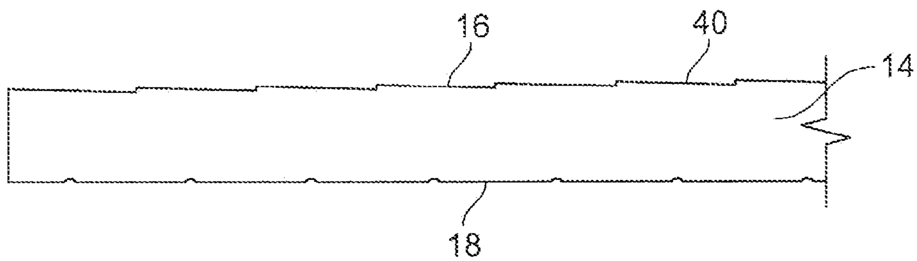


FIG. 6

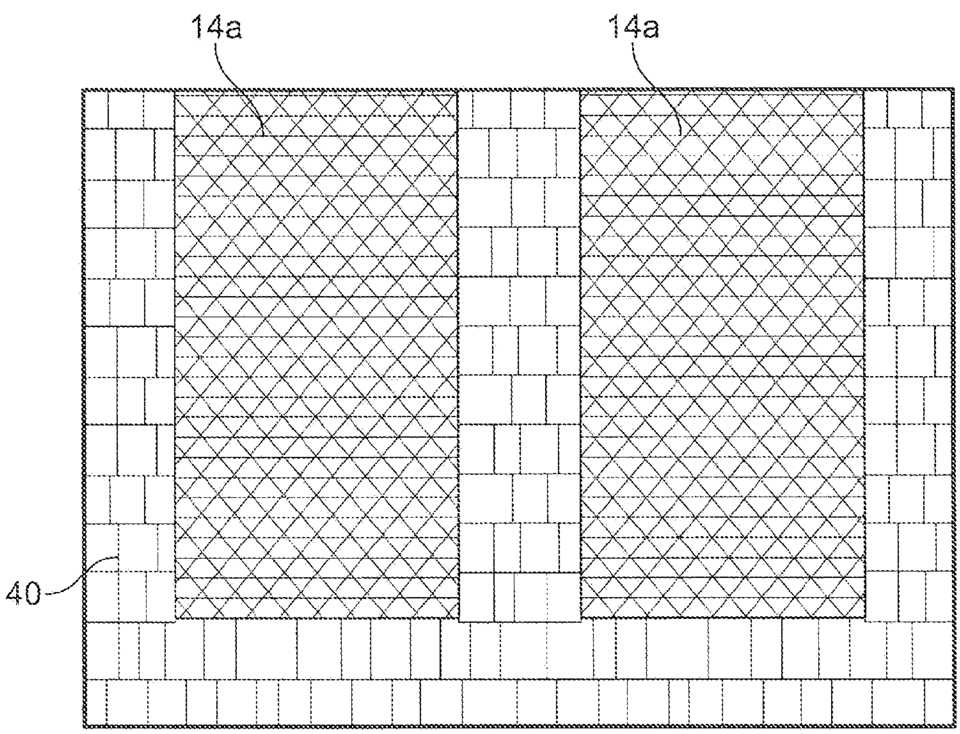


FIG. 7

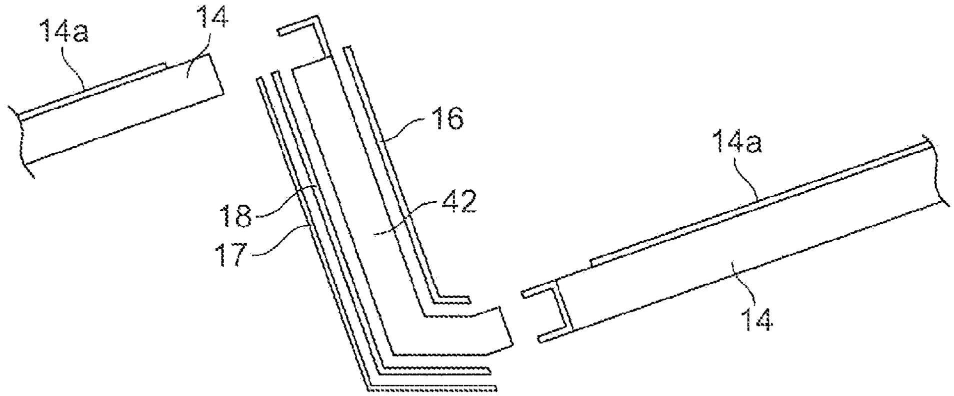


FIG. 8A

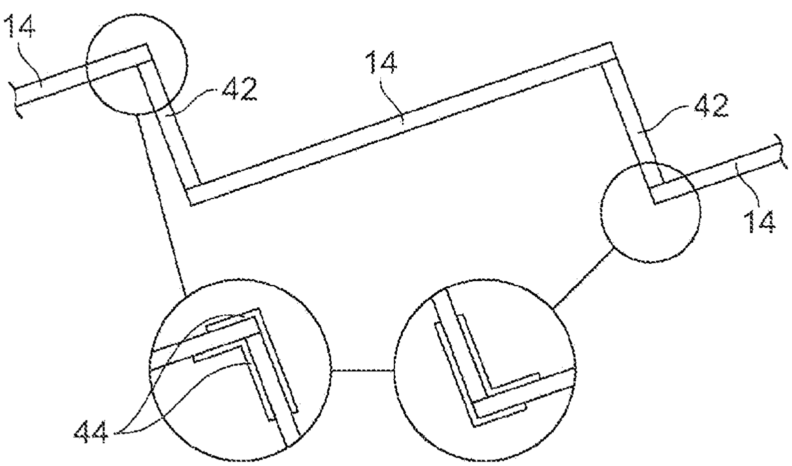


FIG. 8B

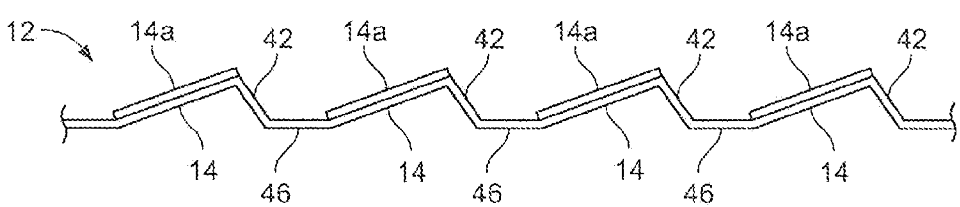
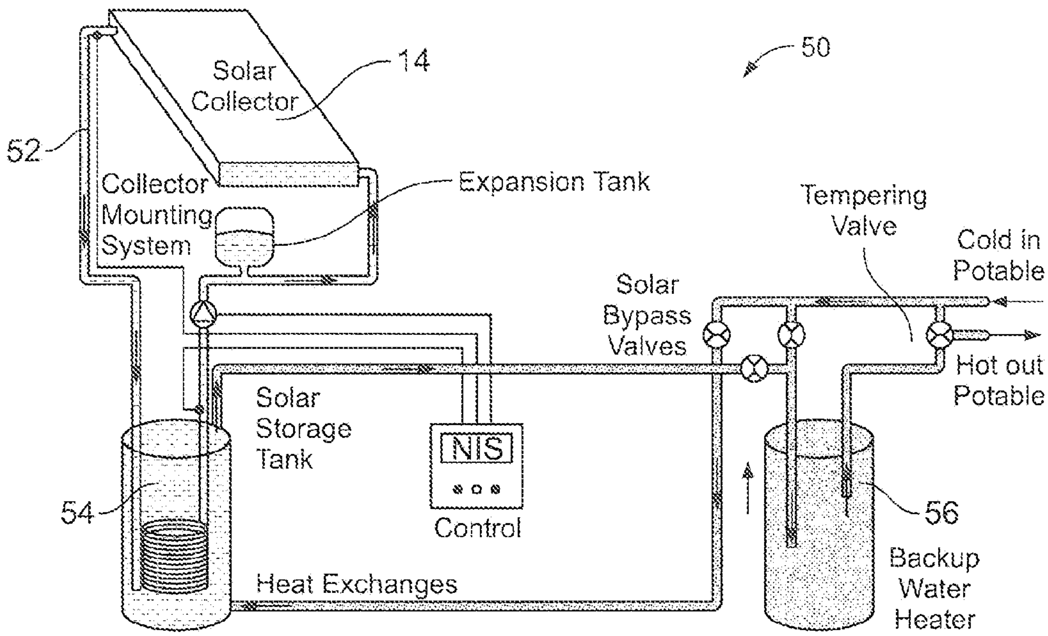
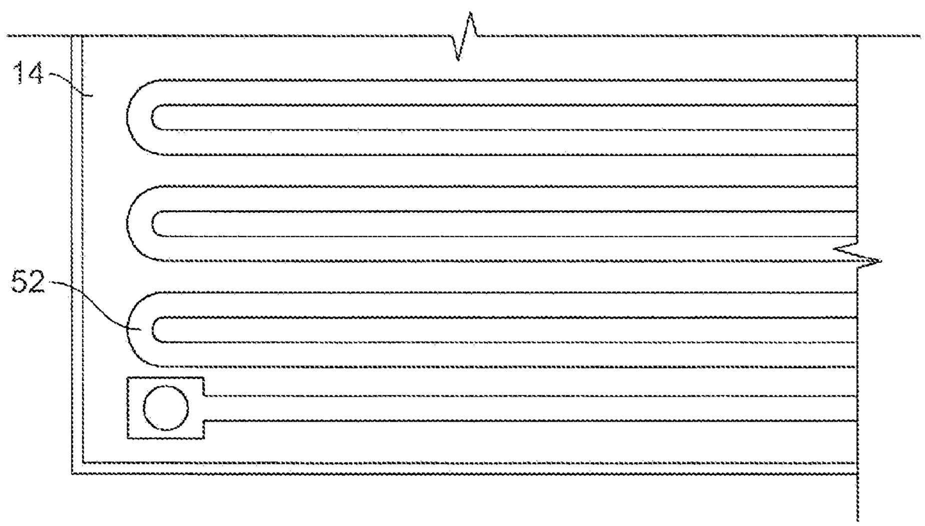


FIG. 9



50
14
Solar
Collector
52
Collector
Mounting
System
Expansion Tank
Tempering
Valve
Cold in
Potable
Solar
Bypass
Valves
Hot out
Potable
Solar
Storage
Tank
NIS
Control
54
56
Backup
Water
Heater
Heat Exchanges

FIG. 10



14
52

FIG. 11

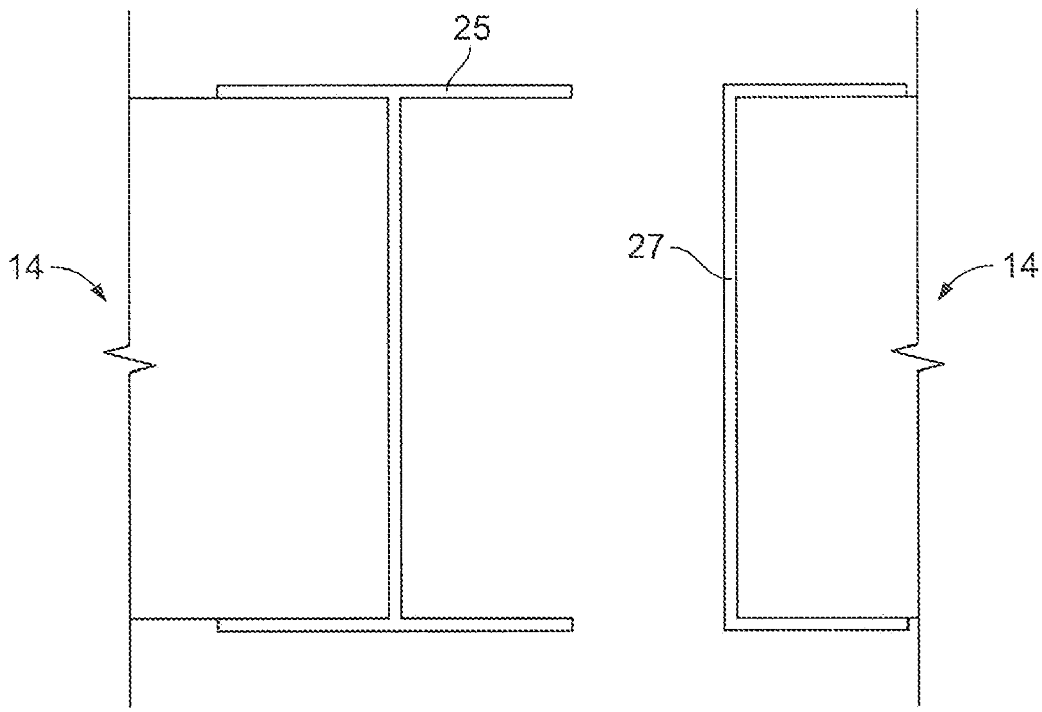


FIG. 12

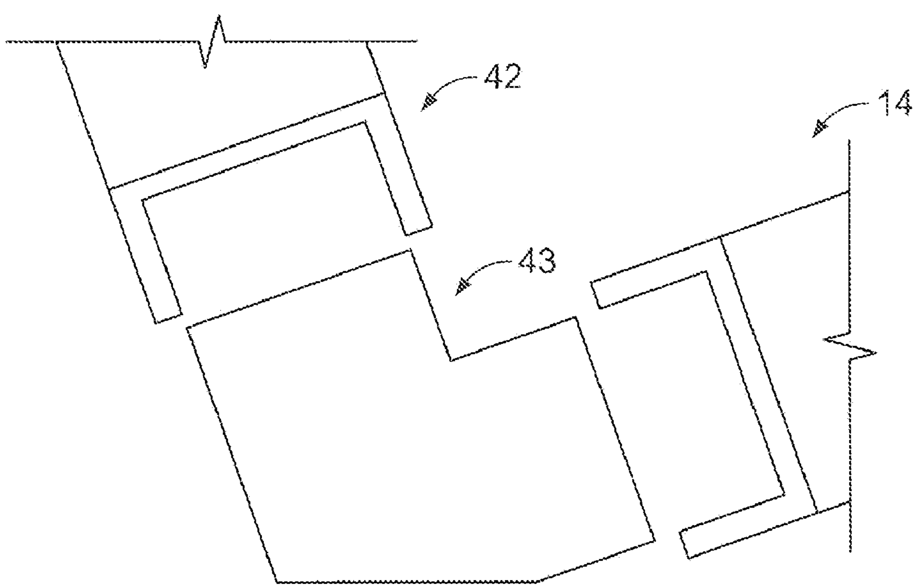


FIG. 13

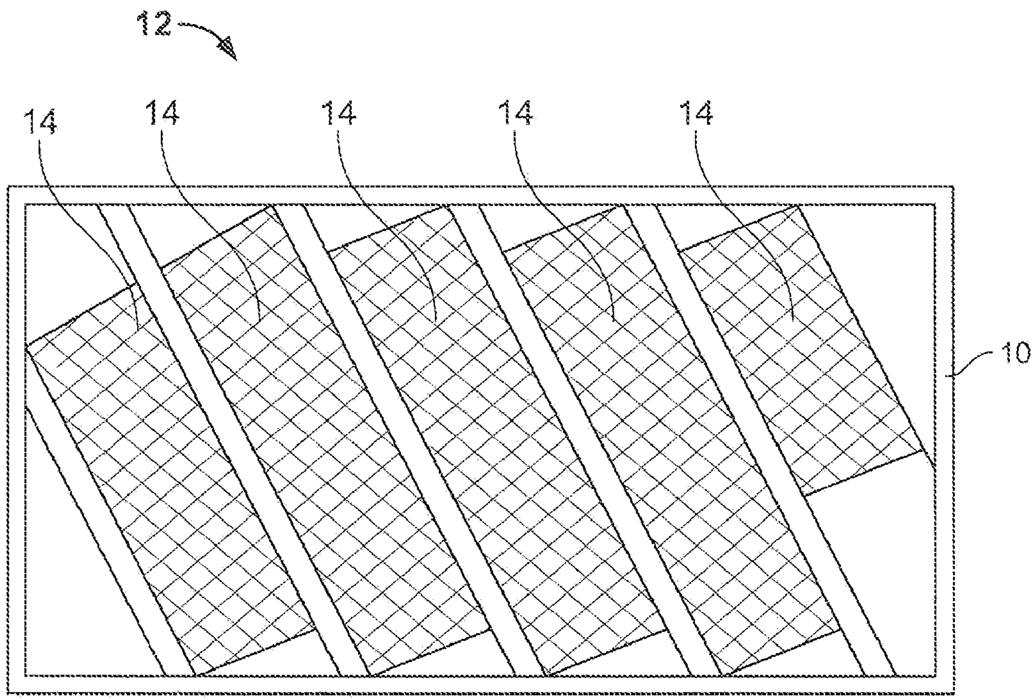


FIG. 14

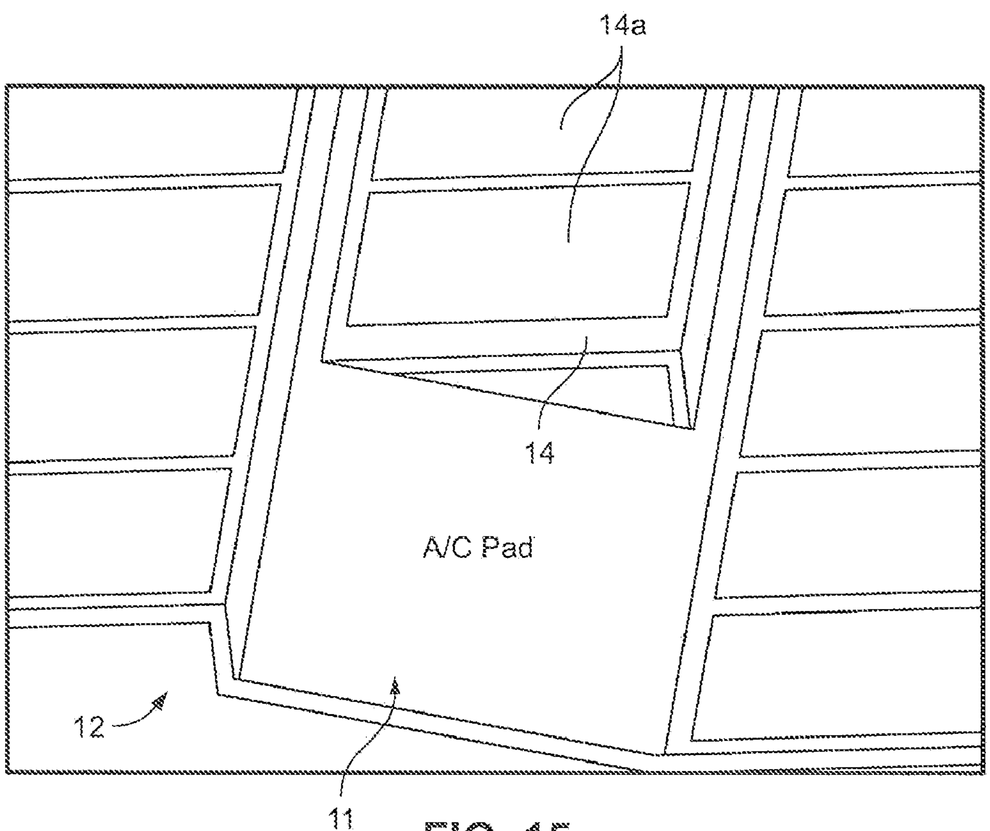


FIG. 15

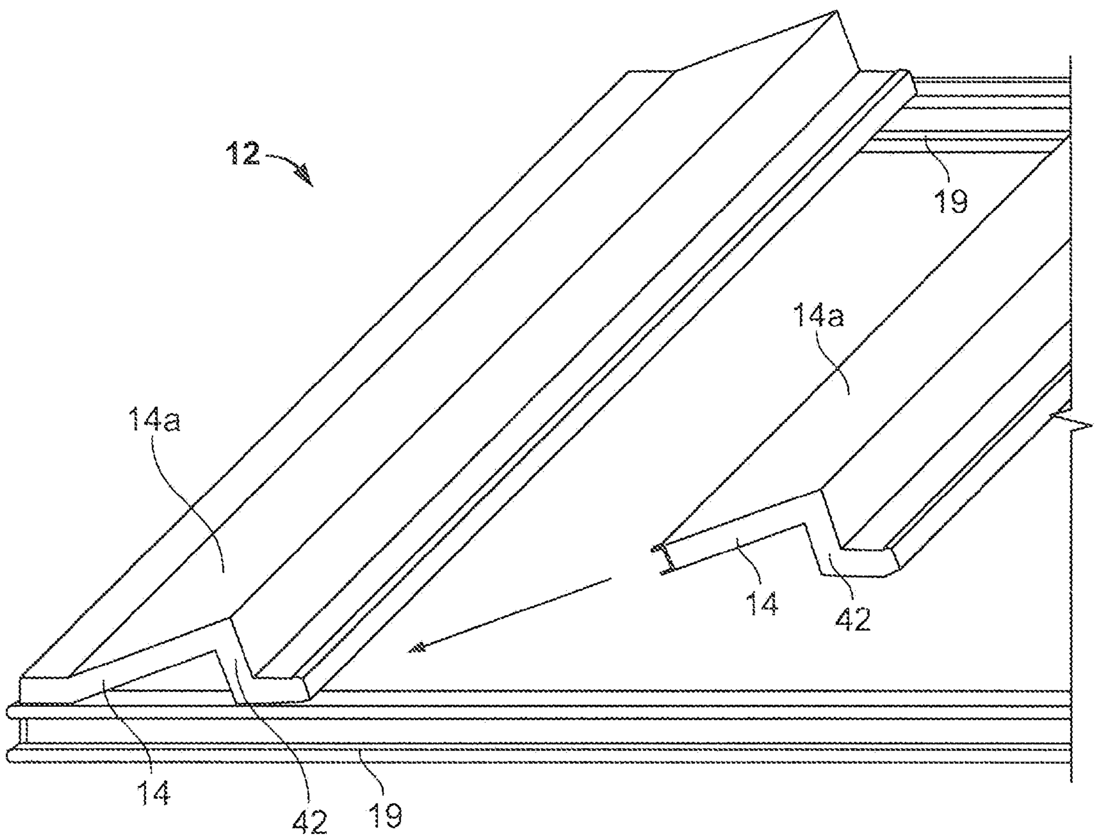


FIG. 16

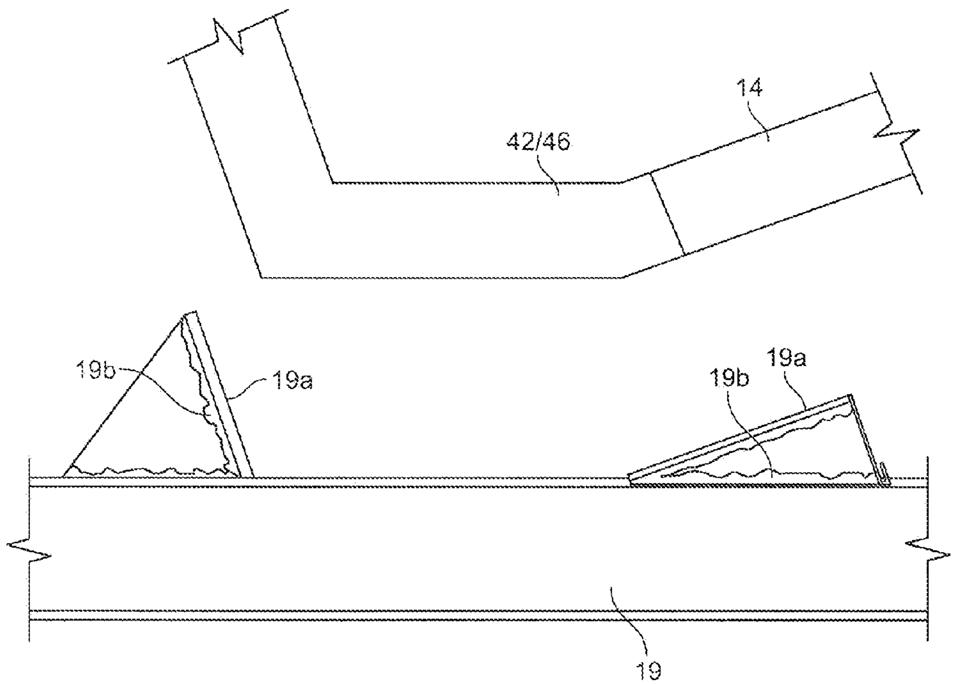


FIG. 17

STRUCTURAL INSULATED MONOLITHIC PHOTOVOLTAIC SOLAR-POWER ROOF AND METHOD OF USE THEREOF

CROSS REFERENCE TO RELATED APPLICATION[S]

[0001] This application claims priority to U.S. Provisional Patent Application to Romesburg entitled "STRUCTURAL INSULATED MONOLITHIC PHOTOVOLTAIC SOLAR-POWER ROOF AND METHOD OF USE THEREOF," Ser. No. 61/405,070, filed Oct. 20, 2010, now pending, the disclosures of which are hereby incorporated entirely herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Technical Field

[0003] This invention relates generally to solar panels, and in particular to a roof structure comprising solar panels.

[0004] 2. State of the Art

[0005] The design and construction of roofs for homes, buildings and other structures has undergone little advancement in technology over time. Currently, most of these roof structures are of similar design characteristics, that being, "stick-built" structures including roofs comprised of joists connected to rafters and covered with plywood sheets and then covered with a moisture barrier and other water-repellant material including steel sheeting, asphalt roofing, rubber roofing, composite shingles or tile shingles. When forces act on the roof, including dead loads, such as the weight of the roof itself, and live loads, such as high wind or heavy snow, are applied to these roofs, "point loads," which occur at the intersecting points between the longitudinal (horizontal) support beams that are attached to the vertical walls that provide support for the roof, are generated that must be addressed at each individual joint.

[0006] These conventional roof structures are oftentimes assembled onsite and require significant time and cost for assembly. Moreover, these roof structures are suspect to insect infestation, dry rot, mold and mildew and frequently do not provide the insulative properties against heating and cooling loss that is desired. Further, conventional roof structures do not provide any photovoltaic properties.

[0007] Accordingly, there is a need for an improved roof structure that addresses the above-mentioned problems. Specifically, there is a need for a roof structure that provides photovoltaic properties, can be quickly and easily assembled, exhibits greater insulative properties over conventional roofs, and improves the overall strength and stability of the roof over conventional roofs.

SUMMARY OF THE INVENTION

[0008] The present invention relates to solar panels and roof structures, and in particular, to a monolithic roof structure comprising an array of solar panels.

[0009] One aspect includes a roof structure comprising a plurality of composite panels; photovoltaic modules; and connectors, wherein the composite panel is comprised of an outer skin, an inner skin, and an insulation layer between the outer and inner skins, the photovoltaic modules are incorporated into the outer skin, and the connectors physically and electrically couple the composite panels to one another to form the roof structure.

[0010] Another aspect of the roof structure includes outer ribs, wherein the outer ribs are positioned between the skins near distal edges of the skins so as to contain the insulation material positioned between the skins. Each of the outer ribs may be configured in a c-shape and a top of the c-shape may engage the outer skin and a bottom of the c-shape may engage the inner skin.

[0011] Another aspect of the roof structure includes inner ribs, wherein the inner ribs may be positioned between the skins at regular intervals within the panel. Each of the inner ribs may be configured in an I-beam shape and a top of the I-beam may engage the outer skin and a bottom of the I-beam may engage the inner skin. Each of the inner ribs may further comprise openings positioned at regular intervals along the length of the I-beam shape.

[0012] Another aspect of the roof structure includes a reinforcement layer coupled to a bottom surface of the inner skin.

[0013] Another aspect of the roof structure includes a portion of the inner and outer skins extending beyond an outer rib, such that the portions of the inner and outer skins that extend beyond the outer rib can couple the panel to an adjacent structure, such as another panel, the support on which the panels rest, or the building itself.

[0014] Another aspect of the roof structure includes a honeycomb structure, wherein the honeycomb structure may be positioned between the inner and outer skins and may prevent the insulation material from penetrating within the honeycomb structure, such that the honeycomb structure and the transparency of the skins allows light to pass through the outer skin, the honeycomb structure, and the inner skin to shed light on the interior of the building.

[0015] Another aspect of the roof structure includes the support on which the roof structure rests being a steel support that is configured to support the weight of the plurality of composite roof panels thereon. The support may further comprise a cradle, wherein the cradle may be fixedly coupled to the steel support and may be structured to receive and secure the roof panels therein.

[0016] Another aspect of the roof structure includes a support panel configured to be positioned between two adjacent roof panels. The support panel may have a first end and a second end, the first end being elevated with respect to the second end. Thus, when one adjacent roof panel is coupled to the first end and the other adjacent roof panel is coupled to the second end, the first end raises the one adjacent roof panel coupled thereto above the level of the other adjacent roof panel coupled to the second end. The successive coupling of roof panels to one another with a support panel therebetween situates the roof panels at an angle with respect to the horizontal. In this way, the roof panels may be angled from between 5 and 33 degrees, inclusive, with respect to the horizontal.

[0017] Another aspect of the roof structure includes the support panel further comprising a horizontal portion between the first and second ends, the horizontal portion forming a flat area between adjacent roof panels coupled to the support panel.

[0018] Another aspect of the roof structure includes electrical components, wherein the electrical components may be incorporated in the panels to electrically couple the photovoltaic modules to the panels, the panels to one another, and the panels to the building, such that the solar energy absorbed by each of the photovoltaic modules can be converted to electric energy and transported to the building to provide consumable power.

[0019] Another aspect of the roof structure includes a heat exchange system, wherein the heat exchange system may pump a heat transfer fluid through a closed loop, the closed loop passing through one or more panels and a water storage tank. The heat transfer fluid can enter the one or more panels and heat up by dissipating and carrying away heat generated by the photovoltaic modules. Then, the heated heat transfer fluid can enter the water storage tank and transfer heat to the potable water contained in the water storage tank to heat the potable water. Thereafter, the relatively cooled heat transfer fluid may exit the water storage tank and return to the one or more panels to be reheated.

[0020] Another aspect of the roof structure includes a method of forming a roof structure of a building, including the steps of forming a plurality of composite roof panels and composite support panels at a location; transporting the composite roof panels from the location to a building location; assembling the composite roof panels to one another with a composite support panel therebetween on top of the building at the building location; electrically coupling the composite roof panels to one another; and electrically coupling the composite roof panels to the building.

[0021] Another aspect of the method includes providing a first skin; providing a second skin; placing inner ribs between the first and second skins at regular intervals; placing outer ribs between the first and second skins at distal ends of the skins; coupling the first skin to the second skin by adhering the first and second skins to opposing edges of the outer ribs; injecting insulation between the first and second skins; integrating photovoltaic modules having solar cells containing photovoltaic material therein onto the first skin; and electrically coupling the photovoltaic modules to the panel.

[0022] Another aspect includes the photovoltaic solar roof panel skins being produced using substrates of fiber reinforced plastic, metal, plywood or any substrate capable of meeting the structural requirements and building codes. A method of producing the sandwich panel skins would be the use of high speed automated continuous or static press. Once the skins are produced, a hydraulic press is used to inject structural insulation rigid foam between the two skins or by adhesively bonding the two skins to pre-formed rigid foam insulation planks When assembled at the jobsite, the photovoltaic solar roof panels are joined in such a way as to form a monolithic solar roof distributing stress loads throughout the entire roof in such a manner as to eliminate point loads that are present in conventional construction methods. The monolithic photovoltaic solar roof construction method of this invention will allow for roofs to be built exhibiting superior strength and durability, ease of assembly, with a much higher "R-Value" and with the ability to produce electricity generated by photovoltaic cells. A roof of this design will be substantially less in cost when compared to roofs built using conventional building methods with conventional photovoltaic solar systems "bolted on" as a separate component.

[0023] Another aspect includes the monolithic roof structure defining a totally different design, manufacturing process, and assembly method to produce a monolithic, structurally insulated, photovoltaic solar roof. The design, materials of choice, and manufacturing techniques were born within the aerospace industry. Aerospace concepts, as applied to the invention submitted, will allow roofs to be produced that will exhibit tremendous improvements over existing production and assembly methods by using a monolithic design, low cost rapid automated manufacturing process and modular prefabrication assembly method, thusly, reducing production and on-site assembly time/cost.

[0024] The foregoing and other features and advantages will be apparent from the following more detailed description of the particular embodiments of the invention, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] FIG. **1**A is a perspective view of a monolithic roof structure on a building in accordance with the present invention.

[0026] FIG. **1**B is a perspective view of a monolithic roof structure on a building in accordance with the present invention

[0027] FIG. **2** is a front perspective sectional view of a panel of the roof structure in accordance with the present invention.

[0028] FIG. **3**A is an exploded cross-sectional view of the panel in accordance with the present invention.

[0029] FIG. **3**B is a sectional side view of a reinforcement member within the panel in accordance with the present invention.

[0030] FIG. **4** is a side view of an embodiment of the interaction of the panels in accordance with the present invention.

[0031] FIG. **5**A is a side view of an embodiment of the interaction between the panel and vertical support member in accordance with the present invention.

[0032] FIG. **5**B is an exploded side view of an embodiment of the interaction between the panel and vertical support member in accordance with the present invention.

[0033] FIG. **5**C is a side view of an embodiment of the interaction between the panel and vertical support member in accordance with the present invention.

[0034] FIG. **6** is side view of the panel in accordance with the present invention.

[0035] FIG. **7** is a top view of the panel of the roof structure in accordance with the present invention.

[0036] FIG. **8**A is a sectional, side view of an embodiment of the monolithic roof structure in accordance with the present invention, including an exploded view of a component of the monolithic roof structure.

[0037] FIG. **8**B is a sectional, side view of an embodiment of the monolithic roof structure in accordance with the present invention.

[0038] FIG. **9** is a side view of the monolithic roof structure in accordance with the present invention.

[0039] FIG. **10** is a schematic of the heat exchanger system in accordance with the present invention.

[0040] FIG. **11** is a sectional, interior view of a panel of the roof structure in accordance with the present invention.

[0041] FIG. **12** is a side view of an embodiment of the interaction of the panels in accordance with the present invention.

[0042] FIG. **13** is a sectional, side view of an embodiment of the monolithic roof structure in accordance with the present invention.

[0043] FIG. **14** is a top view of an embodiment of the monolithic roof structure in accordance with the present invention.

[0044] FIG. **15** is a perspective view of an embodiment of the monolithic roof structure in accordance with the present invention.

[0045] FIG. **16** is a perspective view of an embodiment of the monolithic roof structure in accordance with the present invention.

[0046] FIG. **17** is a side view of an embodiment of the monolithic roof structure in accordance with the present invention

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0047] As discussed above, embodiments relate to solar panels and roof structures, and in particular, to a monolithic roof structure comprising an array of solar panels.

[0048] As shown in FIGS. **1**A and **1**B, a structure/building **10**, representative of any commercial, military, recreational, residential building, or the like, includes a monolithic roof structure **12** according to an embodiment of the present disclosure. The monolithic roof structure **12** comprises at least one solar panel **14**, and in some cases the monolithic roof structure **12** comprises an array of solar panels **14**. The panels **14** may have placed thereon a solar module **14***a*, as shown in FIGS. **3**A and **8**A, comprising one or more photovoltaic cells that convert solar energy to electric energy. The panels **14** may have a plurality of solar modules **14***a* placed thereon, as shown in FIGS. **3**A and **15**. The panels **14** may extend from one end of the roof of the building **10** to an opposing end of the roof, such that a panel **14** extends from one side of the building **10** to the other, for example, as shown in FIGS. **1**A and **1**B.

[0049] As shown in FIG. **2**, the solar panel **14** may be a sandwich panel comprised of photovoltaic solar cells **14***a* incorporated into, or placed on top of, an outer skin **16** and an insulation layer **20** sandwiched between the outer skin **16** and an inner skin **18**. The solar panel **14** may be manufactured using high-speed continuous laminating machines and static presses and by injecting a foam core, the insulation layer **20**, between the skins, **16** and **18**. The solar panel **14** may alternatively be created by adhesively bonding pre-formed rigid foam insulation planks, not shown, to the skins, **16** and **18**, skin **16** adhered to one side of the plank and skin **18** adhered to the opposing side of the plank, thus producing the sandwich panel **14** The skins **16** and **18** themselves may be produced using fiber-reinforced thermoplastics, fire retardant fiber-reinforced thermoset, water based resin, metal, plywood, or any other substrate capable of meeting the structural requirements and building construction codes. The insulation layer **20** may be a fire-retardant foam or other material having fire-retardant properties. The insulation layer **20** may be made from EPS, XPS, and or PU foam.

[0050] As shown in FIG. **3**A, the panel **14** may further comprise a side reinforcement rib **23** and/or an interior reinforcement rib **22**. The reinforcement ribs **22** and **23** may run longitudinally with the length of the panel **14** and may have an I-beam cross-sectional shape, as may be the case for reinforcement ribs **22**, or a C-shaped cross-sectional shape, as may be the case for reinforcement ribs **23**. The I-beam shape and the C-shape help to strengthen the rigidity of the monolithic solar panel **14**. Although the reinforcement rib **22** is shown to have an I-beam cross-sectional shape, it is contemplated that the reinforcement ribs **22** and **23** can have any suitable cross-sectional shape that provides added rigidity and strength to the monolithic solar panel **14**. During the formation of the monolithic solar panel **14**, a plurality of reinforcement ribs **22** and **23** can be placed at regular or irregular intervals in between the skins **16** and **18**. The reinforcement ribs **22** and **23** may be coupled to the skins **16** and **18** by adhesive layer **19**. Thereafter, the insulation layer **20** is placed around the reinforcement ribs **22** and between reinforcement ribs **23**. The insulation layer **20** may serve to further secure the reinforcement ribs **22** in place. In addition, a reinforcement panel **17** may be coupled to the inner skin **18** to further strengthen the panel **14** or provide additional fire retardant property. The reinforcement panel **17** may be, for example, magnesium oxide, a cement-based material or a drywall-based material. Embodiments of the panel **14** may comprise the reinforcement panel **17** being comprised of magnesium oxide that is combined with cement and formed into strong and thin boards and/or panels, such as, but not limited to, magnesia board or magnesia wallboard.

[0051] As shown in FIG. **3**B, the reinforcement ribs **22** may have openings **24** in the middle portion thereof, the openings **24** providing relief to the insulation layer **20**. For example, if the insulation layer **20** is injected in between the skins **16** and **18**, the openings **24** allow the insulation layer **20** to expand through the openings **24**, so as to not expand upward or downward unnecessarily, which may crack or displace the skins **16** and **18** during the manufacture of the solar panel **14**. The reinforcement ribs **22** and **23** can be comprised of fiber-reinforced thermoplastics and/or fire retardant fiber-reinforced thermoset, or any other lightweight material capable of increasing the rigidity and strength of the panel **14**.

[0052] Once formed, each monolithic solar panel **14** may comprise a portion of the overall monolithic roof structure **12**. In fact, the monolithic roof structure **12** may be assembled from a plurality of monolithic solar panels **14** being coupled together, such as in side-by-side configurations or in end-to-end configurations, or varied combinations of both. As shown in FIG. **4**, the outer skin **16** and inner skin **18** of one panel **14** may overhang the edge of the panel **14**. An adjacent panel **14** may have indented portions on the outer skin **16** and inner skin **18** to receive the overhang portions of the one panel **14**. The overhanging portions of the respective skins **16** and **18** may couple to the adjacent panel **14** by sliding over the indented portions of the adjacent panel **14**. Once coupled together, the one panel **14** and the adjacent panel **14** may be fixedly attached to one another by thermowelding the respective skins **16** and **18** together. In the alternative, the panel **14** and the adjacent panel **14** may be fixedly attached to one another by bolts or rivets or cams. Further in the alternative, the panel **14** and the adjacent panel **14** may be fixedly attached to one another by structural adhesive. Additionally in the alternative, the panel **14** and the adjacent panel **14** may be fixedly attached to one another by cam locks. In one particular embodiment, the panel **14** and the adjacent panel **14** may be fixedly attached to one another by embedding electrical "resistance" wires, not shown, by means of thermo-forming the wires within the respective roof panel skins **16** and **18** in such a manner that when electrical current is applied, the wires are heated thus welding the roof panel **14** to the adjacent roof panel **14**. The resistance wires remain within the respective roof panel skins **16** and **18** and, if necessary, the roof panels **14** may be separated by reversing this process. At least in these ways, the panels **14** are coupled together to form a monolithic roof structure **12**.

[0053] As shown in FIG. **12**, adjacent panels **14** may alternatively be coupled together by use of a flange **25** and c-shaped end **27**. For example, an end of one panel **14** may have coupled thereto a flange **25**, such that one end of the flange **25** is fixedly coupled to the one panel **14**. The flange **25** may be coupled to the one panel **12** by adhesive **19**, by bolt, rivet, or cam locks, by welding, or by therm-forming, as described above. An adjacent panel **14** may have fixedly coupled thereto a c-shaped end **27** that may be configured to engage the open end of the flange **25**. The c-shaped end **27** may be coupled to the adjacent panel **14** by adhesive **19**, by bolt, rivet, or cam locks, by welding, or by thermo-forming, as described above. Under the condition that the adjacent panel **14** is advanced toward the one panel **14** to couple together the one panel **14** and the adjacent panel **14**, the c-shaped end **27** is configured to slide within the flange **25** to secure the c-shaped end **27** within the flange **25** to thereby secure the one panel **14** to the adjacent panel **14**. When engaged, the flange **25** and the c-shaped end **27** may be further coupled together by adhesive **19**, by bolt, rivet, or cam locks, by welding, or by thermo-forming, as described above.

[0054] As shown in FIGS. **1** and **14**, the monolithic roof structure **12** may comprise as many individual roof panels **14** as are necessary to construct a roof for a particular building **10**. Thus, each building **10** will be unique in its implementation of the roof structure **12**. Nonetheless, regardless of the number of roof panels **14** needed to construct the roof for the individual building **10**, the properties of the roof structure **12** remain consistent from building to building. For example, the incorporation of the photovoltaic solar cells **14*a*** into the respective outer skin **16** of each of the all-composite roof panels **14**, the roof panels **14** having a limited number of internal reinforcement ribs **22** to strengthen the panels **14**, allows the roof structure **12** to not only convert solar energy to electric energy to power the building, but also to be sufficiently strong to carry its own weight as well as all the external stress loads generated throughout the entire roof **12** and transfer those forces out to the vertical walls of the building **10** and down to the foundation on which the building **10** rests.

[0055] As shown in FIG. **5**A, a vertical wall **30** may be coupled to the roof structure **12**, and specifically the monolithic solar panel **14**, by way of vertical connectors **32**. The vertical connectors **32** may be attached to the monolithic solar panel **14** by thermowelding the vertical connector **32** to the solar panel **14**, by bolting or riveting the vertical connector to the solar panel **14**, or by connecting the vertical connector **32** to the solar panel **14** by structural adhesive or cam locks. Thereafter, the vertical connector **32** may be fixedly coupled to the vertical wall **30** by cam locks, bolts or rivets. Moreover, it is contemplated that although several means for connecting the solar panel **14** to the vertical wall **30** are disclosed, it will be apparent to those of ordinary skill in the art to incorporate any feasible means now known or later developed for connecting the solar panel **14** to the vertical wall **30**, and for that matter, connecting the monolithic solar panel **14** to any vertical support structure, whether it be the exterior vertical wall **30** or an internal vertical support structure. This design dissipates fatiguing and dynamic point load conditions throughout the entire structure rather than transmitting loads directly to the joints as in conventionally designed framed structures.

[0056] As shown in FIG. **5**C, for pitched roofs, the monolithic roof structure **12** may further comprise a roof crown attachment **34**. The roof crown attachment **34** is structured to couple to the main support beam **36** or column of the building. The roof crown attachment **34** is configured to receive and have coupled thereto a monolithic solar panel **14** on each of its sides. The solar panels **14** may be coupled to the roof crown attachment **34** by cam locks **35**, or the solar panels **14** may be coupled to the roof crown attachment **34** by thermowelding the solar panels **14** to the roof crown attachment **34**, by bolting or riveting the monolithic solar panels **14** to the roof crown attachment, or by connecting the solar panels **14** to the roof crown attachment **34** by structural adhesive. Additionally in the alternative, the panel **14** and the adjacent panel **14** may be fixedly attached to one another by cam locks **35**.

[0057] The physical configuration of the monolithic roof structure **12** reduces the number of vertical and horizontal support members that are typically needed to support a building's roof, such as truss members, beams, and columns. As configured, the structural strength of the panels **14** allow the monolithic roof structure **12** to carry the generated stress loads described above equally within the outside skin **16** and inside skin **18** of the composite sandwich panels **14** forming the monolithic solar roof structure **12**. In one regard, the stress loads exhibited on the monolithic solar roof structure **12** causing tension and compression on the panels **14** react as though the roof **12** is not comprised of several inner connected panels **14** but rather as a single monolithic roof structure **12** supporting the total weight of the roof **12** and resisting all external forces.

[0058] Under the condition that the monolithic solar roof panels **14** are produced using fiber reinforced thermoplastic skins, the panel ends may be heated and "post-formed" creating radius corner bends to any degree desired or by thermoforming the solar roof panel edge creating "closed" edges or tongue groove joints for connecting one solar roof panel **14** to another. Additionally, the ability to thermoform the thermoplastic skins **16** and **18** will allow for the skins **16** and **18** to be shaped prior to the process of injecting the insulation layer **20** in between the skins **16** and **18**.

[0059] For example, as shown in FIG. **6**, the outer skin **16** may be formed to look like conventional roof shingles **40** and the inner skin **18** may be formed with cosmetic film to look like tongue and groove paneling. When the monolithic solar roof panels **14**, as described, are installed, no additional fabrication such as a vapor barrier, plywood, shingles, drywall or paint is required. The solar panels **14** will be produced with materials that will meet all International, U.S. and local Class A fire and smoke building codes.

[0060] As shown in FIG. **2**, the individual panels **14** in the array of panels **14** forming the composite monolithic roof structure **12** may further comprise electrical conduits **26** placed within the insulation layer **20** to allow the solar panel **14** to electrically couple to the adjacent solar panel **14** by way of the wiring connection **28**. In this way, each of the photovoltaic cells or modules **14*a*** on the outer skin **16** can be electrically coupled to one another and the electricity produced by the photovoltaic modules **14*a*** can be harnessed and used by the building **10**. The photovoltaic cells or modules **14*a*** contain photovoltaic material, such as, but not limited to, silicon, which can be in the form of crystalline silicon, polycrystalline silicon, or amorphous silicon, cadmium telluride, and/or a solar ink, a solar dye, or a conductive plastic. The photovoltaic material in modules **14*a*** can be any material that converts optical radiation into electrical charge.

[0061] A photovoltaic material converts light rays into electrical charge. Light rays can be sunlight, but are no limited in this aspect. The photovoltaic material in modules **14*a*** generates electrical charge, or current, when sunlight is incident on the module **14*a*** and the photovoltaic material therein. Embodiments of the roof structure **12** include the electrical charge generated by light incident on the photovoltaic material within the modules **14***a* on the panels **14** being harvested and stored in a battery, a plurality of batteries, rechargeable batteries, or in a fuel cell. Embodiments of the roof structure **12** include the electrical charge generated by light incident on the photovoltaic material within the modules **14***a* on the panels **14** being harvested and directly consumed.

[0062] Embodiments of the roof structure **12** include the electrical charge being collected and regulated by a charge controller, or a charge regulator. The charge controller may collect the electrical charge, or current, created by the photovoltaic material and convert it into voltage or current. The photovoltaic panels **14** used in the invention can be electrically connected in parallel to increase current or in series to increase voltage or in series/parallel to increase both current and voltage.

[0063] Embodiments of the roof structure **12** include the collective monolithic solar panels **14** being electrically coupled to an inverter. The harnessed DC power is converted to AC power through the inverter. Any power overage that the building **10** does not use directly may be stored in the battery for later use by the building **10** or may alternatively be sold by the building **10** to "grid-tied" power generation companies.

[0064] In the alternative to the electrical conduits **26** being placed within the solar panel **14**, the wiring and wiring connection **28** can be placed on the outside of the solar panels **14** and fully exposed to the naked eye, or the wiring and wiring connection **28** can be placed within a removable cover plate incorporated into the solar panels **14**. As shown in FIG. **5**B, the monolithic solar panel **14** may also be physically and electrically coupled to any internal or external vertical support structure **31** or **36**.

[0065] Because the individual panels **14** comprising the structural insulated photovoltaic solar roof **12** can be prefabricated away from the jobsite where the building **10** is being constructed/erected and transported to the jobsite, the assembly of the roof **12** at the jobsite will require no additional fabrication. For example, as shown in FIG. **7**, for pitched roofs, perimeter shingles **40** on the roof **12** surrounding the photovoltaic solar cells **14***a* and panel edges may be factory installed. The structural insulated photovoltaic solar roof panels **14** are manufactured to be as light as 2.5 lbs. per sq. ft., including the weight of the solar modules **14***a*. These panels **14** can thus be easily transported to the assembly site and can be lifted into place and secured in place to the adjacent panels **14** or the vertical support walls **30** of the structure, as described above.

[0066] The roof **12** may also have fire protection sprinklers incorporated within the sandwich roof panels **14**. The fire sprinklers can be installed internally between the sandwich panel skins **16** and **18** prior to the process of placing the insulation layer **20** between the respective skins to form the panel **14**. Attachment fittings would protrude out of the inner panel skin **18** to facilitate the fastening and attachment of the fire sprinkler head down inside the interior space of the building **10**. The sprinkler pipes forming the fire sprinkler system can be inter-connected from panel **14** to adjacent panel **14**, much like the electrical wiring connections **38** within the respective panels **14**, until the sprinkler pipes and fire sprinkler system is connected to the vertical main water supply pipe of the building **10**.

[0067] As an additional option, the solar roof panels **14**, as herein described, may have skylights or localized translucent areas formed therein. The translucent area may be formed by inserting honeycomb, or other spacious and see-through material, between the two sandwich panel skins **16** and **18** prior to the injecting or placing the insulation layer **20** between the respective skins **16** and **18** to form the panel **14**. Thus, if the insulation layer **20** is injected between the skins **16** and **18**, the honeycomb prevents the insulation layer **20** from forming within the honeycomb between the skins **16** and **18**. As a result, the honeycomb prevents the insulation layer **20** from creeping into the honeycomb between the skins **16** and **18** that would otherwise block the light that can pass through the skins **16** and **18** and the honeycomb structure, which thereby produces a skylight or localized translucent area through which ambient light may pass.

[0068] In one embodiment of the structural insulated photovoltaic solar roof **12**, the roof **12** may be comprised of several monolithic solar roof panels **14**, the panels **14** being typically 4 to 10 inches thick and exhibiting insulative properties, typically R-42, being 4 ft. to 10 ft. wide, and having lengths of 12 ft. to 60 ft., as shown in FIG. **14**, and as dictated by the configuration of the needs of the roof **12** of the building **10**. For example, as shown in FIG. **14**, when viewed from above the roof **12**, the panels **14** may be oriented at an angle with respect the exterior walls or edges of the building **10**. On the other hand, as shown in FIGS. **1**A and **1**B, and when viewed from above the roof **12**, the panels **14** may be oriented orthogonal or parallel with the orientation of the exterior walls or edges of the building **10**.

[0069] In addition to the above, under the condition that a building **10** needs a flat roof structure design, the photovoltaic solar roof panels **14** may simply be installed side-by-side in a horizontal and flat configuration, orthogonal to the vertical support walls **30**. On the other hand, as shown in FIG. **8**A, the photovoltaic solar roof panels **14** may be assembled in the configuration shown, such that the photovoltaic solar roof panels **14** may be assembled at a predetermined angle from the horizontal. To do so, the solar panels **14** may be connected to a support panel **42** or a lower joint **43**. As seen in FIG. **8**A, the support panel **42** may be placed between adjacent solar panels **14** to angle the solar panels **14** at the predetermined angle from the horizontal. The predetermined angle can be based on the longitude and latitude of the building **10** on the face of the earth and the time of year, as these factors determine the optimal angle at which the monolithic solar panels **14**, and specifically the photovoltaic solar cells **14***a* should be configured. For example, based on the building's location on the earth's surface and the time of year, the rays of the sun will contact the building **10**, and thus the solar panels **14**, at varying angles. Because the monolithic solar panels **14** form part of a rigid roof structure **12**, the panels **14** are not intended to move with the sun. Instead, the predetermined angle of the solar panels **14** can be set to minimize the incidence angle of the incoming ray of sunshine on the solar panel **14**. Specifically, the incidence angle is the angle that a ray of solar energy makes with a line perpendicular to the surface contacted by the ray of sunshine. Thus, for optimal solar energy results from the solar panels **14**, the angle of the solar panels **14** should be set such that the perpendicular angle from the surface of the solar panels **14** should be parallel with the ray of sunshine. Or in other words, the angle between the ray of sunshine shining on the monolithic solar panel **14** and the line perpendicular to the angle of the surface of the solar panel **14** should be as close to zero as possible. However, because the angle of the incoming ray of sunshine changes throughout the year, the angle of the monolithic solar panels **14** should be set to an average of the incidence angle over the course of the year to thus minimize the variance of the perpendicular line to the surface of the monolithic solar panels **14** from the angle of the ray of sunshine. In certain embodiments, the predetermined angle may be between 5 and 33 degrees, inclusive, from the horizontal.

[0070] As shown in FIG. **8**A, the panel **14** is angled at the predetermined angle. The base of the support panel **42** connects to the base of the panel **14**. The top of the support panel **42** connects to the top of the adjacent panel **14**. This configuration continues until the monolithic roof structure **12** is formed. The panels **14** and the support panel **42** can be coupled together in a similar fashion to the coupling of individual panels **14** described above and shown in FIG. **4**. Support panel **42** can also be comprised of the same materials used to fabricate the solar panels **14**. For example, the support panel **42** may comprise inner and outer skins **16** and **18**, as well as reinforcement panel **17**. The support panel **42** may have photovoltaic cells and modules **14***a* placed thereon to aid in the conversion of solar power to electric power. Embodiments of the roof structure **12** may include the support panels **42** being adjustable during installation of the panels **14** to allow the panels **14** to assume varied angles from the horizontal. The support panels **42** can also include the honeycomb structure described above to create a skylight in the support panels **42**, if desired.

[0071] Alternatively, as shown in FIG. **8**B, the support panel **42** and the individual panels **14** can be coupled together by braces **44** shown in the cut outs. The braces **44** may be coupled to the panels **14** by rivets, bolts, structural adhesive, welding, or like manner. Further, as shown in FIG. **12**, the lower joint **43** may serve to couple the lower end of the panel **12** to a lower end of the vertical support panel **42**.

[0072] Further in the alternative, as shown in FIG. **9**, the photovoltaic solar panels **14** can be arranged as described above, but may also include a flat section **46** coupled to the bottom of the support panel **42** and the adjacent monolithic solar panel **14**. In this configuration, the monolithic roof structure **12** may accommodate air conditioning and heating units, vents, and/or service walkways in the flat section **46**. Alternatively, as shown in FIG. **15**, the length of one of the plurality of solar panels **14** may be shortened, with respect to the edge of the building **10**, so as to leave a flat section **11** between the panel **14** and the edge of the building **10**, whereon an A/C unit, or other similar appliance may be accommodated. The flat sections **11** or **46** can be comprised of the same materials used to fabricate the monolithic solar panels **14**. The flat section **46** can also include the honeycomb structure described above to create a skylight in the flat section **46**, if desired. Also, the flat section **46** may, but typically does not, include photovoltaic modules **14***a* thereon.

[0073] With regard to FIGS. **16** and **17**, each panel **14** may be supported on a support beam **19** that runs along an edge of the building **10** or runs between edges of the building **10**, such that each side of each panel **14** may rest upon and be supported by the support beam **19**. Support beam **19** may be formed of a strong and sturdy material, such as steel, to provide support to the collective roof structure **12**, formed of individual panels **14** coupled together, as described herein. Support beam **19** may be integral with the building **10**, such that the building **10** supports the weight of the support beam **19** and the roof structure **12** that is placed thereon. Alternatively, the support beam **19** may be fixedly coupled to the building **10** by fasteners, bolts, or other like coupling means that fasten the support beam **19** to the building **10** to allow the building **10** to support the support beam **19** and the roof structure **12** that will be placed thereon. The support beam **19** may run along the inner surface of the perimeter vertical walls of the building **10** or may also run along the top surface of the perimeter vertical walls of the building **10**. The support beam **19** may also run between opposing vertical walls of the building **10**. The support beam **19** may also run between other support beams **19** in a grid-like pattern, if necessary. In fact, the support beam **19** may assume any configuration with respect to the building **10** that allows the roof structure **12** to be placed thereon and supported thereby to provide a solar-powered roof for the building **10**. Moreover, as depicted in FIG. **17**, a cradle **19***a* may be welded, or otherwise adhered, by using a welding material **19***b*, to the top of the support beam **19**. Thereafter, the panel **12** and support member **42** may be placed within, supported by, and/or secured to the cradle **19***a*. The panel **12** and the support member **42** may thereafter be welded, or otherwise adhered, to the cradle **19***a*. Optionally, the panel **12** and the support member **42** may be welded, or otherwise adhered directly to the top of the support beam **19** without the use of the cradle **19***a*.

[0074] As shown in FIGS. **10** and **11**, embodiments of the monolithic roof structure **12** may include a heat exchanger system **50** built into the panels **14**. Piping **52** of the heat exchanger system **50** may be installed internally between the sandwich panel skins **16** and **18** prior to the injection or placement of the insulation layer **20** between the skins **16** and **18**. Alternatively, the piping **52** may be placed between the photovoltaic modules **14***a* and the outer skin **16** of the respective panels **14**.

[0075] The heat exchanger system **50** re-circulates fluid, in certain embodiments the fluid is glycol, through the piping **52** to provide a dual function. First, the heat generated by the photovoltaic solar modules **14***a* can be dissipated by the fluid flowing through the piping **52**, which dissipation of heat lowers the operating temperature of the solar modules **14***a*, which increases the efficiency of the photovoltaic modules **14***a* thus increasing not only the total wattage of electricity produced by the modules **14***a* but also the life expectantly of the photovoltaic solar modules **14***a*. Second, the heated fluid that has passed through the panel **14** may be used in the heat exchange system **50** to heat water in a storage tank **54** that is used by the building **10**. Specifically, potable cold water enters the system **50** from a main water line and travels into the storage tank **54**. The cold water in the storage tank **54** is gradually heated by the fluid that has been heated by the panel **14** and flows through the pipes **52** within the storage tank **54**. As the potable water heats up, it rises within the storage tank **54** and flows out of the storage tank as hot water. The hot water travels to the water heater **56** and is stored therein until needed by the building **10**. Similarly, the fluid that passes through the pipes **52** within the storage tank **54** and dissipates its heat to the potable water in the storage tank **54** is pumped by a pump back into the panel **14**. Upon entering the panel **14**, the fluid heats up by dissipating the heat from the solar modules **14***a* on the panel **14**. Once heated, the fluid passes back into the pipes **52** that lead into and coil within the storage tank **54**. The heat exchange between the fluid in the pipes and the potable water within the tank **54** begins again, or more accurately continues. As a result of the heat exchange system **50**, the building **10** is more efficient. Specifically, instead of requiring the water heater **56** to heat potable water from the temperature of the cold main water line to the desired hot temperature, the water heater **56** need only maintain, or even simply store, the potable water that has been heated in the storage tank **54** and transported to the water heater **56**. Thus, the water heater **56** need not work nearly as hard as it otherwise might have to, thus requiring less energy to operate the water heater **56**.

[0076] A method of manufacturing and assembling the monolithic roof structure **12** will hereinafter be described. The panel **14** comprising the roof structure may be manufactured by providing an outer skin, providing an inner skin, and providing a rib therebetween to secure the outer skin apart from the inner skin and provide structural rigidity to the panel. Thereafter an insulating layer may be injected or otherwise placed within the inner and outer skins A photovoltaic module may be coupled or incorporated in the outer skin of the panel to thus receive the rays of the sun and convert solar energy to electric energy. The panel may further be manufactured by providing a reinforcement layer on the inner skin to further reinforce the strength and rigidity of the panel.

[0077] Manufacturing of the panel may further include forming the shape and texture of the outer and inner skins. Manufacturing of the panel may further include placing a honeycomb structure between the skins, such that the insulating layer is prohibited from entering the honeycomb structure. Manufacturing of the panel may further include placing electrical wiring within the panel, the electrical wiring being configured to connect to wiring of adjacent panels or to the existing wiring of the building on which the panels will be placed. Manufacturing of the panel may further include placing plumbing within the panel, the plumbing being configured to connect to the plumbing of adjacent panels or to the existing plumbing of the building on which the panels will be placed. The plumbing of the panels may further comprise being outfitted to have connected thereto sprinkler heads, such that the sprinkler heads and plumbing form part of a fire prevention and fire extinguisher system.

[0078] The building may have assembled thereon a roof structure comprising one or more panels described above. The roof structure may be formed on the building by forming a predetermined number of panels at a location, transporting the panels from the location to a location of the building, moving the panels up to the level of the roof of the building, and assembling the panels in a preconfigured orientation by coupling the panels to one another or to support structures positioned between respective panels. The panels may be assembled side-by-side in a horizontal fashion, as described above, or may also be assembled in a side-by-side fashion wherein the individual panels are angled with respect to the horizontal, as described above. The individual panels may be angled with respect to the horizontal by coupling the panels to a support member that positions one end of a panel above an opposing end and at the same time allows adjacent panels to connect to the support member placed between the adjacent panels. In other words, the support member supports a lower end of one panel while likewise supporting an upper end of an adjacent panel. The panels may further be assembled by connecting electrical connections between adjacent panels and between panels and the electrical connections within vertical members of the building. The panels may further be assembled by connecting plumbing between adjacent panels and between panels and the plumbing in the vertical members of the building. The panels may be adjusted to place the panels at the best angle with respect to the horizontal to permit the photovoltaic modules on the respective panels to best absorb the solar energy and convert that energy to electricity. The panels may further be assembled to create a monolithic roof structure that may not require vertical support members connected thereto within the interior space of the building, thus creating more usable space within the building.

[0079] The embodiments and examples set forth herein were presented in order to best explain the present invention and its practical application and to thereby enable those of ordinary skill in the art to make and use the invention. However, those of ordinary skill in the art will recognize that the foregoing description and examples have been presented for the purposes of illustration and example only. The description as set forth is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the teachings above without departing from the spirit and scope of the forthcoming claims.

What is claimed is:

1. A composite roof panel, the composite roof panel comprising:

an outer skin;

an inner skin;

an insulation material positioned between the inner and outer skins; and

photovoltaic cells containing photovoltaic materials integrated onto the outer skin.

2. The panel of claim **1**, further comprising outer ribs, wherein the outer ribs are positioned between the skins near distal edges of the skins so as to contain the insulation material positioned between the skins

3. The panel of claim **2**, wherein each of the outer ribs is configured in a c-shape and a top of the c-shape engages the outer skin and a bottom of the c-shape engages the inner skin.

4. The panel of claim **1**, further comprising inner ribs, wherein the inner ribs are positioned between the skins at regular intervals within the panel.

5. The panel of claim **4**, wherein each of the inner ribs is configured in an I-beam shape and a top of the I-beam engages the outer skin and a bottom of the I-beam engages the inner skin.

6. The panel of claim **5**, wherein each of the inner ribs further comprises openings therein positioned at regular intervals along the length of the I-beam shape.

7. The panel of claim **1**, further comprising a reinforcement layer coupled to a bottom surface of the inner skin.

8. The panel of claim **1**, wherein a portion of the inner and outer skins extend beyond an outer rib, such that the portions of the inner and outer skins that extend beyond the outer rib are structured to couple the panel to an adjacent structure.

9. The panel of claim **1**, further comprising a honeycomb structure, wherein the honeycomb structure is positioned between the inner and outer skins and prevents the insulation material from penetrating within the honeycomb structure so as to allow light to pass through the outer skin, the honeycomb structure, and the inner skin.

10. A roof structure of a building, the roof structure comprising:

a plurality of composite roof panels having an outer skin, an inner skin, and an insulation layer therebetween;

a support; and

photovoltaic modules,

wherein one or more of the plurality of roof panels are coupled together and positioned on and collectively supported by the support, and wherein one or more of the photovoltaic modules are integrated onto the outer skin of each panel.

11. The roof structure of claim **10**, wherein the support is a steel support and is configured to support the plurality of composite roof panels thereby.

12. The roof structure of claim **11**, further comprising a cradle, wherein the cradle is fixedly coupled to the steel support and is structured to receive and secure the roof panels therein.

13. The roof structure of claim **10**, further comprising a support panel configured to be positioned between two adjacent roof panels and having a first end and a second end, the first end being elevated with respect to the second end, wherein one adjacent roof panel couples to the first end and the other adjacent roof panel couples to the second end, such that the first end raises the one adjacent roof panel coupled thereto above the level of the other adjacent roof panel coupled to the second end.

14. The roof structure of claim **13**, wherein successive coupling of roof panels to one another with a support panel therebetween situates the roof panels at an angle with respect to the horizontal.

15. The roof structure of claim **14**, wherein the roof panels are angled from between 5 and 33 degrees, inclusive, with respect to the horizontal.

16. The roof structure of claim **14**, wherein the support panel further comprises a horizontal portion between the first and second ends, the horizontal portion forming a flat area between adjacent roof panels coupled to the support panel.

17. The roof structure of claim **10**, further comprising electrical components, wherein the electrical components are incorporated in the panels to electrically couple the photovoltaic modules to the panels, the panels to one another, and the panels to the building, such that the solar energy absorbed by each of the photovoltaic modules is converted to electric energy and transported to the building to power the building.

18. The roof structure of claim **10**, further comprising a heat exchange system, wherein the heat exchange system pumps a fluid through a closed loop that passes through one or more panels and a water storage tank, the fluid entering the one or more panels and heating up by dissipating and carrying away heat generated by the photovoltaic modules, the heated fluid thereafter entering the water storage tank and transferring heat to the potable water contained in the water storage tank to heat the potable water, the cooled fluid thereafter exiting the water storage tank and returning to the one or more panels to be reheated.

19. A method of forming a roof structure of a building comprising:

forming a plurality of composite roof panels and composite support panels at a location;

transporting the composite roof panels from the location to a building location;

assembling the composite roof panels to one another with a composite support panel therebetween on top of the building at the building location;

electrically coupling the composite roof panels to one another; and

electrically coupling the composite roof panels to the building.

20. The method of claim **19**, the forming a plurality of composite roof panels further comprises:

providing a first skin;

providing a second skin;

placing inner ribs between the first and second skins at regular intervals;

placing outer ribs between the first and second skins at distal ends of the skins;

coupling the first skin to the second skin by adhering the first and second skins to opposing edges of the outer ribs;

injecting or placing insulation between the first and second skins;

integrating photovoltaic modules having solar cells containing photovoltaic material therein onto the first skin; and

electrically coupling the photovoltaic modules to the panel.

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