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(54) **FLEXIBLE ROOF-MOUNT SYSTEM AND METHOD FOR SOLAR PANELS**

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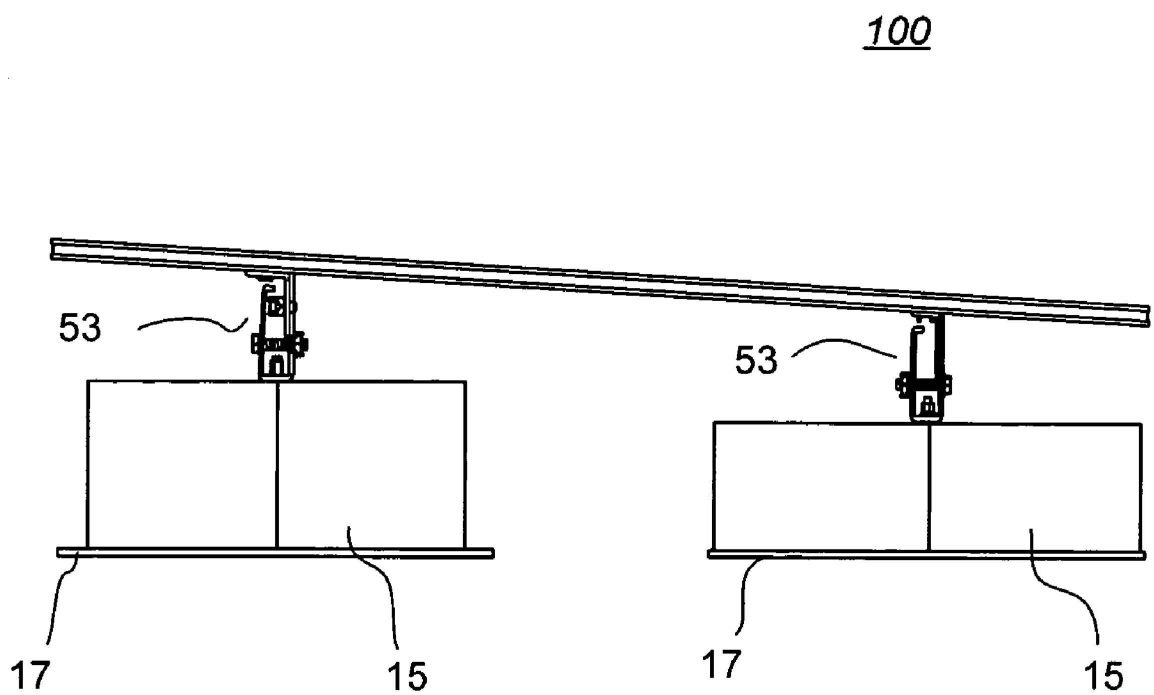
(57) **ABSTRACT**

Systems and methods are disclosed for efficiently securing solar panels on a roof surface that does not require penetration of the roof membrane. Supports for the solar panels are designed with a small footprint with sufficient spacing to allow free drainage between the supports. A simple, low-cost attachment member or clip can be integrated with each support to attach the panel to the support, and in some instances the clip (or its mount on the support) can also be used to lift the support to the roof. The panels can include one or more rails that can slide through a loosened clip, but be held securely in place by a tightened clip. The panels can be installed initially with the clips grasping the rails loosely and once the supports and rails are in their final positions, the clips can be fully tightened to form a rigid solar panel array.



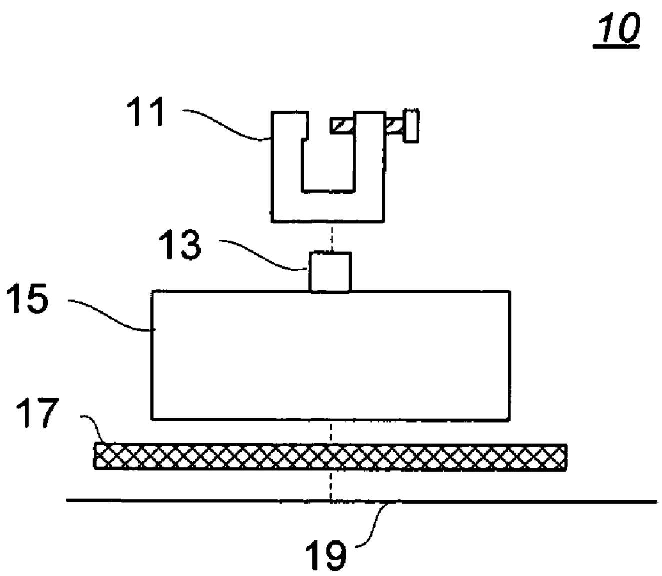


FIG. 1A

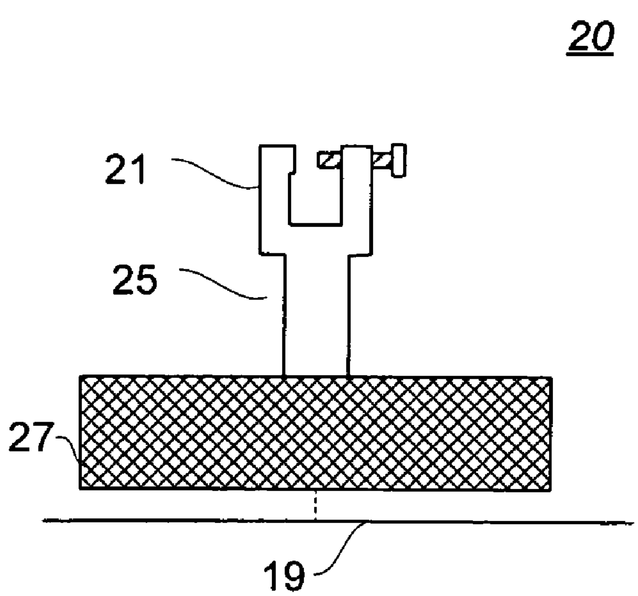


FIG. 1B

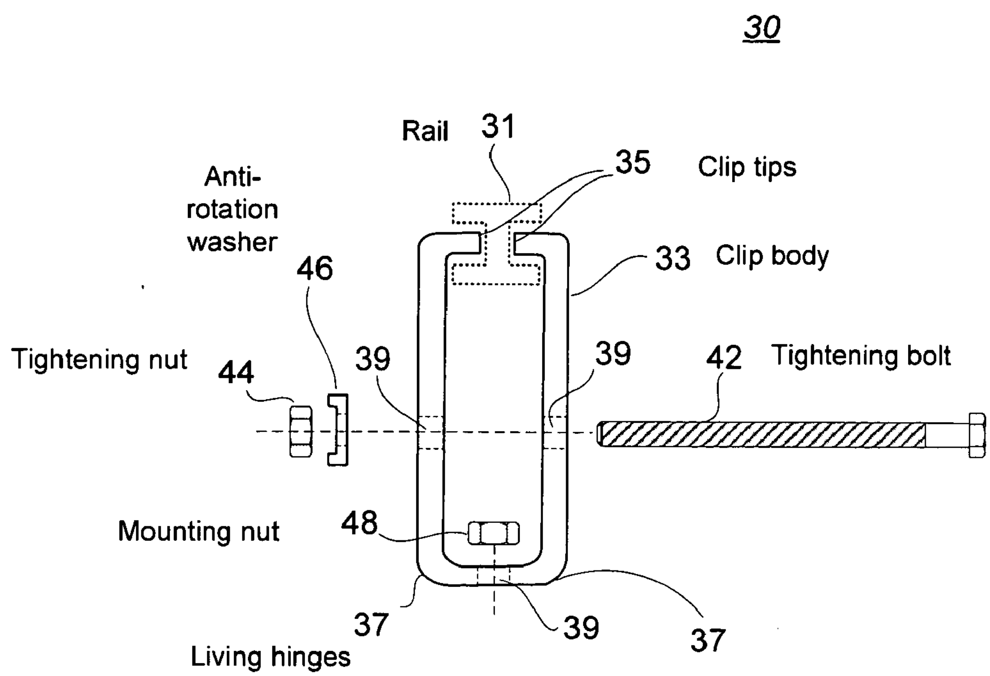

30
Rail
31
35
Clip tips
Anti-
rotation
washer
46
33
Clip body
Tightening nut
44
39
39
42
Tightening bolt
Mounting nut
48
37
39
37
Living hinges

FIG. 2A

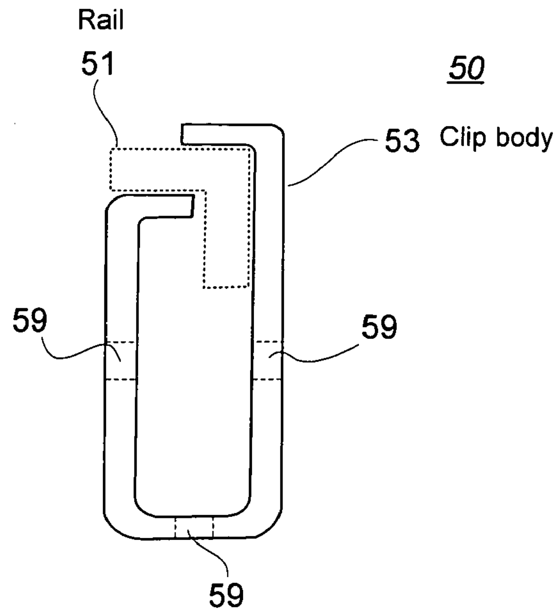

Rail
51
50
53
Clip body
59
59
59

FIG. 2B

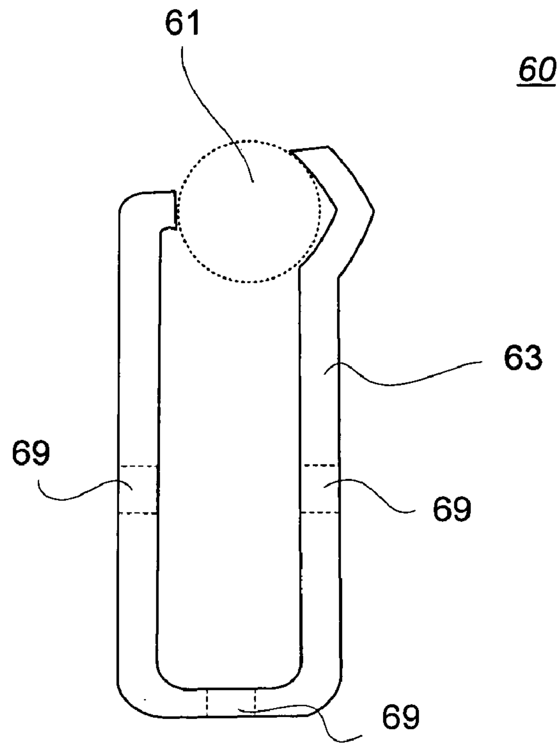


FIG. 2C

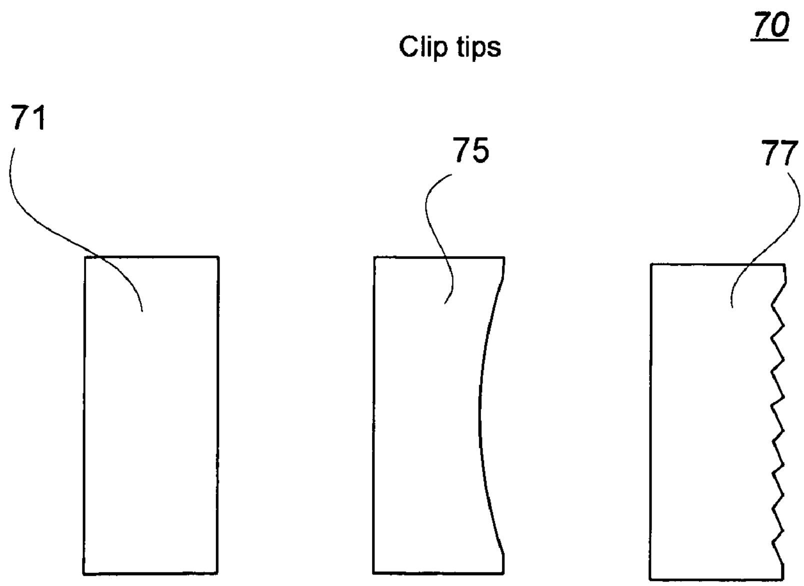


FIG. 3

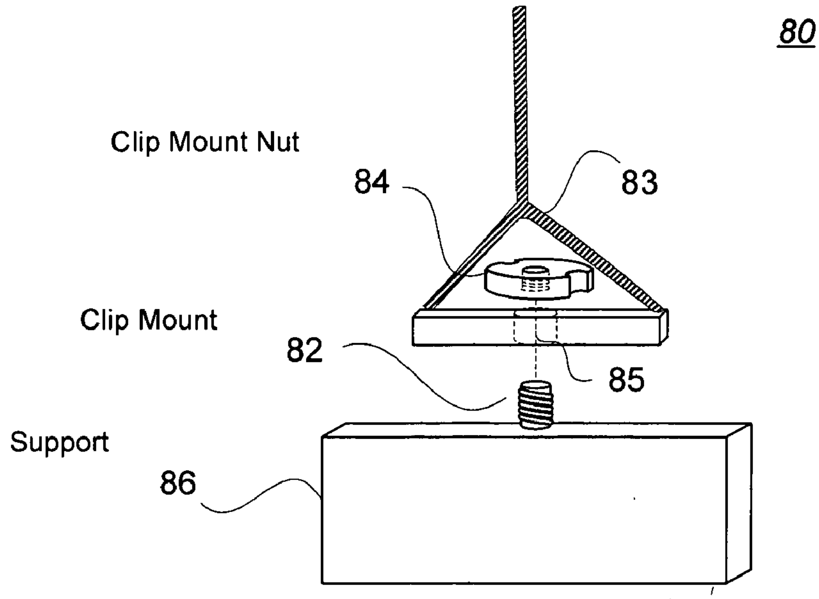

80
Clip Mount Nut
84
83
Clip Mount
82
85
Support
86

FIG. 4A

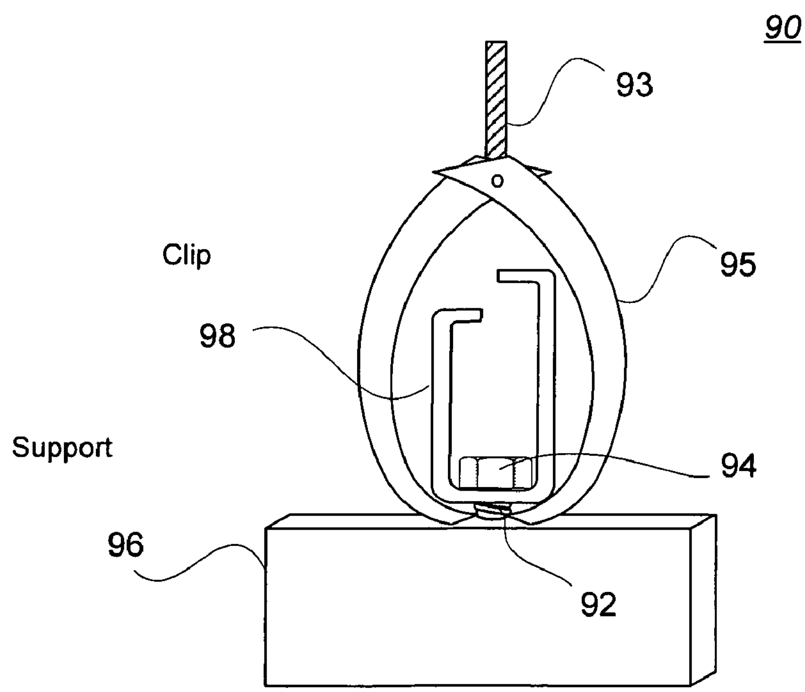

90
93
Clip
95
98
Support
94
96
92

FIG. 4B

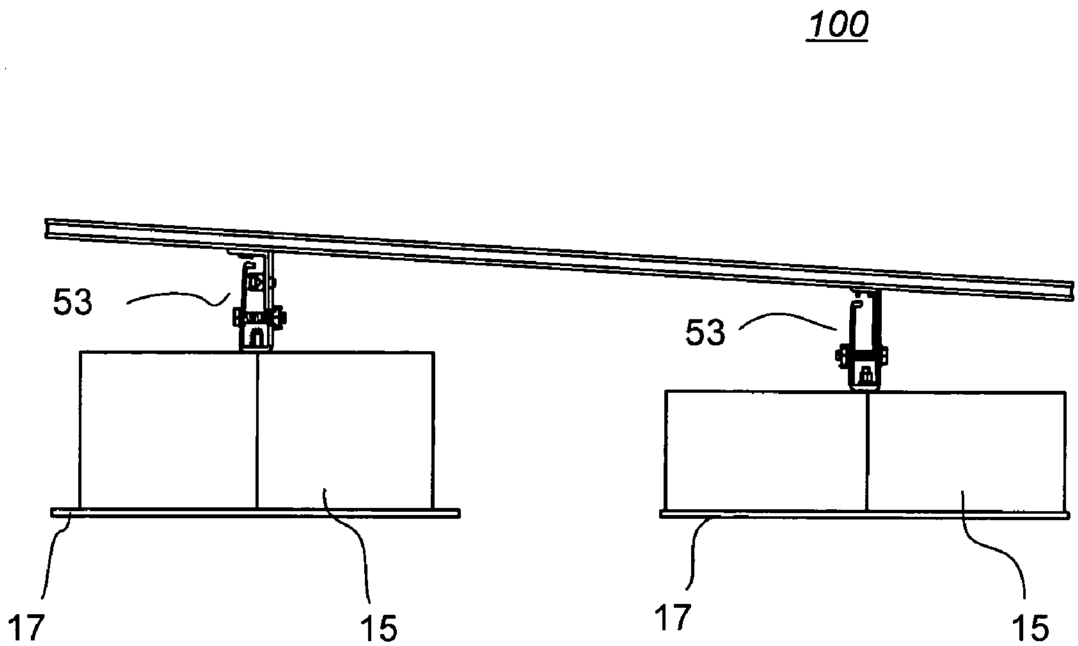


FIG. 5

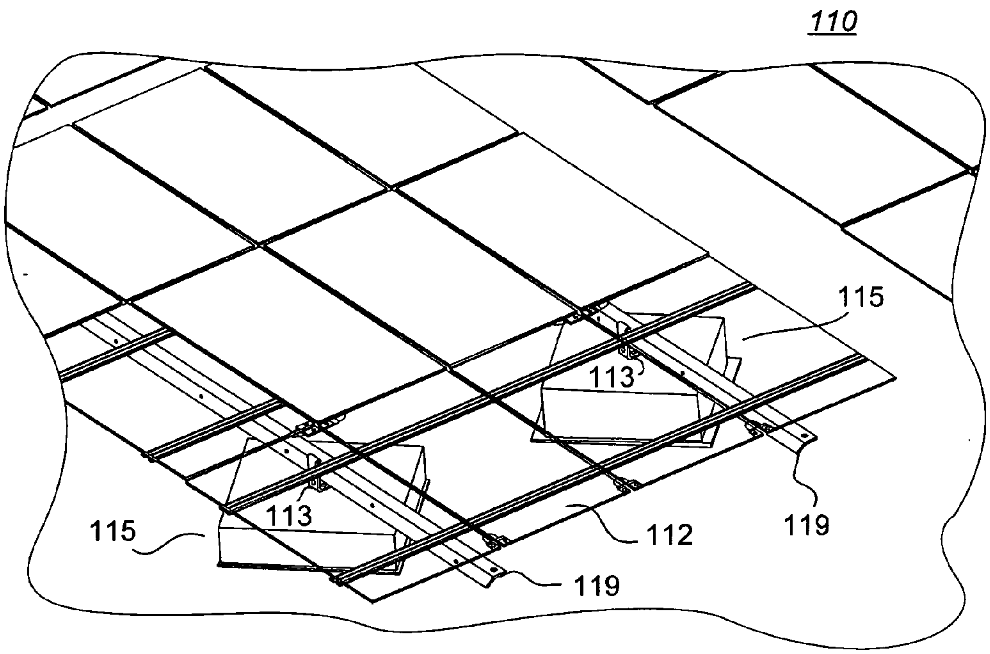

110
115
113
113
115
112
119
119

FIG. 6A

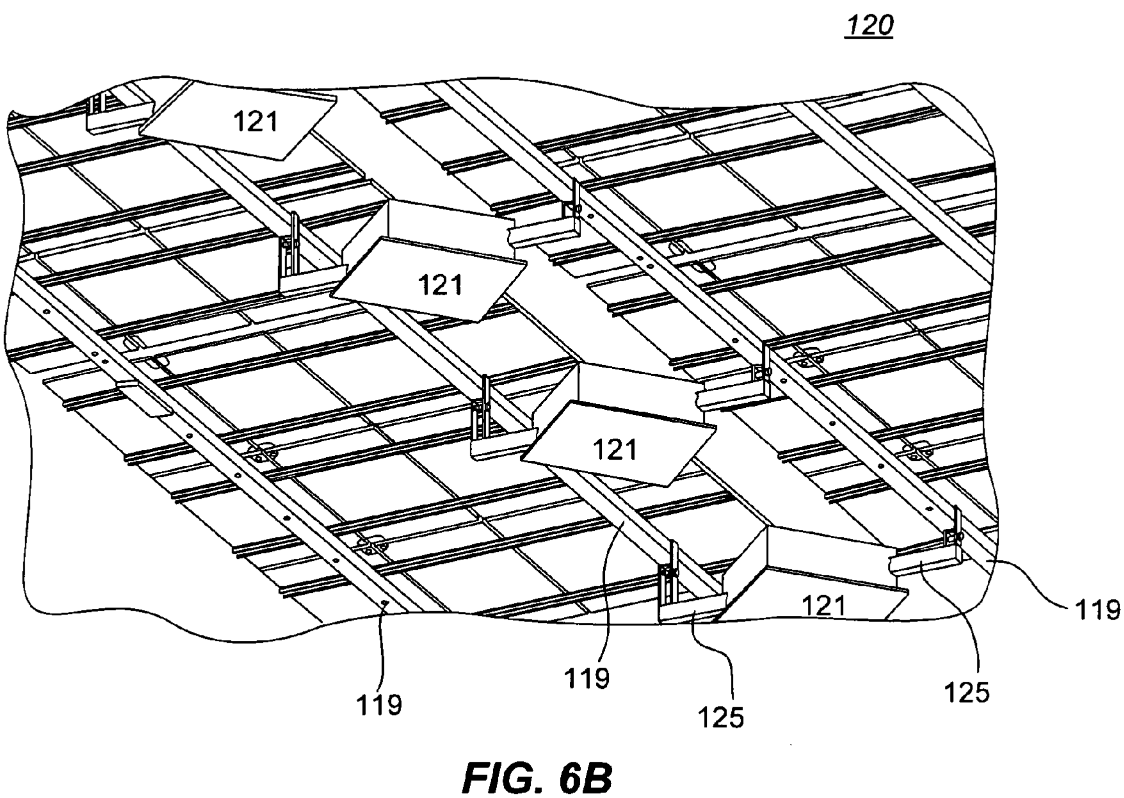

120
121
121
121
121
119
119
119
125
125

FIG. 6B

FLEXIBLE ROOF-MOUNT SYSTEM AND METHOD FOR SOLAR PANELS

BACKGROUND

[0001] 1. Field

[0002] This disclosure relates to a roof mounting system for solar panels. More particularly, systems and methods for mounting solar panels in a manner that is low-cost and non-invasive are disclosed.

[0003] 2. Background

[0004] Installing photovoltaic (PV) panels onto roof tops requires careful consideration of the roof structure design and its capacity to react to loads beyond its own mass (dead loads) and dynamic loads including wind and rain (live loads). As roofing structures are primarily designed for environmental protection, they are typically not well suited for bearing loads or for mounting other structures without the potential for compromising their shielding ability. Therefore,—rooftop PV installation should not cause roof leaks or significantly interfere with drainage (some existing solar systems have "rails" running directly on the roof membrane and prevent runoff of rain, especially heavy rain; this design quickly creates ponding and accumulation of debris, leaves, etc.) Also, rooftop PV panels—often are installed around existing roof-components such as chimneys, vents, antennas, stairwells, skylights, signage, etc., in a way that does not interfere with their function. Roofs come in different 3-D shapes with differently arranged slopes. Roofing materials expand and contract as their temperature changes, and the—interface of PV panels and the roofing material should not cause additional stress due to their different thermal expansion rates. Electrical continuity must also be maintained throughout the entire PV array.

[0005] Due to the wide variety of roof shapes, existing roof features, roof construction methods, and environmental barriers used on commercial rooftops, a design approach to install PV panels has many conflicting considerations. For instance, standard sizes and positions for rails, frames and other panel mounting features reduce production costs by enabling easy automation of manufacturing and economy of scale. However, panel supports cannot always be spaced regularly on a roof; their positions are constrained by the locations of underlying load-reacting members, and other roof features such as pipes, vents, skylights, antennas, etc.

[0006] As well, installation costs can often be the highest of the overall system costs. Raising the panels and support structures onto the roof accounts for one significant fraction of the cost. Positioning them is also costly, particularly if major disassembly and starting over results from each discovery of a misalignment. Ideally, installed panels should be easy to replace during maintenance, repair, or upgrade operations.

[0007] Therefore, there has been a long-standing need for an attachment scheme that would address many of the problems stated above.

SUMMARY

[0008] The foregoing needs are met, to a great extent, by the present disclosure, wherein systems and methods for the easy and rapid placement of solar panels on a roofing structure are provided. In one of various aspects of the disclosure, a non-invasive, roof-mounting system for flexible configurations of photo-voltaic (PV) panels having an attachment member is provided, comprising: a non-slip pad suitable for placement on a roof surface; a PV-panel support resting on the non-slip pad; and a clip attached to the support, the clip capable of being tightened to the attachment member of the PV panel to affix the PV panel above the roof.

[0009] In one of various aspects of the disclosure, a non-invasive, roof-mounting system for flexible configurations of photo-voltaic (PV) panels having an attachment member is provided, comprising: means for non-slipping suitable for placement on a roof surface; means for supporting a PV-panel, the supporting means resting on the means for non-slipping; and means for attaching the support to the PV-panel, the means for attaching being attached to a rail of the PV-panel and having the capability to be tightened to the rail to affix the PV panel above the roof.

[0010] In one of various aspects of the disclosure, a method for non-invasive, flexibly configured mounting of photo-voltaic (PV) panels having an attachment member to a roof is provided, comprising: placing a non-slip pad on a membrane of the roof; placing a PV-panel support on the non-slip pad; attaching a clip to the support; and attaching the clip to the attachment member of the PV panel, wherein the PV panels are supported above the roof by a network of the non-slip pads, PV-panel supports and clips.

[0011] In another of various aspects of the disclosure, a method for non-invasive, flexibly configured mounting of photo-voltaic (PV) panels having n aattachment member to a roof is provided, comprising: placing a non-slip pad on a membrane of the roof; attaching a clip to a PV-panel support; lifting the PV-panel support onto the non-slip pad using a portion of the clip as a lifting point; and attaching the clip to the attachment member of the PV panel, wherein the PV panels are supported above the roof by a network of the non-slip pads, PV-panel supports and clips.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIGS. **1**A-B are exploded views of the exemplary mounting systems.

[0013] FIGS. **2**A-**2**C are side views of example variations of types of low-cost clips.

[0014] FIG. **3** is an illustration of some examples of clip tips that form electrical contacts with the rails when the clip is tightened.

[0015] FIGS. **4**A-B are illustrations of possible alternatives for support lifting schemes.

[0016] FIG. **5** is a side view illustration showing different support heights can be used to mount the panels at a particular tilt angle that maximizes the sun exposure.

[0017] FIG. **6**A is a partial see-through view of an installed array, where the panels are mounted in independent rows.

[0018] FIG. **6**B is a bottom view of an installed array

DETAILED DESCRIPTION

[0019] Aspects of the disclosed systems and methods are elucidated in the accompanying figures and following detailed description. In various embodiments, friction and cushioning providing slip pads are utilized between low-cost, small-footprint supports and the roof membrane. The slip pads ensure that the supports stay in place on the roof without penetrating the roof membrane. The supports are designed to have a small footprint with sufficient spacing to allow free drainage between the supports.

[0020] A simple, low-cost attachment "clip" can be integrated with each support to attach the panel to the support, either flexibly or rigidly, depending on the amount of tightening applied to the clip. The clip (or its mount on the support) can also be used in some embodiments to lift the support to the roof. The panels can include one or more rails that can slide through a loosened clip, but be held securely in place by a tightened clip. The panels can be installed initially with the clips grasping the rails loosely. Any further fine alignment can be done with no time-consuming disassembly. Once the supports and rails are in their final positions, the clips can be fully tightened and the array becomes a rigid "web" to counter the wind loads that would otherwise tend to uplift and displace the panels. The clip also is capable of providing an electrical ground and mechanically secures the panels in the single, very simple operation of tightening on the rail. Thus, the PV array configuration is flexible during installation, but structurally rigid after installation, and is also compatible with a wide variety of roof designs.

[0021] As made apparent in the following description, the exemplary clips can be tightened and loosened—. The clip can be spring loaded and adjusted using a single tool, for example, a socket wrench, on the tightening bolt. Initially, the clips may only be partially tightened to the panels so that, if a misalignment is discovered, the rails can be slid through the clips to refine the alignment without moving the supports or disassembling any rail structures. This saves considerable installation time, and thereby reduces cost.

[0022] When the positioning is satisfactory throughout the array, the clips are fully tightened, locking the array in place. Tightening can also function to create an electrical contact between the clip tips and rails, ensuring electrical continuity of all the metallic structural members—for grounding. However, the clips can be re-loosened and re-used if panels ever need to be replaced.

[0023] FIGS. **1**A-B are exploded views **10** and **20** of exemplary mounting systems. The mounting system contains a clip **11** or **21** that is positioned above a roof membrane **19**. In FIG. **1**A, the clip **11** is mounted onto a clip mount **13** which is coupled to or integrated with a support **15**. The support **15** rests on a slip pad **17**, **27** with is placed above the roof membrane **19**. The slip pad **17**, **27** may be a thin underlying sheet as seen in FIG. **1**A or a thick stabilizing base as seen in FIG. **1**B, or any variation thereof. Any material that provides adequate cushioning between the bottom of the support **15**, **25** and the top of the roof membrane **19**, and is difficult to slide against either of those surfaces (e.g. EPDM or other elastomers as one of several possible examples) is suitable for use as the slip pad **17**, **27**. The slip pad **17**, **27** may be individual sheets or a roll or any variation thereof, including being attached to the support **15**, **25**, according to implementation preference. The support **15**, **25** may be wide as shown in FIG. **1**A or narrow as shown in FIG. **1**B. Multiple shapes or versions of the support **15**, **25** may be devised as according to design preference. Accordingly, the support embodiments shown in FIGS. **1**A-B are understood to be non-limiting examples, whereas variations and modifications in size, shape, number, orientation and so forth may be made without departing from the spirit and scope of the disclosure.

[0024] The support **15**, **25** may also be placed atop the slip pad **17**, **27** and held in place by friction, for example, as in FIG. **1**A or pre-attached or integrated, for example, as shown in FIG. **1**B. Any suitable structural material (for instance, concrete or another structural composite, or a metal such as aluminum, and so forth) may be used for the support **15**, **25**. Both the slip pad **19** and the support **15**, **25** may be any suitable shape; however, they may be designed and arranged so that no long straight edge impedes any rainwater, leaves, or other debris from blowing or washing off the roof.

[0025] More than one clip **11**, **21** may be attached to each support **15**, **25** and the clips need not be centered. For instance, in some configurations an off-center clip position may shift the center of gravity to more efficiently react to dynamic loads such as wind, as well as for heavier panels that may need a different arrangement of the clips. It should be noted that the U-shaped clips **11**, **21** shown in FIGS. **1**A-B may be replaced with alternative shapes or gripping mechanisms, examples of some alternatives being shown below. In various embodiments, the body of the clip **11**, **21** may be made of a conductive material. Also, tips of the clips **11**, **21** may be of any desired shape.

[0026] FIGS. **2**A-**2**C are side views **30**, **50**, and **60**, respectively of example variations of types of simple clips. The clip body **33**, **53**, **63** can be made from inexpensive metal, sheet metal, for example, or any other type of suitable material. The "living" hinges **37** can be created by bending, and the through-holes **39**, **59**, **69** by punching, for example. A mounting nut **48** or fixture can attach the clip to a threaded bolt integrated into the support (not shown). In various embodiments, the use of a tightening bolt **42**, anti-rotation washer **46** and tightening nut **44** allows the clip to be tightened or loosened with a single tool. The clip body **33**, **53**, **63** can be designed for different rail cross-sections **31**, **51**, **61**.

[0027] As should be readily apparent to one of ordinary skill in the art, other forms of tightening or loosening may be devised as there are numerous mechanisms and methods for tightening an object to another object. For example, a captive fastener, such as a bolt as a non-limiting example, can be used which tightens or loosens the exemplary clips **11**, **21** by being turned in one direction or another. Accordingly, variations of the clip types and the methods, devices for affixing and so forth are understood to be within the scope of the description provided herein.

[0028] FIG. **3** is an illustration **70** of some examples of clip tips that can be used to form electrical contacts with the rails when the clip is tightened. In many cases a plain tip **71** (far left) will prove to be sufficient for providing gripping as well as electrical contact as compared to the curved tip **75** (center). Optionally, teeth can be added to the clip tip as shown in the far-right example **77**. In some embodiments, only a portion of the tip may be electrically conductive, or there may be an insulative or protective barrier placed about a portion of the tip to prevent corrosion. It is envisioned that in these embodiments, a grounding or conductive cable may be coupled to the clips either through the described mechanical connection, or using a separate intermediate connector/cable. Also, in some embodiments, it is contemplated that a secondary tightening or electrical contact ensuring mechanism may be utilized, if so desired. That is, electrical contact may be further facilitated by pressure exerted by a secondary bolt or screw and so forth, in addition to, or rather than solely by the tightening bolt **42**.

[0029] Installation of the exemplary embodiments can be performed by positioning the slip pads **17**, **27** on the roofing membrane **19**. The slip pads **17**, **27** operate to create friction when the supports, rails, and panels are placed on top of them. Along with the weight of the array, the friction prevents the array or any of its components from sliding out of position.

The slip pads also cushion the roof membrane **19** against any scratches or localized pressure points the bottoms of the supports might otherwise inflict.

[0030] Supports, weighing less than the roof's safe maximum point-load, can be raised to the roof and positioned on the slip pads **17**, **27**. If the support is liftable and the clip is resilient to mechanical strain, the temporarily tightened clip itself may be attached to the hoist, allowing the panels to be lifted to the roof using the clip as the hoist-to-support attachment member.

[0031] FIGS. **4**A-B are illustrations **80** and **90** of possible alternatives for support **86**, **96** lifting schemes. The hoist **83**, **93** can be attached to the clip mount **82**, **92** via arms **85**, **95** before clip attachment as shown, for example, in FIG. **4**A. Or the hoist **83**, **93** can grip underneath the clip **98** that is already attached (or where the clip is made as part of the support) as shown in FIG. **4**B. In FIG. **4**B, by attaching the clip **98** to the support **96**, via the clip mount nut **94**, the hoist **93** can use the clip **98** as the lifting point for the support/array. Alternatively, as seen in FIG. **4**A, the hoist **83** may be attached to the support **86** via the arm **85** and secured thereto by the clip mount nut **84**, and the lifting force can be borne by the clip mount **82** rather than by the clip.

[0032] It should be noted that the clip mounts **82**, **92** illustrated in FIGS. **4**A-B are not limiting examples. That is, the threaded clip mounts **82**, **92** may be implemented using an alternative mechanical means. For example, a "snap-in" coupler or other applicable coupler may be used, according to design preference. Accordingly, modifications and changes may be made to the clip mounts **82**, **92** as well as to other features of the disclosed embodiments, without departing from the spirit and scope herein.

[0033] Because the clip **98** shown in FIG. **4**B can grasp any point along the rail's length, the supports **86**, **96** (and underlying slip pads) can be placed over the major structural members of the roof that can best react to the extra mass of the support—wherever those members may be—and the clips **98** will still be able to position and electrically ground the rail. Thus, the disclosed mounting systems provide an added degree of freedom with respect to placement on the roof.

[0034] FIG. **5** is a side view illustration **100** showing different support heights that can be used to mount the panels at a particular tilt angle that maximizes (or reduces) the sun exposure. As may be apparent in FIG. **5**, if the clips **53** are of sufficient height and flexibility, they will accommodate "off-plane" or tilting at the surface of the clip tip and the rail. That is, accommodation of the tilt angle by the panel can be made without requiring adjustment or actual bending of the clip. In some instances, however, it may be necessary to accommodate the tilt angle, if severe enough, by placing an angle or height modifier (not shown) at the top of the clips **53**. Also, while the exemplary mounting systems are shown with "square" support structures, alternative shapes such as round, rectangular, pyramidal, and so forth may be utilized.

[0035] FIG. **6**A is a partial see-through view **110** of an installed array, where the panels **112** are mounted in independent rows. The bottom of each PV panel **112** is shown being elevated off the roof surface. The clips **113** are attached to the rails **119** which are coupled to the panels **112**. Though FIG. **6**A illustrates the exemplary mounting system **115** as being placed in a parallel fashion, it may be desirable, in some circumstances to stagger the mounting system **115**, for example, in a zig-zag pattern. Of course, based on implementation constraints or other factors, the mounting system **115** may be arranged in varying patterns, as desired. Also, while only a single clip **113** is attached to the rail **119**, per mounting structure, multiple clips may be utilized as desired.

[0036] FIG. **6**B is a bottom view **120** of an installed array where the rows are mechanically coupled by having the rails **119** of adjacent panel rows clipped to common supports **121** via the clip supports **125**. Here we see that multiple panels or rails **119** can be supported by a single support **121**. Also, FIG. **6**B is instructive in showing that the support **121** does not need to be directly under the panel to provide the needed support. This configuration is understood to provide better wind reactance by shifting the centers of gravity to the points between the rows where an uplifting wind would enter.

[0037] It should be apparent that as multiple clips from a single support **121** can be used to support the panels, in some embodiments it may be desirable to have a single support **121** configured to bridge two or more slip pads. That is, while the exemplary embodiments described herein illustrate a one-to-one correspondence between the supports and the underlying slip pads, it is understood that a single support resting on several slip pads or several supports resting on a single slip pad may also be used. Thus, modifications may be made to the various embodiments herein without departing from the spirit and scope herein.

[0038] Various advantages can now be realized as demonstrated, for example:

[0039] Lower-profile objects that are part of the roof (e.g. air conditioning pipes, conduit, small obstacles) could "disappear" underneath the array and among the ballasts. They do not interfere with the array, nor the array with them.

[0040] Because the clips and rails make panel removal and replacement easy, the roof features under the array can be accessed for any necessary maintenance.

[0041] Because it is not necessary for the support to physically touch the roof, and since they make relatively small footprints with plenty of space between them, any water landing on the roof easily drains away between the blocks. With this mounting system, the chain of panels "floats" over the top of the roof independently of the structural arrangement built into the roof to react live and dead loads. This allows great flexibility in designing the array configuration to work around existing roof throughout the array's operating life, the clip accommodates the daily growth and shrinkage of metallic components exposed to the wide ambient temperature ranges seen on large rooftops.

[0042] Further, the ability to re-use or recycle the support components would reduce both cost and waste.

[0043] Importantly, no modification or penetration of the roof is necessary for installation. This feature addresses one of the primary concerns of roof-mounted systems, as it is well known that most, if not all, roof-mounted systems require some penetration of the roof membrane or surface, resulting in eventual near or long term roof failure.

[0044] An exemplary installation would include connecting a chain of mechanically linked PV panels to supports or support feet such that the panels were easy to install, that thermal expansion and contraction could be accommodated without wear and fatigue, that electrical continuity could be accommodated, and to enable the array to accommodate the shape of the roof, at very low cost.

[0045] While the above embodiments describe the exemplary mounting/support system(s) as not requiring any modification of the roof, it may be desirable in some embodiments to physically link or couple a portion of the support system to the roof, to strategically anchor the panel network. That is, various portions or critical points in the linked PV panels may be directly connected to the roof or to some support or structural member of the roof to provide a "hard" mechanical anchor, while other portions of the linked PV panels may be supported using the exemplary supporting system(s) described herein. By minimizing the number of "penetration" points, concern for the roof's integrity can be minimized. If the anchoring points are situated at locations that are not part of the roof membrane (e.g, pillar, chimney, and so forth), then this embodiment will provide the same degree of roof membrane integrity as the embodiments described above.

[0046] It will be understood that many additional changes in the details, materials, steps and arrangement of parts, which have been herein described and illustrated to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

What is claimed is:

1. A non-invasive, roof-mounting system for flexible configurations of photo-voltaic (PV) panels having an attachment member, comprising:

a non-slip pad suitable for placement on a roof surface;

a PV-panel support resting on the non-slip pad; and

a clip attached to the support, the clip capable of being tightened to the attachment member of the PV panel to affix the PV panel above the roof.

2. The PV roof mounting system of claim **1**, wherein the clip provides an electrical connection to the attachment member of the PV-panel.

3. The PV roof mounting system of claim **1**, wherein the support is of sufficient weight to hold the non-slip pad to the roof surface.

4. The PV roof mounting system of claim **1**, wherein the support is of a form factor that permits water and debris to flow around it.

5. The PV roof mounting system of claim **1**, wherein the support is formed from concrete.

6. The PV roof mounting system of claim **1**, wherein the clip is integral to the support.

7. The PV roof mounting system of claim **1**, wherein the clip is captive, wherein loosening is performed by motioning in one direction and tightening is performed by motioning in an opposite direction.

8. The PV roof mounting system of claim **1**, wherein the clip is predominately in the shape of a U.

9. The PV roof mounting system of claim **1**, wherein the clip is attached to the support via a clip mount.

10. The PV roof mounting system of claim **1**, wherein the clip is configured with a shape that accommodates a contour of the attachment member, whereby the attachment member can be slid thorugh the clip when the clip is loosely attached to the attachment member.

11. A non-invasive, roof-mounting system for flexible configurations of photo-voltaic (PV) panels having an attachment member, comprising:

means for non-slipping suitable for placement on a roof surface;

means for supporting a PV-panel, the supporting means resting on the means for non-slipping; and

means for attaching the support to the PV-panel, the means for attaching being attached to a rail of the PV-panel and capable of being tightened to the rail to affix the PV panel above the roof.

12. The PV roof mounting system of claim **11** wherein the means for attaching provides an electrical connection to the rail of the PV-panel.

13. The PV roof mounting system of claim **11**, wherein the means for supporting is of sufficient weight to hold the non-slipping means to the roof surface.

14. The PV roof mounting system of claim **11**, wherein the means for supporting is of a form factor that permits water and debris to flow around it.

15. The PV roof mounting system of claim **11**, wherein the means for attachment is integral to the means for supporting.

16. The PV roof mounting system of claim **11**, wherein the means for attachment is attached to the means for supporting via a mounting means.

17. A method for non-invasive, flexibly configured mounting of photo-voltaic (PV) panels having an attachment member to a roof, comprising:

placing a non-slip pad on a membrane of the roof;

placing a PV-panel support on the non-slip pad;

attaching a clip to the support; and

attaching the clip to the attachment member of the PV panel, wherein the PV panels are supported above the roof by a network of the non-slip pads, PV-panel supports and clips.

18. The method of claim **17**, wherein the step of attaching includes loosing the clip to allow the attachment member to be slid through the clip and tightening the clip to fix the attachment member.

19. A method for non-invasive, flexibly configured mounting of photo-voltaic (PV) panels having an attachment member to a roof, comprising:

placing a non-slip pad on a membrane of the roof;

attaching a clip to a PV-panel support;

lifting the PV-panel support onto the non-slip pad using a portion of the clip as a lifting point; and

attaching the clip to the attachment member of the PV panel, wherein the PV panels are supported above the roof by a network of the non-slip pads, PV-panel supports and clips.

20. The method of claim **19**, wherein attaching the clip is performed by motioning a bolt in a determined direction, and opening the clip by motioning in an opposite determined direction.

* * * * *