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Danning

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(54) **LEVELER FOR SOLAR MODULE ARRAY**

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E04D 13/18 (2014.01)
H02S 20/30 (2014.01)
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(52) **U.S. Cl.**
CPC ***H02S 20/30*** (2014.12); ***B23P 11/00*** (2013.01); ***F16B 5/004*** (2013.01); ***F16B 5/0233*** (2013.01); ***F24J 2/5211*** (2013.01); ***F24J 2/5245*** (2013.01); ***F24J 2/5258*** (2013.01); ***F24J 2/5262*** (2013.01); ***F24J 2/5264*** (2013.01); ***H02S 20/00*** (2013.01); ***H02S 20/23*** (2014.12); ***H02S 30/10*** (2014.12); *F16B 33/002* (2013.01); *F24J 2/5207* (2013.01);
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USPC 52/173.3
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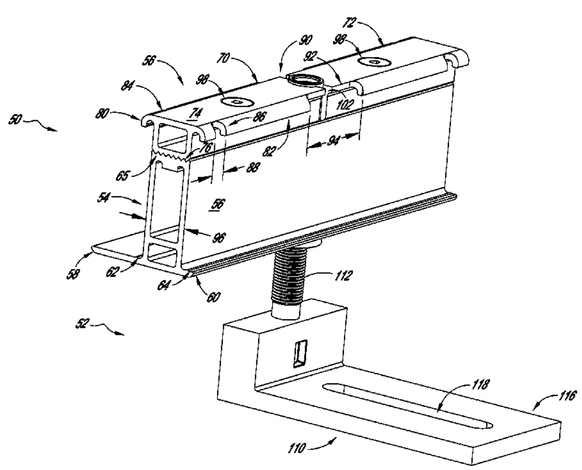
(57) **ABSTRACT**

A leveler for a solar module can include a base, a rotatable adjuster, and a follower. The rotatable adjuster can be mounted to the base with a swaging process, or other techniques. The follower can be embedded within a coupler configured to be connectable to solar modules. Turning the rotatable height adjuster changes the relative spacing between the solar module and the base.

18 Claims, 14 Drawing Sheets



(51) **Int. Cl.**

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F16B 5/00	(2006.01)
F16B 5/02	(2006.01)
H01L 31/042	(2014.01)
H02S 20/23	(2014.01)
H02S 30/10	(2014.01)
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CPC *F24J 2002/4672* (2013.01); *Y02B 10/12* (2013.01); *Y02E 10/47* (2013.01); *Y02E 10/50* (2013.01); *Y10T 29/49826* (2015.01)

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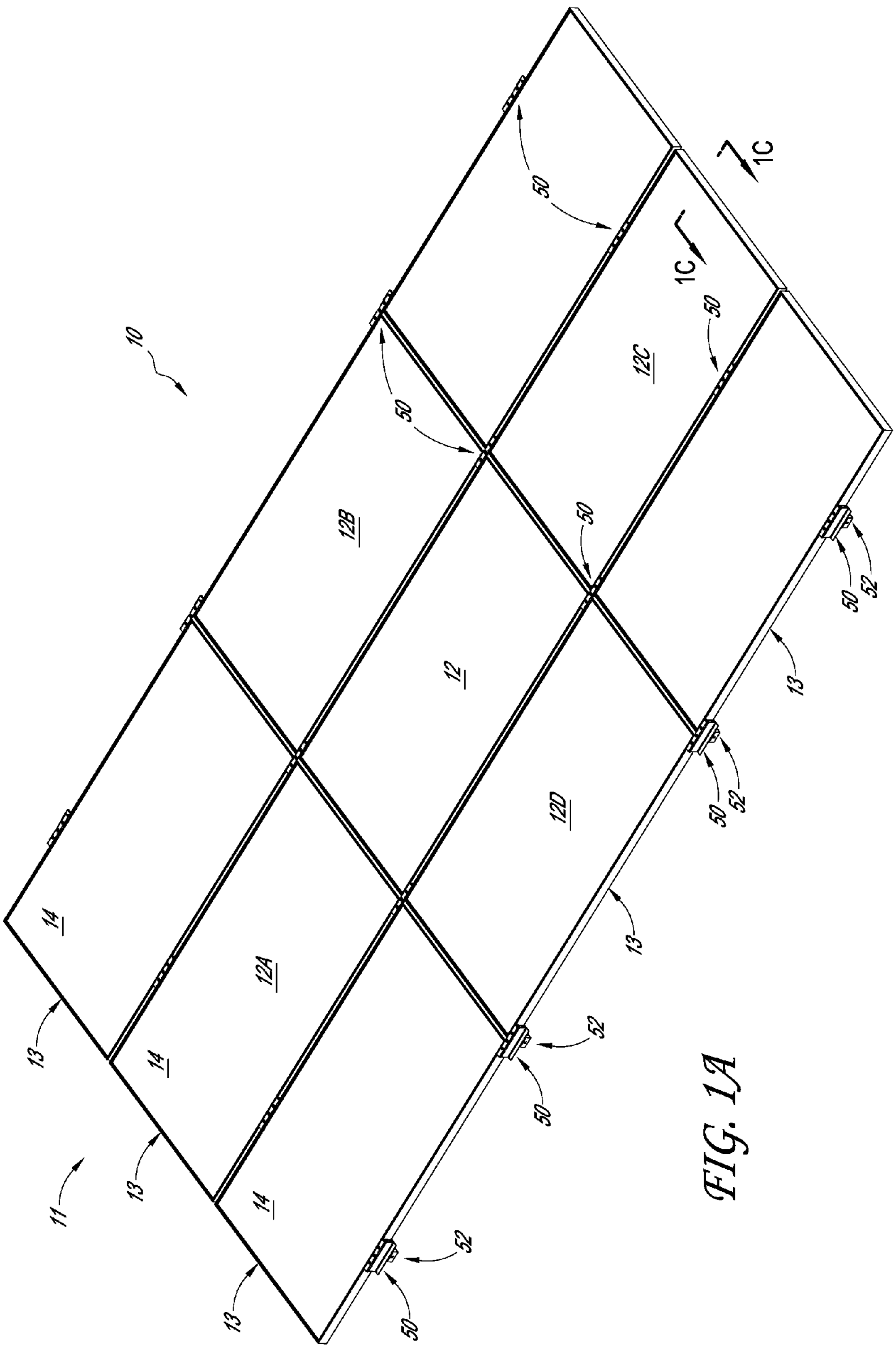
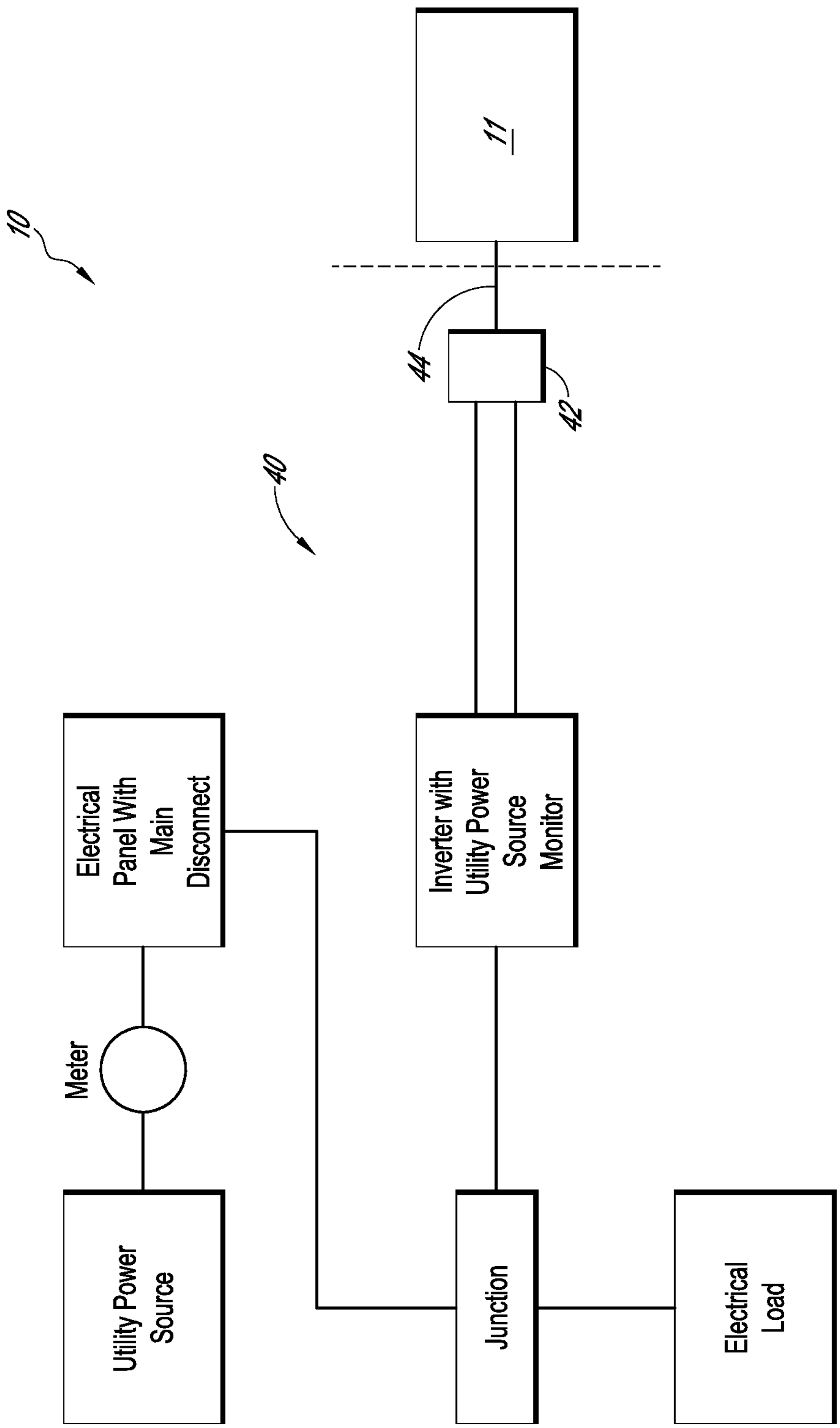


FIG. 1A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Electrical Panel With Main Disconnect
Inverter with Utility Power Source Monitor
Meter
Utility Power Source
Junction
Electrical Load

FIG. 1B

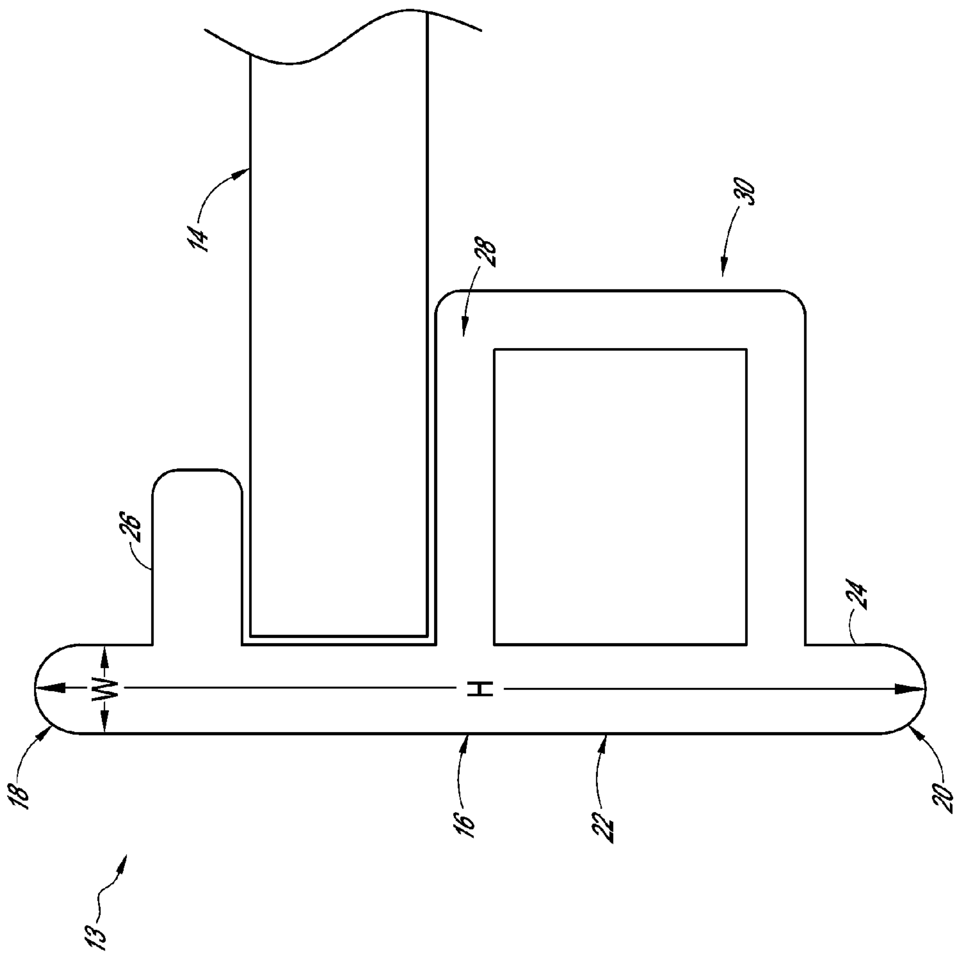

FIG. 1C

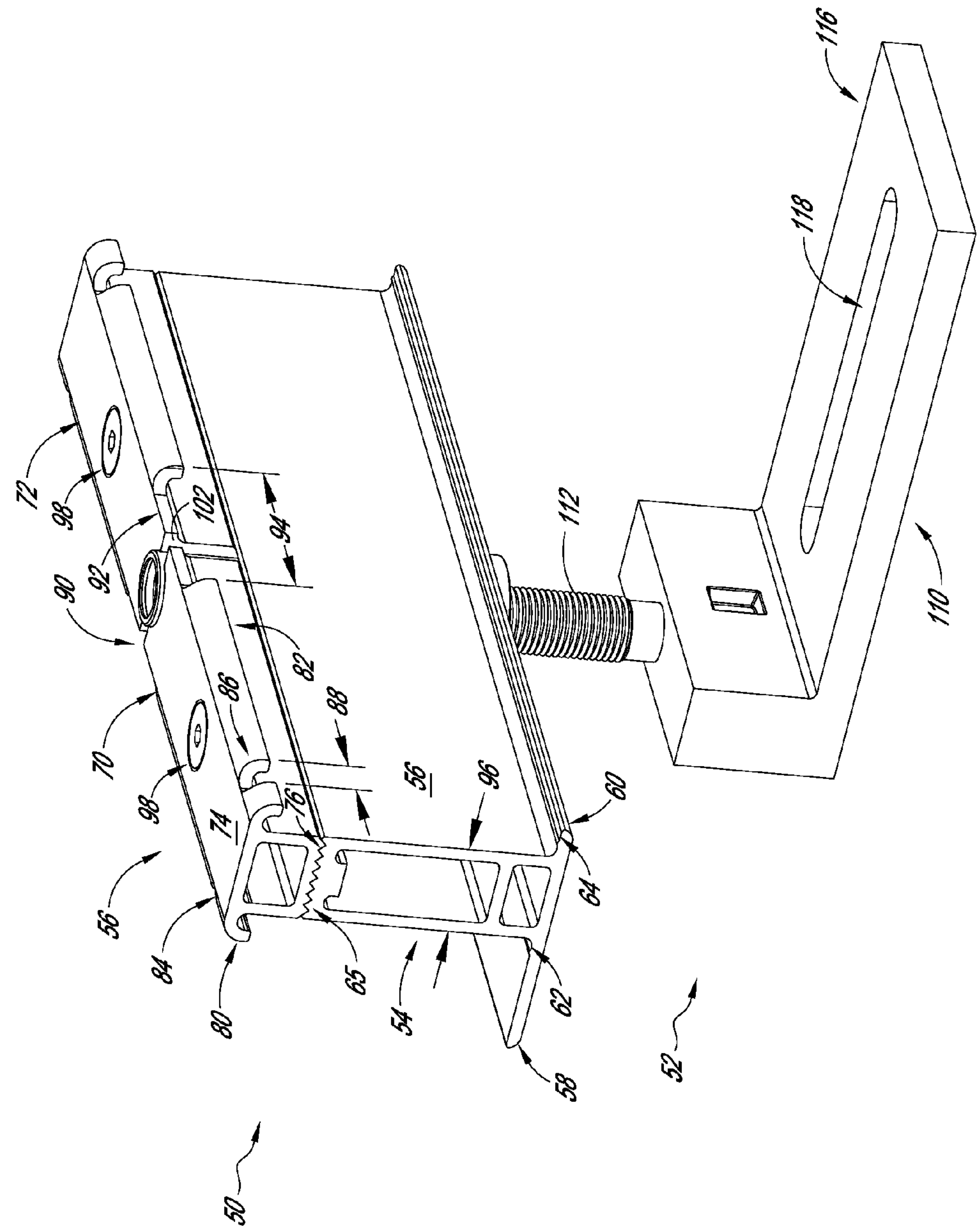
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FIG. 2A

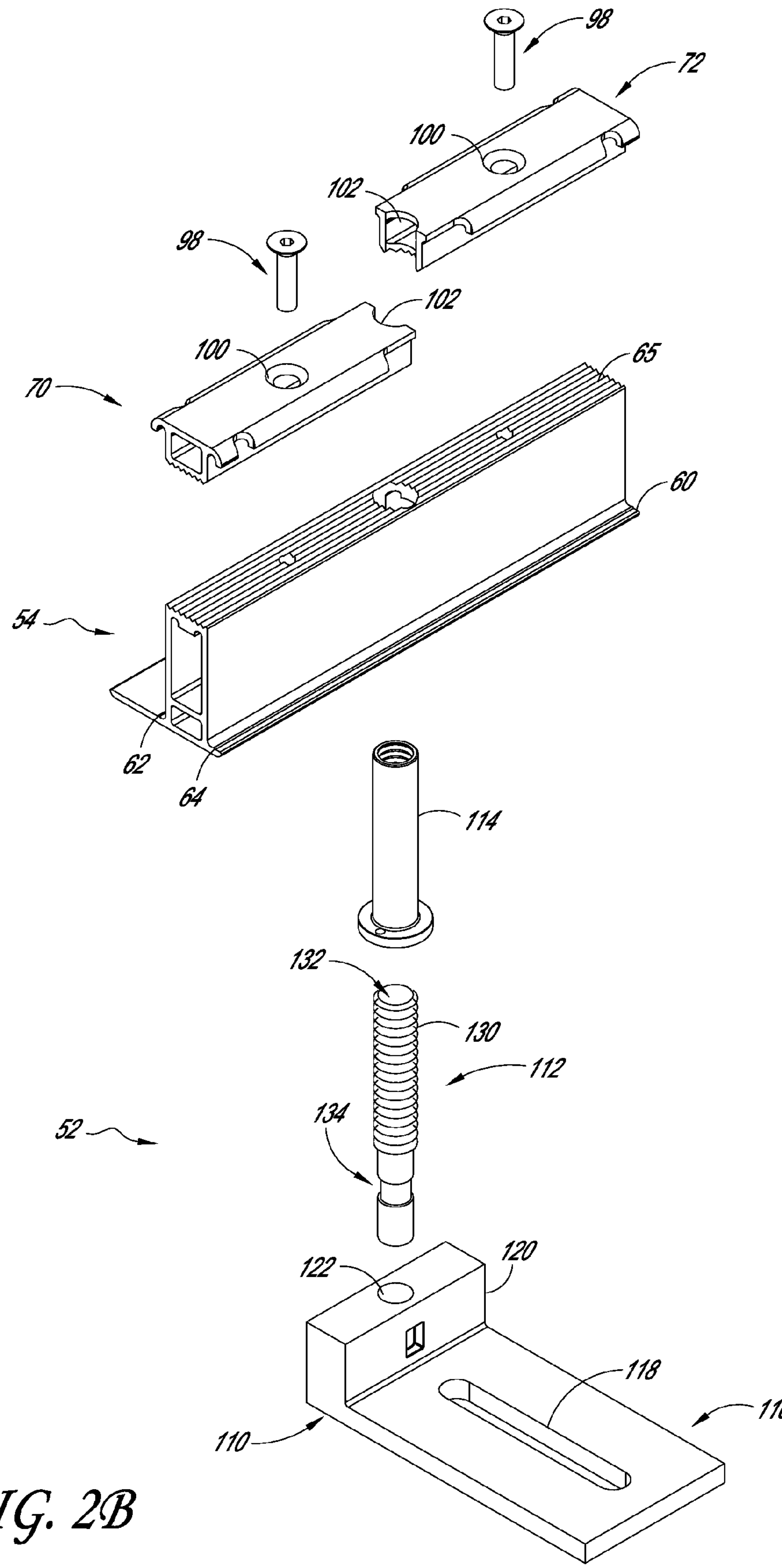
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FIG. 2B

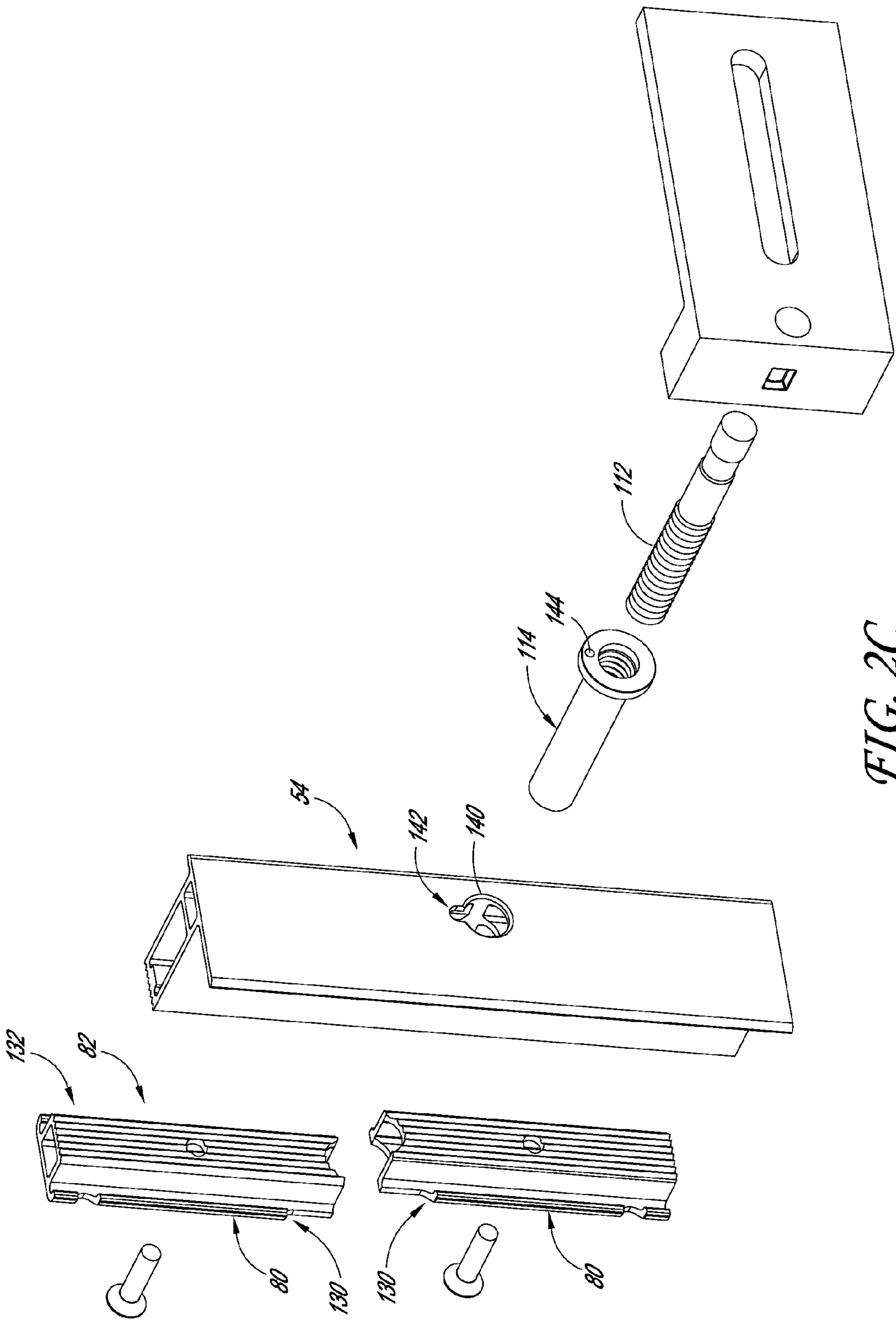

FIG. 2C

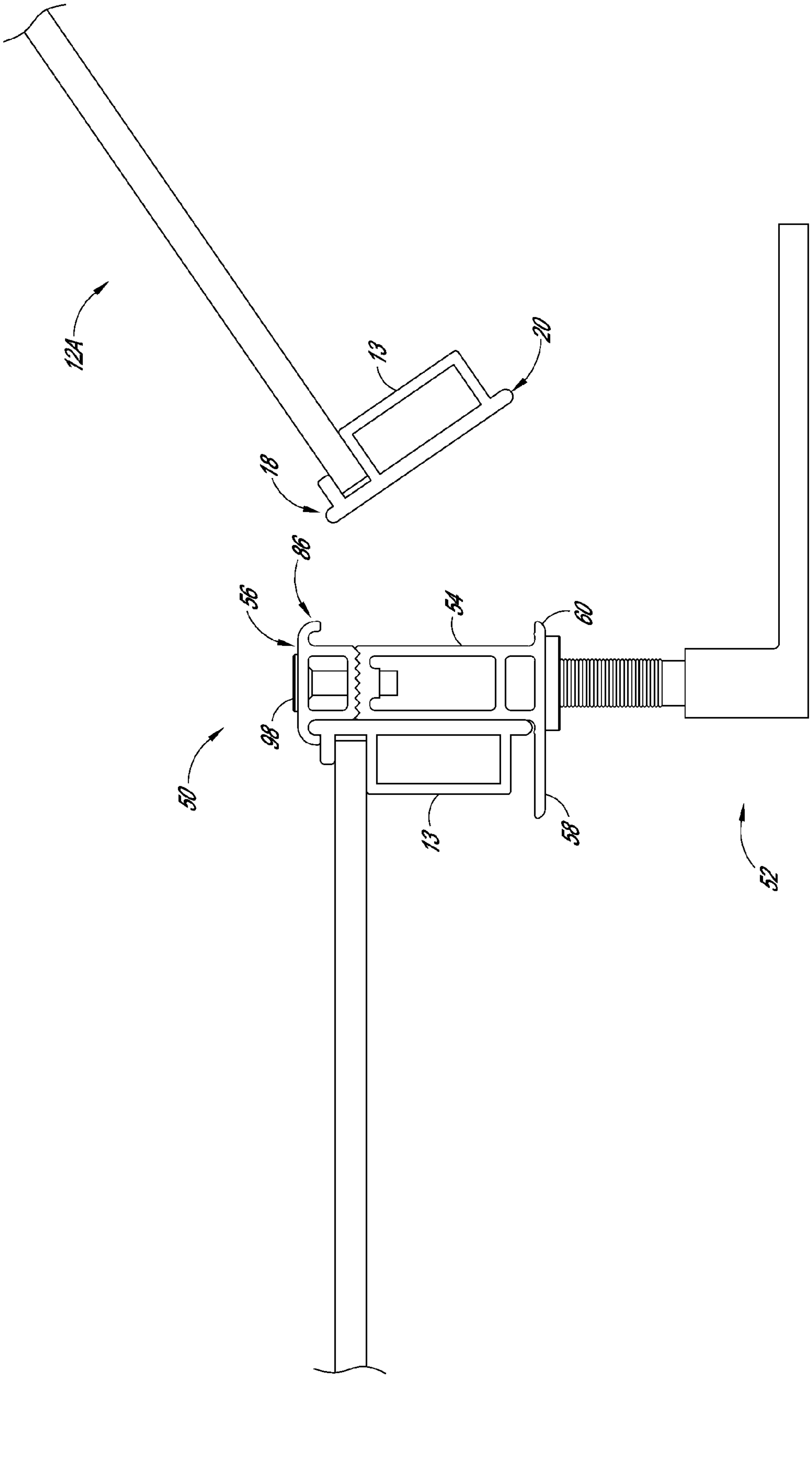

FIG. 2D

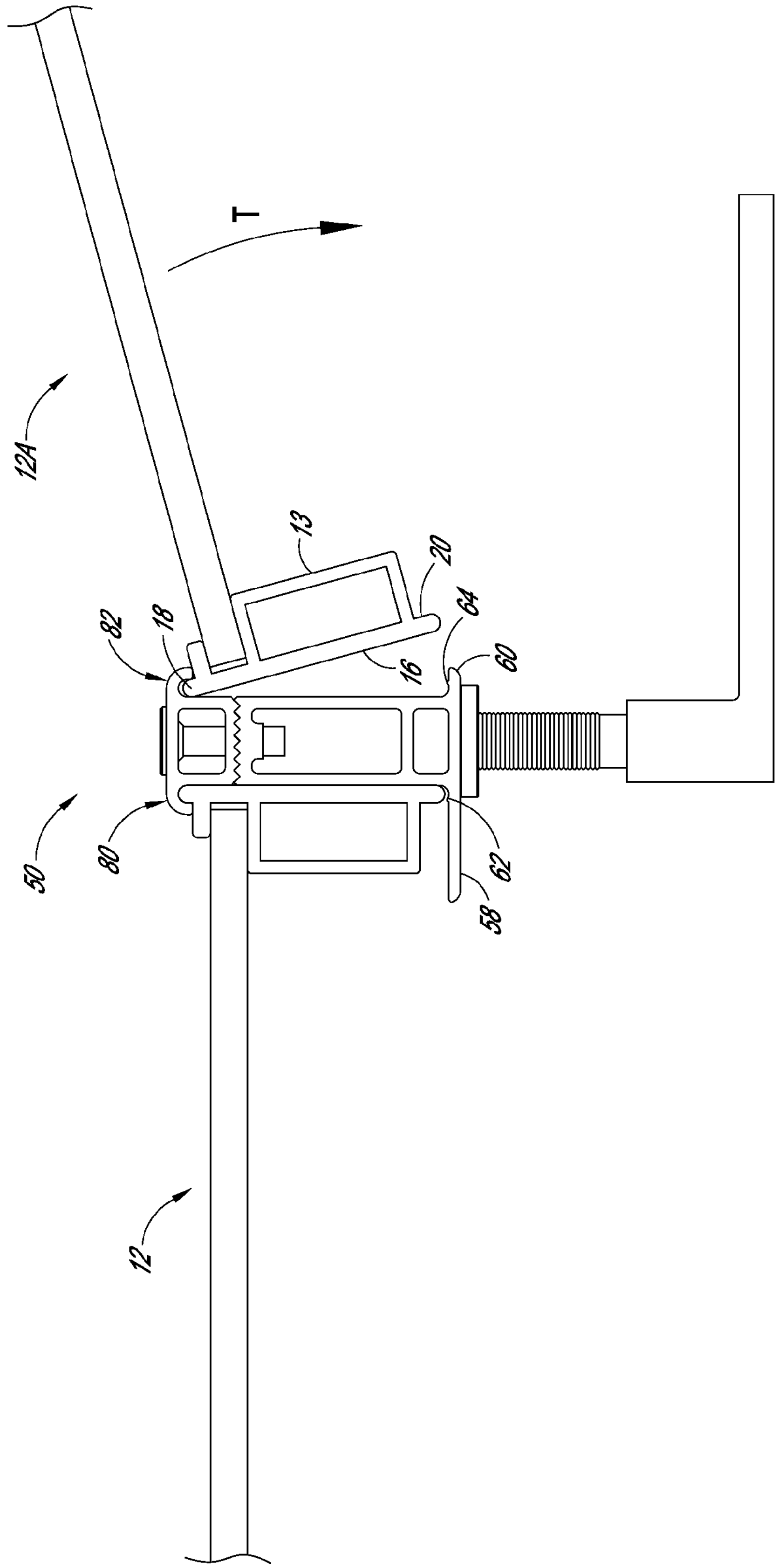

FIG. 2E

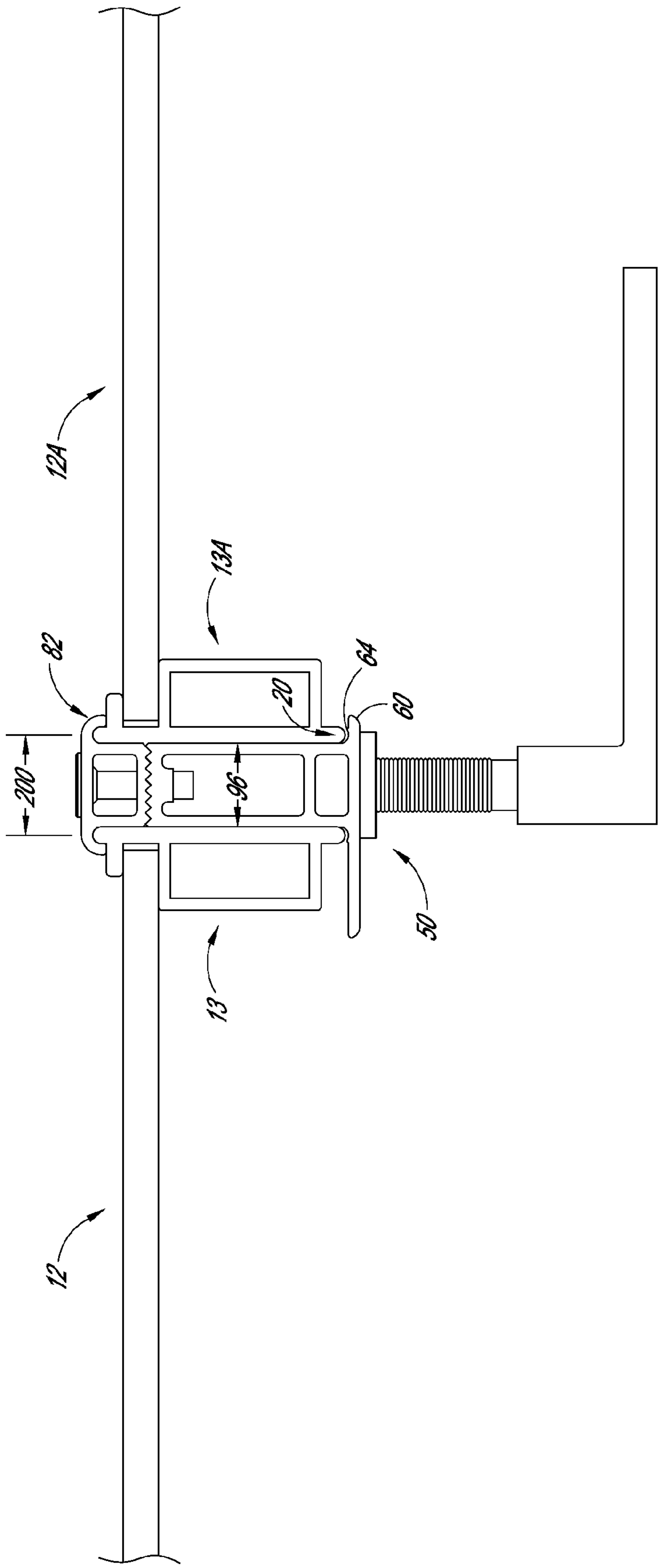

FIG. 2F

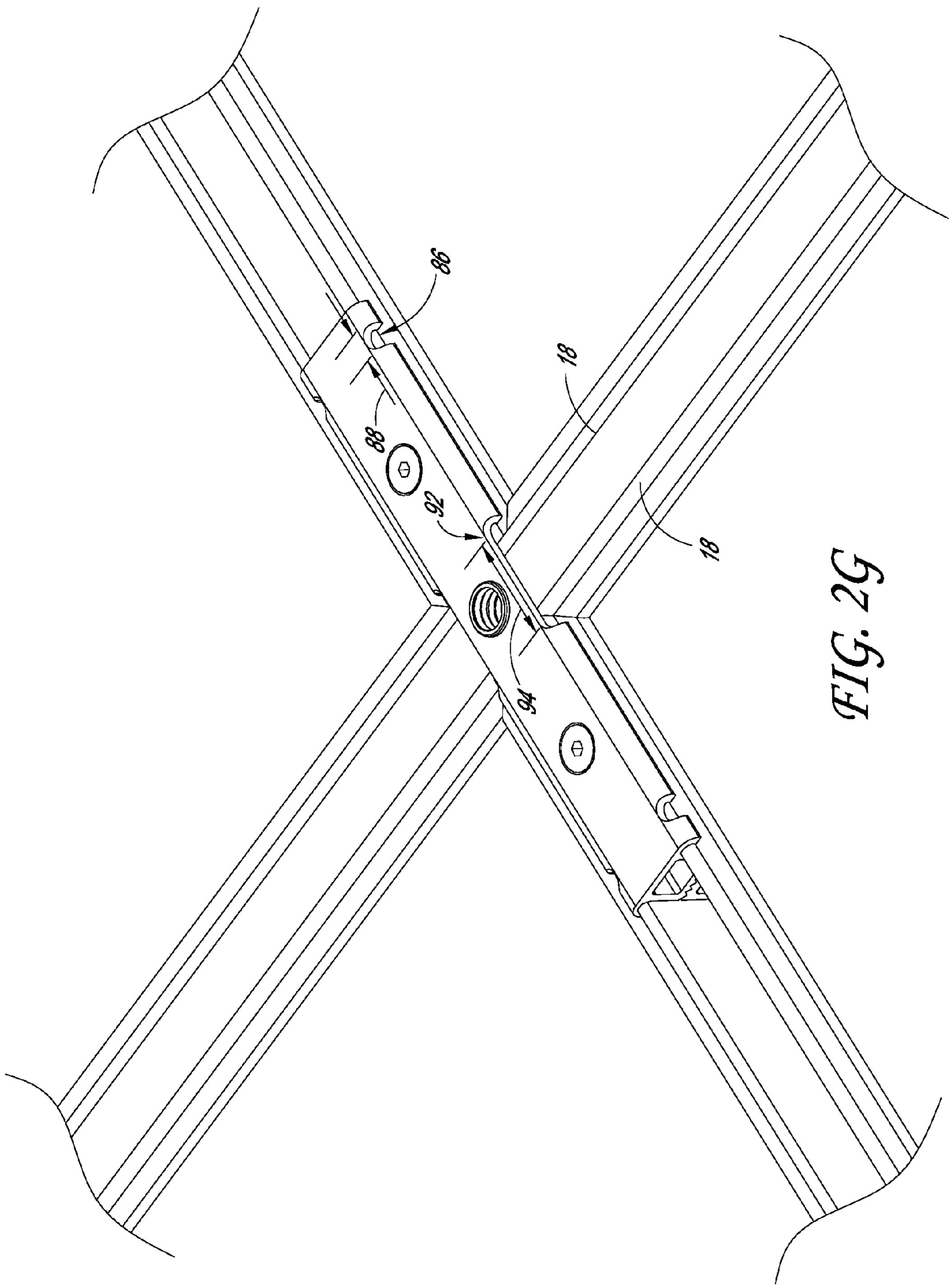

FIG. 2G

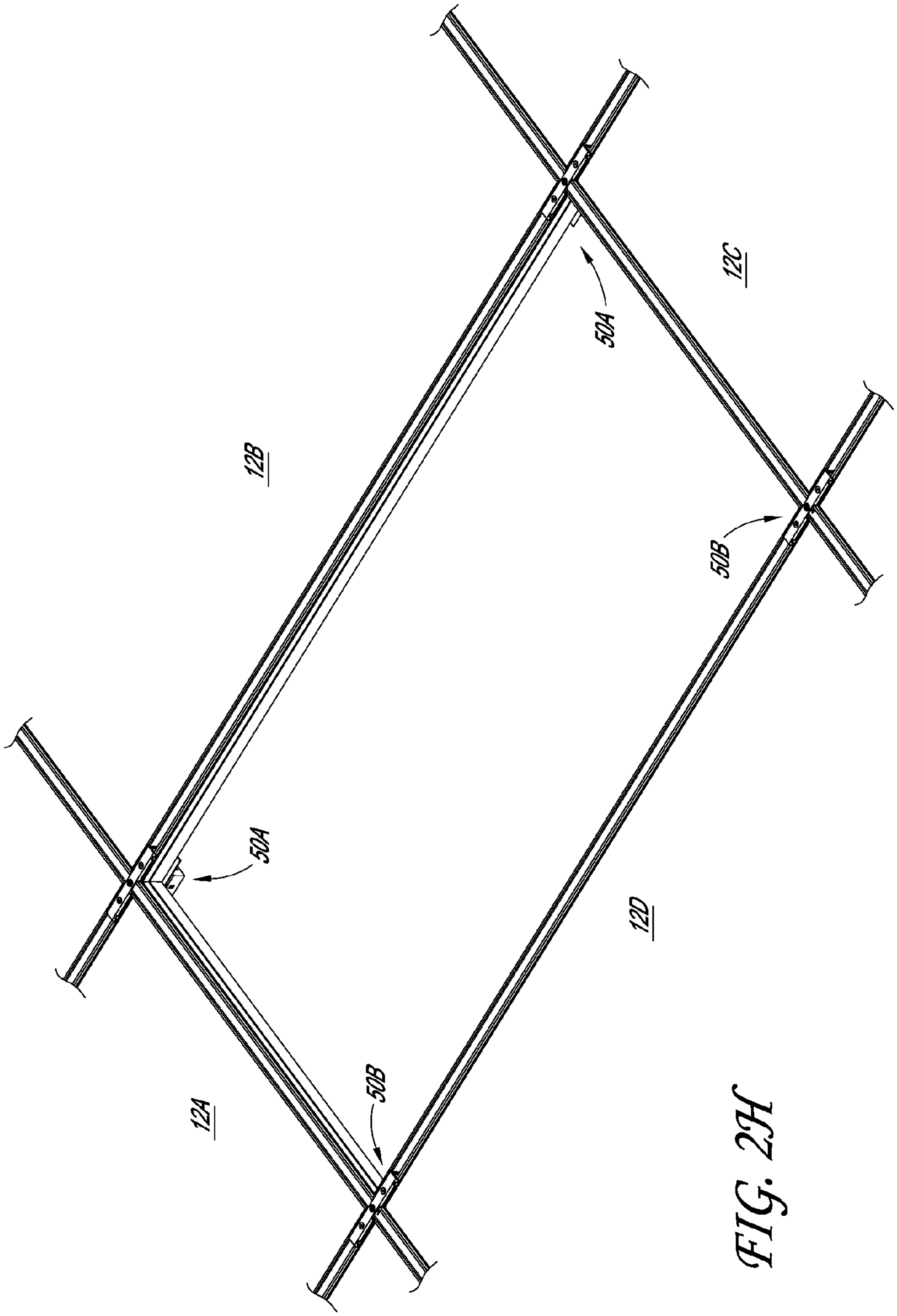

FIG. 2H

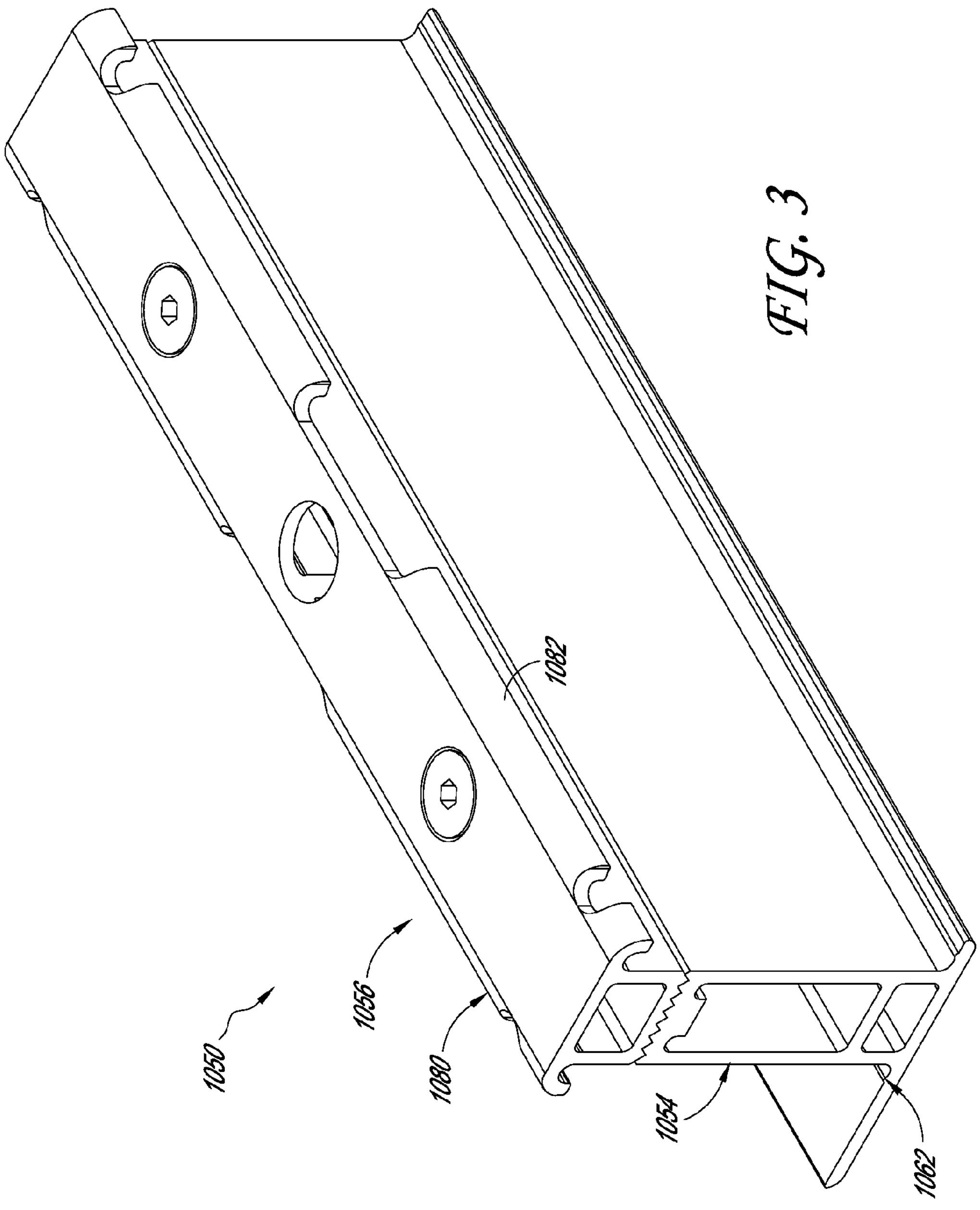

FIG. 3

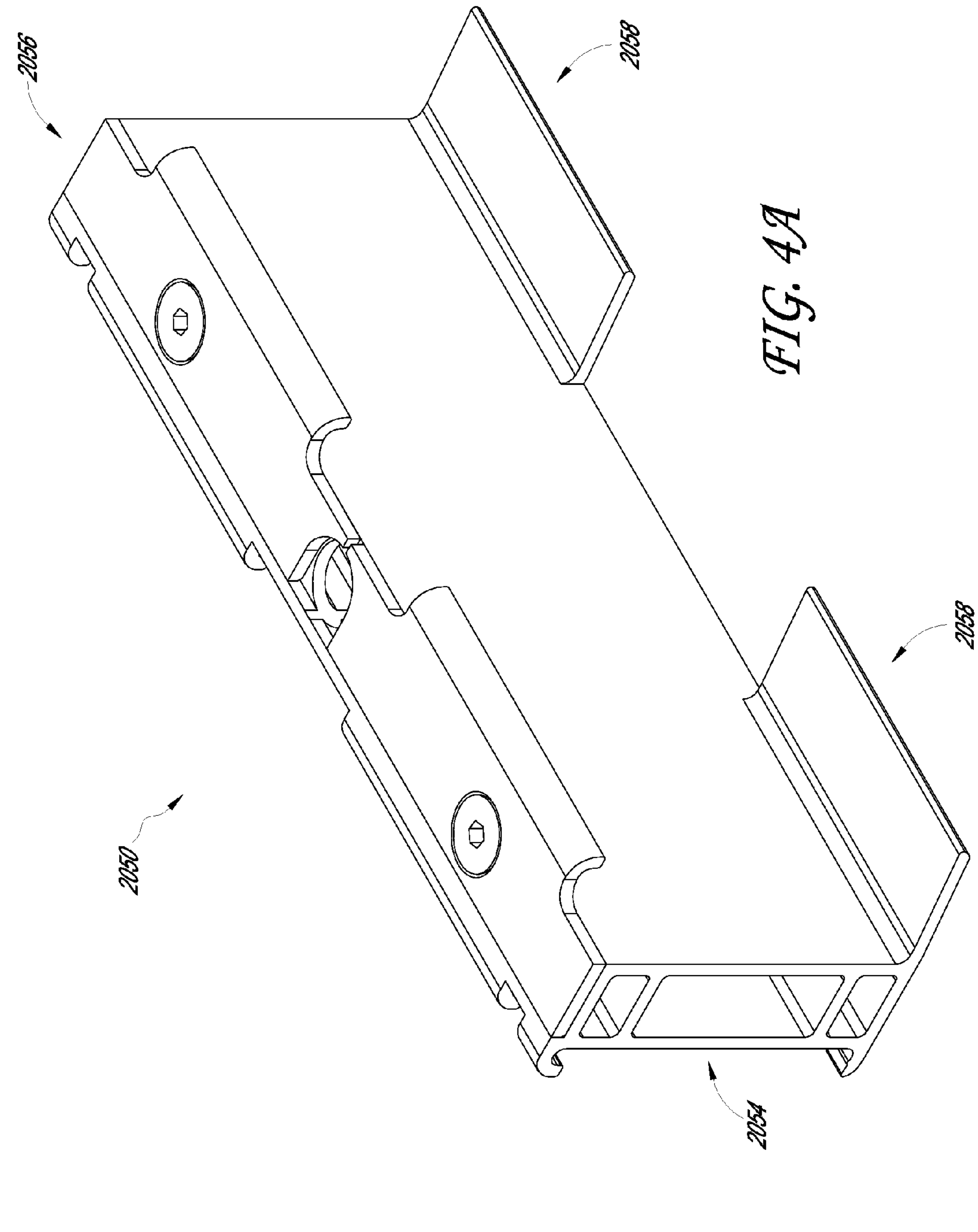

FIG. 4A

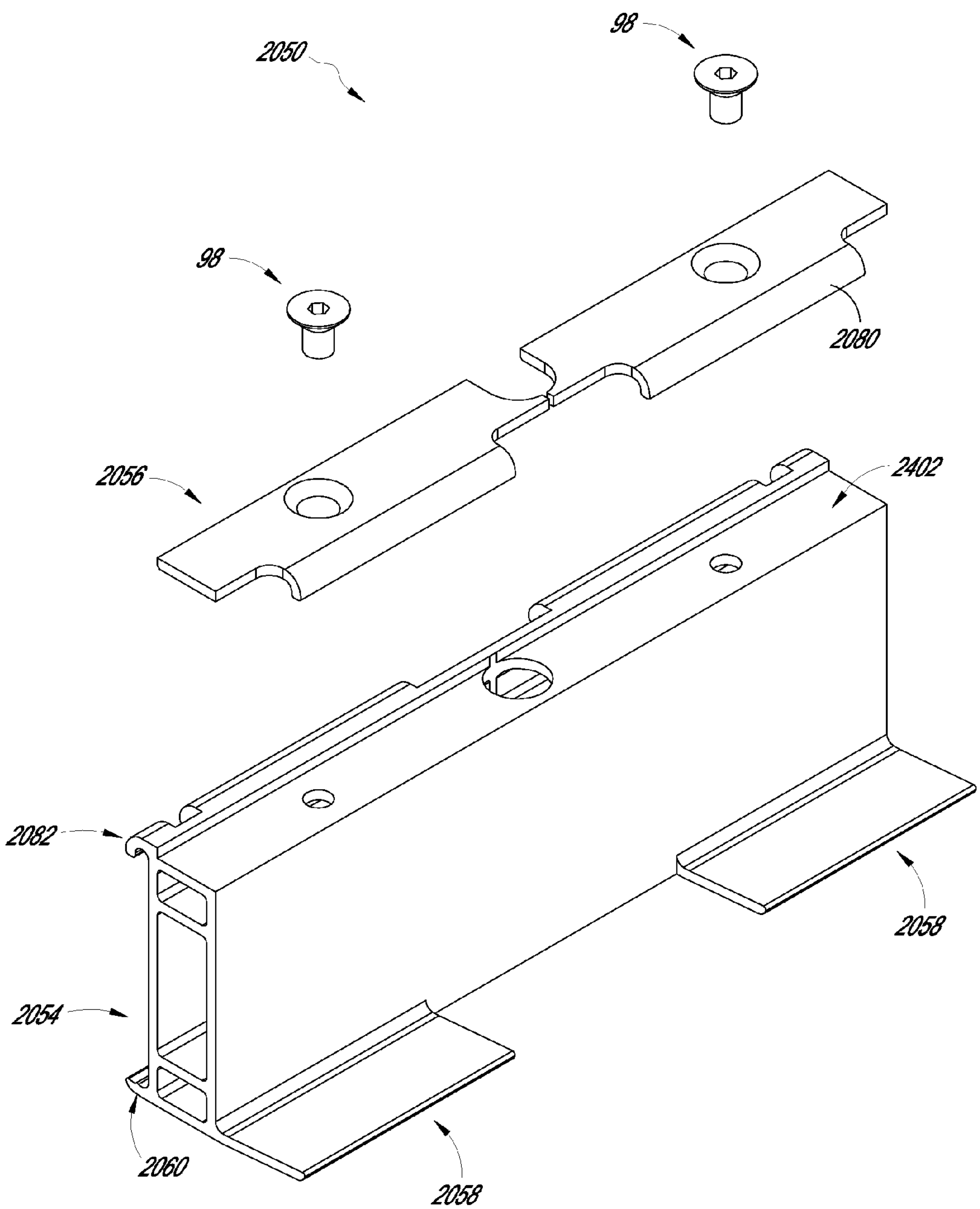

FIG. 4B

LEVELER FOR SOLAR MODULE ARRAY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 14/690,053, filed on Apr. 17, 2015, titled "LEVELER FOR SOLAR MODULE ARRAY," which is a continuation of U.S. patent application Ser. No. 13/532,728, filed on Jun. 25, 2012, titled "LEVELER FOR SOLAR MODULE ARRAY," the contents of each of which are incorporated by reference herein in their entirety and for all purposes.

BACKGROUND

1. Field of the Inventions

Embodiments of the subject matter described herein relate generally to devices and systems from mounting solar modules to fixed surfaces such as roofs.

2. Description of the Related Art

Solar power has long been viewed as an important alternative energy source. To this end, substantial efforts and investments have been made to develop and improve upon solar energy collection technology. Of particular interest are residential-, industrial- and commercial-type applications in which relatively significant amounts of solar energy can be collected and utilized in supplementing or satisfying power needs. One way of implementing solar energy collection technology is by assembling an array of multiple solar modules.

One type of solar energy system is a solar photovoltaic system. Solar photovoltaic systems ("photovoltaic systems") can employ solar panels made of silicon or other materials (e.g., III-V cells such as GaAs) to convert sunlight into electricity. Photovoltaic systems typically include a plurality of photovoltaic (PV) modules (or "solar tiles") interconnected with wiring to one or more appropriate electrical components (e.g., switches, inverters, junction boxes, etc.).

A typical conventional PV module includes a PV laminate or panel having an assembly of crystalline or amorphous semiconductor devices ("PV cells") electrically interconnected and encapsulated within a weather-proof barrier. One or more electrical conductors are housed inside the PV laminate through which the solar-generated current is conducted.

Regardless of an exact construction of the PV laminate, most PV applications entail placing an array of solar modules at the installation site in a location where sunlight is readily present. This is especially true for residential, commercial or industrial applications in which multiple solar modules are desirable for generating substantial amounts of energy, with the rooftop of the structure providing a convenient surface at which the solar modules can be placed.

As a point of reference, many commercial buildings have large, flat roofs that are inherently conducive to placement of a solar module array, and are the most efficient use of existing space. By contrast, many residential roofs may be sloped or angled such that placement of a solar module may be more difficult due to gravitational forces imposed on the angled modules. While rooftop installation is thus highly variable, it can be important to ensure that the array of solar modules is reliably and stably anchored to the roof, whether the roof is an angled or flat roof. Moreover, it can be important to ensure that a user can easily, effectively, and rapidly mount one or more solar module(s) to the roof.

SUMMARY

An aspect of at least one of the embodiments disclosed herein includes the realization that certain known mounting systems for mounting solar modules to fixed surfaces such as roofs include excessive components that can be either reduced or eliminated and can require excessive labor for removing and replacing modules. For example, one known solar module mounting system is commercially available from Zep Solar. The Zep Solar system from mounting photovoltaic modules to a fixed surface such as a roof include three unique parts.

Firstly, the Zep Solar system includes splicing interlocks which are used to connect the frames of two adjacent modules together. A separate leveling foot is used only in locations where the leveling foot can be attached directly to frame of a module and where it is necessary to include a roof anchor. A third device known as a "hybrid interlock", includes both splicing/interlock features for attaching two adjacent modules to each other as well as a connection for anchoring the splicing device to the roof.

Other known solar module mounting systems include rails that are initially mounted directly to a roof. The solar modules are then engaged with the rails and then slid laterally into their final desired location. Once in a desired location, the modules are fixed to the rails.

Occasionally, a solar module that is surrounded by other solar modules in an array, is damaged and thus requires replacement. Solar mounting systems in which the solar modules must be slid along rails present a significant difficulty when the need arises for replacing a solar module. In this situation, the rail-mounted array must be partially disassembled, i.e., the undamaged solar modules adjacent to the damaged module must be slid off of the rail first before the damaged module can be removed. The replacement module is then slid along the rails back into place. In a large array, this method of repair can require the removal of many solar modules. Thus, a solar module mounting system that can allow individual solar modules to be removed from an array, without removing adjacent modules can provide a significant labor savings.

The Zep Solar mounting system noted above, also suffers from difficulties. For example, the Zep Solar splice device includes a rotatable fastener that extends and rotates about an axis that is generally horizontal. The rotatable fastener includes an engagement face for engaging a tool that also must faces horizontally. Thus, in order to remove a solar module that is surrounded by other solar modules, a special tool is needed that includes a fastener engaging portion that extends at a right angle. The tool must be inserted between two adjacent solar modules and moved so that the engagement portion reaches the engagement face of the rotatable fastener. This procedure can be particularly difficult when a worker is attempting to reach solar module that is surrounded by other modules, and thus in a position in which it is difficult to achieve the alignment of the special tool and the engagement face of the rotatable fastener.

Thus, in accordance with at least some embodiments disclosed herein, a mounting system for mounting solar modules to a fixed structure such as a roof can be configured to allow solar modules to be removed from an array of solar modules without the need to slide adjacent solar modules off of rails. Further benefits can be achieved by configuring a solar module mounting system such that the engagement portions of the mounting system can be removed by engaging upwardly facing fasteners. Additionally, further benefits can be achieved by configuring a solar module mounting system such that vertical adjustments can be made to the mounting height of solar modules by engaging adjustment mechanism with an upwardly facing engagement portion.

In accordance with at least one embodiment, a height-adjustable roof anchor for solar modules can comprise a base having a hole therein, the hole comprising an inner wall. A height adjustment member can have an upper portion configured to engage at least one solar module, the height adjustment member extending from the hole of the base and upwardly away from the base, the height adjustment member having an annular groove formed around the circumference of the rod, the annular groove positioned within the hole. A locking portion can engage the annular groove so as to retain the height adjustment member in the hole and allow the height adjustment member to rotate about a rotational axis, wherein the height adjustment member is configured to adjust a height of the at least one solar module during rotation about the rotational axis.

In another embodiment, a method can be provided for assembling a height-adjustable roof anchor for solar modules which includes a base having a hole therein, the hole comprising an inner wall and a height adjustment member having an annular groove formed around a circumference of the height adjustment member. The method can comprise inserting the height adjustment member in the hole such that the annular groove is positioned within the hole and positioning a locking portion so as to extend into the annular groove.

In accordance with another embodiment, a solar array can comprise a plurality of solar modules, each solar module having at least four sides and a frame extending around the four sides of each solar module. The plurality of braces supporting at least one side of one of the frames can be shorter than twice a length of one of the sides of one of the frames. Additionally, a plurality of roof anchors can be configured to be mounted to a roof, each roof anchor coupled to one of the plurality of braces.

In another embodiment, a method of assembling a solar array can comprise mounting a plurality of roof anchors to a roof. The method can also include coupling a brace to each roof anchor, positioning an edge of a solar module on each brace, and swinging the solar module downward to engage the end of the solar module with the brace.

In another embodiment, a kit for assembling a solar array can include a plurality of roof anchors configured to be coupled to a roof. The kit can also include a plurality of braces, each brace configured to support one or more frames of a solar module and configured to couple to one of the plurality of roof anchors, each brace being shorter than twice a length of a side of one of the frames.

In accordance with an embodiment, a solar array can comprise a plurality of solar modules, each solar module having at least four sides and comprising a solar module frame extending around at least a portion of the periphery of the solar module. At least a first brace member can have a first support surface extending below at least a first solar module frame of the first solar module. At least a second brace member can have a second support surface extending over the first solar module frame. A first connector can connect the first brace member to the second brace member such that the first solar module is captured between the first and second support surfaces.

In accordance with another embodiment, a solar array can comprise at least first, second, third, fourth, and fifth solar modules, each solar module having at least four sides, wherein the first, second, third, and fourth solar modules are respectively disposed adjacent to the four sides of the fifth solar module. Additionally, the array can include braces for removal of the bracing the juxtaposed sides of the solar modules to each other so that the fifth solar module can be disconnected from the first, second, third, and fourth solar modules and lifted upwardly without the need to slide the fifth solar module laterally.

In accordance with another embodiment, a brace for connecting solar modules can comprise a body member having first and second sides spaced from each other, a first lip extending outwardly from and along the first side of the body and configured to extend below a frame of a first solar module disposed adjacent to the first side and a second lip extending outwardly from and along a second side of the body and configured to extend below a frame to a second solar module disposed adjacent to the second side. The brace can also include at least a first top member configured to be connected to the body member and having a first engagement portion extending outwardly from and along a first side of the top member, the first engagement portion configured to engage in upwardly extending ridge of a first solar module frame, and a second engagement portion extending outwardly from and along a second side of the top member, the second engagement portion configured to engage in upwardly extending ridge of a second solar module disposed adjacent to the first solar module. A connector can be configured to connect the first top member to the body member so as to press the frames of the two adjacent solar modules disposed along the first and second sides of the body member between the lips of the body member and the engagement portions of the top member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a perspective view of a solar power array including a plurality of solar modules.

FIG. **1**B is a schematic diagram of an optional electrical system that can be connected to the array of FIG. **1**A.

FIG. **1**C is an enlarged sectional view showing a typical cross section of the frame of each of the plurality of solar modules.

FIG. **2**A is a perspective view of a first embodiment of a solar module coupler and a detachable height adjustment device.

FIG. **2**B is an exploded view of the coupler and detachable height adjustment device of FIG. **2**A.

FIG. **2**C is a bottom perspective, exploded view of the coupler of FIG. **2**B.

FIG. **2**D is a side elevational view of the coupler and height adjustment device of FIG. **2**A connecting two solar modules to each other.

FIG. **2**E is a side elevational view of the coupler connected to one solar module and a second solar module tilted relative to the coupler.

FIG. **2**F is a side elevational view of the arrangement shown in FIG. **2**E, with one solar module engaging a hook portion of the coupler and being tilted into an engagement position.

FIG. **2**G is a perspective view of the coupler of FIG. **2**A connecting four solar modules together at their corners.

FIG. **2**H is a perspective view of an array of solar modules with one solar module removed.

FIG. **3** is a perspective view of a second embodiment of the coupler of FIG. **2**A.

FIG. **4**A is a perspective view of a third embodiment of the coupler of FIG. **2**A.

FIG. **4**B is an exploded perspective view of the coupler of FIG. **4**A.

DETAILED DESCRIPTION

The following detailed description is merely illustrative in nature and is not intended to limit the embodiments of the subject matter or the application and uses of such embodiments. As used herein, the word “exemplary” means “serving as an example, instance, or illustration.” Any implementation described herein as exemplary is not necessarily to be construed as preferred or advantageous over other implementations. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field, background, brief summary or the following detailed description.

“Coupled”—The following description refers to elements or nodes or features being “coupled” together. As used herein, unless expressly stated otherwise, “coupled” means that one element/node/feature is directly or indirectly joined to (or directly or indirectly communicates with) another element/node/feature.

“Adjust”—Some elements, components, and/or features are described as being adjustable or adjusted. As used herein, unless expressly stated otherwise, “adjust” means to position, modify, alter, or dispose an element or component or portion thereof as suitable to the circumstance and embodiment. In certain cases, the element or component, or portion thereof, can remain in an unchanged position, state, and/or condition as a result of adjustment, if appropriate or desirable for the embodiment under the circumstances. In some cases, the element or component can be altered, changed, or modified to a new position, state, and/or condition as a result of adjustment, if appropriate or desired

In addition, certain terminology may also be used in the following description for the purpose of reference only, and thus are not intended to be limiting. For example, terms such as “upper”, “lower”, “above”, and “below” refer to directions in the drawings to which reference is made. Terms such as “front”, “back”, “rear”, and “side” describe the orientation and/or location of portions of the component within a consistent but arbitrary frame of reference which is made clear by reference to the text and the associated drawings describing the component under discussion. Such terminology may include the words specifically mentioned above, derivatives thereof, and words of similar import. Similarly, the terms “first”, “second”, and other such numerical terms referring to structures do not imply a sequence or order unless clearly indicated by the context.

The inventions disclosed herein are often described in the context of photovoltaic arrays and modules. However, these inventions can be used in other contexts as well, such as concentrated PV systems, thermal solar systems, etc.

FIGS. **1**A and **1**B illustrate a solar power system **10** including a solar array **11** having a plurality of solar modules **12**. Each solar module **12** can include a laminate **14** supported by a frame **13**. In some embodiments, the solar modules **12** can be the same as or similar to the modules disclosed in U.S. Patent Publication No. 2009/0320908, which is incorporated by reference herein in its entirety for all purposes.

With reference to FIG. **1**B, the solar power system **10** can be incorporated into electrical system **40** connected to the array **11**. For example, the electrical system **40** can include the array **11** as a power source connected to a remote connection device **42** with power lines **44**. The electrical system **40** can also include a utility power source, a meter, an electrical panel with a main disconnect, a junction, electrical loads, and/or an inverter with the utility power source monitor. The electrical system **40** can be configured and can operate in accordance with the descriptions set forth in U.S. Patent Publication No. 2010/0071744, the entire contents of which are hereby expressly incorporated by reference in its entirety for all purposes.

With continued reference to FIGS. **1**A and **1**C, each laminate **14** can include an array of solar cells, such as PV cells, configured to convert light into electricity. The frame **13** can provide structural support for the corresponding laminate **14** around the peripheral edges of the laminate **14**. In some embodiments, the frame **13** can be a separate component that is coupled to the laminate **14**.

The cross section of FIG. **1**C illustrates the typical cross section of the peripheral members forming the frame **13**. Each of the members forming the frames **13** can be formed of longitudinally extending the frame members, each having the cross section illustrated in FIG. **1**C, and joined at the corners using 45 degree cuts. However, other techniques can also be used.

In the illustrated embodiment, the frame **13** includes a first outer member **16** which extends generally perpendicular to the laminate **14**. The outer member **16** includes an upwardly projecting ridge **18** and a downwardly projecting ridge **20**. In the illustrated embodiment, the upper protrusion **18** has a width W.

The outer member **16** includes an outwardly facing surface **22** which generally forms the lateral, outwardly facing surface of the module **12**. Projecting from the inner surface **24** of the outer member **16**, the frame **13** can include an upper sealing ledge **26** and a lower sealing ledge **28**. The upper and lower ledges **26**, **28** are spaced apart such that the laminate **14** can fit therebetween. Optionally, various sealing techniques can be used to seal the edge of the laminate **14** between the upper and lower ledges **28**.

In the illustrated embodiment, the lower ledge **28** forms part of a stiffening assembly **30** which also extends from the inner surface **24** of the outer member **16**. The size and shape of the stiffening assembly **30** can be chosen to provide the desired stiffness of the frame **13**. In the illustrated embodiment, the stiffening assembly **30** includes a rectangular tubular configuration. However, other shapes can also be used.

The frame **13**, along with the components noted above, can be formed as a straight monolithic sections. For example, the frame pieces **13** can be extruded from aluminum, other metals or molded from plastic, or other materials. In some embodiments, the frame **13** is made from aluminum. Other configurations and dimensions can also be used.

With reference to FIG. **1**A, the array **11** includes modules **12** mounted to each other and, collectively, to a roof structure (not shown) with a plurality of brace assemblies **50**. Some of the brace assemblies **50** include optional height adjustment devices **52**.

With reference to FIG. **2**A, the brace assembly **50** can include a lower portion **54** and an upper portion **56**. The lower and upper portions **54**, **56** can be configured to capture a portion of the frames **13**.

In some embodiments, the lower portion **54** can include a central body portion **56**. In the illustrated embodiment, the central body portion **56** is in the configuration of a box beam that extends in a generally longitudinal direction. At a lower edge of the central body portion **56**, the lower portion **54** can include a first lip **58** extending outwardly from and along a lower edge of the main body portion **56**.

Optionally, the lower portion **54** can include a second lip **60** extending outwardly from and generally along a lower edge of the central body portion **56** on a side opposite from the first lip **58**. The first and second lips **58**, **60** are sized and configured to support a portion of the frame **13**.

For example, in some embodiments, the first and second lips **58**, **60** are sized to support the lower ridge **20** (FIG. **1**C) of two juxtaposed frames **13**. Optionally, in some embodiments, the first and second lips **58**, **60** include retention ridges **62**, **64** that are sized and configured to help retain the lower protrusion **20**, for example, by providing for a snap-fit engagement of the frame **13**. The engagement of the frame **13** with the ridges **62**, **64** is described in greater detail below with reference to FIGS. **2**D-**2**F.

The upper portion **56** of the coupling member **50** can be formed in one or more pieces. In the illustrated embodiment, the upper portion is formed from a first portion **70** and a second portion **72**. The first and second portions **70**, **72** have essentially the same configuration and shape except that they are mirror images of one another. Thus, only the first portion **70** is described in detail below, with the understanding that the portions of the second portion **72** which are not expressly described below, are essentially the same as the corresponding components of the first portion **70**, except in a mirror image orientation.

With continued reference to FIGS. **2**A and **2**B, the first portion **70** includes a central elongated portion **74** which extends general longitudinally and parallel to the portion **56** of the lower portion **54**. Optionally, a lower surface **76** can include ridges complimentary to the ridges of the upper surface **65** of the lower portion **54**. In the illustrated embodiment, the ridges on both the upper surface **65** and the lower surface **76** extend generally longitudinally along the coupling member **50**. As such, wherein at least one of the upper surface **65** and the lower surface **76** includes ridges, the engagement and electrical coupling between the upper portion **56** and the lower portion **54** is further ensured thereby ensuring reliable electrical grounding between the upper portion **56** and the lower portion **54**. However, other configurations can also be used.

The first portion **74** also includes a first lip **80** extending outwardly from and along an upper edge of the first portion **74** and a second lip **82** extending outwardly from and generally along an upper edge of the first portion **74**. The first lip **80** is configured to cooperate with the first lip **58** of the lower portion **54** to capture a portion of a frame **13** there between.

In the illustrated embodiment, the first and second lips **80**, **82** are generally hook shaped, extending first, outwardly from the first portion **74**, then downwardly toward the lower portion **54**. As such, the first and second lips **80**, **82** can provide a further advantage in simplifying a method for connecting a frame **13** to the coupling device **50**, described in greater detail below with reference to FIGS. **2**D-**2**F.

The first portion **74** can also include notches **84**, **86** in the first and second lips **80**, **82**, respectively. The notches **84**, **86** can have a width **88** that is at least as wide as the width W of the upper ridge **18** of the frame **13** (FIG. **1**C). As such, the coupler **50** can be connected to a frame **13** at a corner, wherein one part of the frame **16** extends perpendicular to the coupler **50**, and another side where the frame extends parallel to the coupler **50**.

Optionally, the upper portion **56** can include centrally positioned notches **90**, **92** on the first and second lips **80**, **82**. In the illustrated embodiment, the notches **90**, **92** have a width **94** that is greater than the width **88**.

In some embodiments, the width **94** can be about the same size as or greater than a thickness **96** of the central portion **56** plus two times the width W of the upper ridge **18** (FIG. **1**C). Sized as such, the notch **94** can allow more flexibility in the placement of the coupler **50**, and in particular, can allow the coupler **50** to be used in a position attaching the corners of two modules **12** and straddling the corner. This arrangement is described in greater detail below with reference to FIG. **2**G.

With continued reference to FIG. **2**B, each of the first and second portions **80**, **72** can be attached to the lower portion **54** in any known manner. In the illustrated embodiment, threaded fasteners **98** extend through apertures **100** to secure the first and second portion **70**, **72** to the lower portion **54**.

Optionally, the upper portion **56** can include a height adjustment aperture **102**. In the illustrated embodiment, because the upper portion **56** is formed of two portions **70**, **72**, each of the first and second portions **70**, **72** form approximately half of the aperture **102**. However, other configurations can also be used.

The height adjustment aperture **102** can be size to accommodate the insertion of a tool, from a position above the coupler **50**, and down into the interior of the coupler **50**, to engage the height adjustment device **52**.

The height adjustment device **52** can include a base portion **110**, a rotatable height adjuster **112** which cooperates with a fixed threaded member **114** which can be fixed to the coupler **50**. The base portion **110** can be formed in any configuration designed for a fixed connection to a structure such as a roof. In some embodiments, the base portion **110** can be configured to be connectable to a roof stud, or other structural member, with a threaded fastener such as a lag screw or the like.

In the illustrated embodiment, the base portion includes a mounting plate portion **116** with an elongated slot **118**. The elongated slot **118** is preferably sized to receive an appropriately sized lag screw, designed for the engagement of a roof structure and/or a roofing stud. The base portion **110** can also include a receiver portion **120** for engagement with the rotatable adjuster **112**.

In the illustrated embodiment, the receiver portion **120** is generally block shaped with an upper aperture **122**. The rotatable adjuster **112** can include a threaded body portion **130**, an upwardly facing engagement surface **132**, and a neck portion **134**. The neck portion **134** can be in the form of an annular groove disposed on the outer surface of the rotatable adjuster **112**.

In some embodiments, the rotatable adjuster **112** can be swaged into the block portion **120**. For example, the rotatable adjuster **112** can be inserted through the aperture **122** into the block **120**. Using an appropriate swaging technique, a portion of the block **120** can be pressed inwardly such that an inner wall of the aperture **122** extends into the necked portion **134**, thereby trapping the rotatable adjuster **112** within the block **120**, but allowing the rotatable adjuster **112** to freely rotate relative to the base **110**. In some embodiments, the base portion and the block portion **120** can be made from aluminum, the swaging of which is well known in the art.

In the illustrated embodiment, the engagement surface **132** is in the form of a female allen wrench head. However, other engagement surfaces can also be used.

With the rotatable adjuster **112** mounted as such, the threads of the rotatable adjuster **112** can cooperate with internal threads on the coupler **50**, so as to allow the coupler **50** to be moved upward and downwardly relative to the base **110**. In some embodiments, as noted above, an internal thread member **114** can be directly formed in the lower portion **54**.

With reference to FIG. **2**C, the internal thread member **114** can extend through an aperture **140** extending through the lower portion **54**. Optionally, the lower portion **54** can include an anti-rotation recess **142** configured to cooperate with a portion of the internal thread member **114** such that the thread member **114** can be fixed relative to lower portion **54**. In some embodiments, the internal threaded member **114** can include an anti-rotation aperture **144** configured to receive a fastener (not shown) extending through the aperture **144** and into the anti-rotation recess **142** so as to prevent any relative rotation between threaded member **114** and the lower portion **54**. As such, when the rotatable adjuster **112** is rotated relative to the lower portion **54**, and thus relative to the internal thread member **114**, the rotatable adjuster **112** operates as a jack screw, as the rotatable adjuster **112** is rotated clockwise or counter clockwise. Other configurations can also be used.

In some embodiments, the threaded sleeve can also include a feature (not shown) that allows the threaded sleeve to be snapped into the base, but that will prevent the threaded sleeve from being removed unintentionally, such as by wind forces. The feature can be a spring-loaded detent, barb formed in the sleeve, or any other suitable mechanism.

Optionally, with reference to FIG. **2**C, the first and second lips **80**, **82** can optionally include one or more ridges, teeth, or spikes on the distal end thereof. In the illustrated embodiment, the first and second lips **80**, **82** include a sharpened edge **130**, **132** so that when they are pressed into engagement with a frame **13**, the sharpened edges **130**, **132** penetrate the outermost surface of the frame **13**, to thereby provide better electrical contact with the frame **13**. For example, in some embodiments, the frame **13** can be aluminum with a anodized outer coating. As such, the sharpened edges **130**, **132** can help pierce the outermost anodizing of the frame **13**, and thereby provide better electrical contact between the coupler **50** and the frame **13**. Further, the sharpened edges **130**, **132** can also be further beneficial where the coupler **50** is made from a different material than the frame **13**, for example, but without limitation, where the coupler **50** is made from stainless steel and the frame **13** is made from aluminum.

With continued reference to Figures D, E and F, the above configuration can accommodate two different methods for attaching coupler **50** to a module **12**. Firstly, as is apparent from the above description, the upper portion **56** of a coupler **50** can be removed, the frame of the module can be placed such that the upper ridge **18** of a frame engages the hook shaped lip **80** with the lower protrusion **20** of the frame supported by the lower lip **58**. The upper portion **56** can be secured to the lower portion **54** of the coupler with the threaded fasteners **98**.

Additionally, the above configuration of the coupler also allows a module **12** to be connected to the coupler **50** by a "hook and swing motion." For example, as shown in FIG. **2**D, the coupler is fully assembled with the upper portion **56** attached to the lower portion **54**. A solar module **12**A is illustrated in the position in which it is tilted relative to coupler **50**. The module **12**A can be manually moved into a position in which the upper protrusion **18** is engaged with the hook shaped lip **82**. Then, the module **12**A can be tilted downwardly, in the direction of arrow T until the module **12**A reaches the orientation illustrated in FIG. **2**F.

As noted above, the lip **60** can include a ridge **64** configured to cooperate with the lower protrusion **20** of the frame **13** so as to provide a snap fit. Those of ordinary skill in the art fully understand how to size and configure the lips **60**, **82** and the ridge **64** to provide such a snap fit.

For example, the minimum distance between the uppermost portion of the ridge **64** and the uppermost portion of the inner surface of the hook shaped lip **82** can be slightly closer than the overall vertical Height of the outer portion **16** of the frame **13**. As such, as the module **12**A is tilted in the direction indicated in FIG. **2**E, and the lower protrusion **20** reaches the ridge **64**, the inherent elasticity of the coupler **50** and in particular the hook shaped lip **82** and the lip **60** can allow the lips **82**, **60** to slightly spread apart as the lower protrusion **20** passes over the ridge **64**, then due to their elasticity, snap back to their original spacing, thereby trapping the outer member **16** of the frame **13** in the position illustrated in FIG. **2**F. Similarly, the lips **58**, **80** and ridge **62** can be configured in essentially the same manner such that solar modules **12**, **12**A can be attached to both sides of the coupler **50** without the need for moving the lips **80**, **82** relative to the lower lips **58**, **60**.

With continued reference to FIG. **2**F, where a coupler **50** is used to connect two adjacent solar modules **12**, **12**A, the solar modules **12**, **12**A are spaced apart such that the inwardly facing surfaces of their respective upper ridges **18** as defined by the width **200**. The width **200**, in the illustrated configuration, is approximately the width **96** of the central portion of the coupler **50** plus two times the width W of the outer portion **16** of the frames **13**. This spacing is about the same as or less than the width **94** of the notch **92** (FIG. **2**A) described above.

More particularly, with reference to FIG. **2**G, when a coupler **50** is used to connect two or more modules at a corner, the width **94** of the notch **92** allows the notch **92** to straddle the spaced apart upper ridges **18** of two adjacent modules **12**. Note that the laminates **14** of the solar modules illustrated in FIG. **2**G have been removed for purposes of illustration. Additionally, as also noted above, the width **88** of the notches **86** also allow the coupler **50** to be positioned near a corner of a module **12**, but not straddling the spacing between two adjacent modules **12**. Rather, the notches **86** could be aligned with single upper ridge **18** of a frame **13**.

With reference to FIG. **2**H, the couplers **50** can accommodate further advantageous methods for removing and reinstalling a solar module **12** from an array of solar modules. As shown in FIG. **2**H, the upper portions **56** of two couplers **50** have been removed and the module **12** (FIG. **1**A) has been removed by lifting and tilting the module **12** out of the fully assembled couplers **50**B.

In order to reinstall another solar module into the original placement of the solar module **12**, one edge of the solar module **12** can be lowered into position, into the orientation illustrated in FIG. **2**E, such that in upper protrusion **18** of the frame **13** of the solar module **12** engages the hook shaped lip **82** of the couplers **50**B. As the module **12** is tilted into place, the lower protrusion **20** can engage with the ridge **64** of the couplers **50**B. Similarly, on the opposite edge of the module **12**, the lower protrusion **20** eventually comes to rest on the first lip **58** of the couplers **50**A. The lowering of the solar module **12** can be accomplished using suction cups (not shown) temporarily attached to the upper surface of the laminate **14**, or other techniques. After the module **12**A has been lowered into position, the upper portions **56** of the couplers **50**A can be replaced, thereby returning the array **11** into the state illustrated in FIG. **1**A.

Further, when installing and/or servicing the array **11**, all of the couplers, **50**, **50**A, **50**B, which are attached to height adjustment mechanisms, can all be adjusted to desired heights by inserting, directly from above, an engagement tool configured to engage the engagement surface **132** (FIG. **2**B) of the rotatable height adjuster **112** so as to raise or lower each of the modules **12**, to the desired height. As such, the heights of the various modules **12** of the array **12** can be easily adjusted.

FIG. **3** illustrates another embodiment of the coupler **50**, identified by the reference numeral **1050**. The components of the coupler **1050** that are the same or similar to the coupler **50**, are identified with the same reference numeral, except that 1000 has been added thereto.

As shown in FIG. **3**, the coupler **1050** can include an upper portion **1056** that is made from a single piece instead of two separate pieces **70**, **72** of the coupler **50**. The remaining components of the coupler **1050** as well as the use and operation, are essentially the same as the coupler **50**.

In yet another alternative embodiment, the coupler **1050** can be formed such that the upper portion **1056** is permanently affixed to the lower portion **1054**. For example, the coupler **1050** could be made from a single piece of material into a monolific body. Alternatively, the coupler **1050** could be made from two separate pieces such as the lower and upper portions **1054**, **1056**, but permanently affixed to one another.

Such an integrated design for the coupler **1050** can further reduce costs of such a system, by reducing the part counts, and reduce manufacturing costs. In use, such as single piece coupler **1050** can be connected to a fixed solar module by hooking the lip **1080** to an upper ridge **18** of a solar module **12**, then tilting the coupler **1050** relative to the solar module **12**, until the lower protrusion **20** of the frame **13** of the solar module engages the ridge **1062**. Then, with the coupler **1050** fit onto one solar module **12**, an adjacent solar module **12** can be connected to the coupler **1050** by hooking the corresponding upper protrusion **18** of a solar module **12** into the hook shaped lip **1082** of the coupler **1050**, then tilting the solar module **12** downwardly, in the direction of RT of FIG. **2**E, until the lower protrusion **20** engages the ridge **64** and is oriented in the position shown in FIG. **2**F. As such, such a single piece coupler **1050** can be used without removing the upper portion **156**.

FIG. **4**A illustrates another embodiment of the coupler **50**, identified by the reference numeral **2050**. The components of the coupler **2050** that are the same or similar to the couplers **50** or **2050** are identified with the same reference numeral, except that 2000 has been added thereto.

With reference to FIGS. **4**A and **4**B, the coupler **2050** can include a lower portion **2054** and an upper portion **2056**. In the illustrated embodiment, the lower portion **2054** includes the lip **82** and an upper mounting surface **2402** for receiving the upper portion **2056**. Additionally, similarly to the embodiments of FIGS. **2**B and **3**, the upper portion **2056** can be made from one or more parts.

The upper portion **2056** can include a lip only on one side, in the illustrated embodiment, the lip **2080**. The coupler **2050** can be engaged with a solar module **12** by hooking and tilting the coupler relative to solar module **12** as described above with reference to FIG. **3**. Additionally, the coupler **2050** can be connected to and removed from engagement with solar modules by removing the fasteners **98** and the upper portion **2056**. As such, the upper portion **2056** can be removed while the other side of the coupler **2050**, including the upper lip **82** can remain engaged with a solar module, thereby maintaining the coupler **2050** in its position.

This can provide a further advantage when using the coupler **2050** in an array **11**, and in particular, when removing and reinstalling the solar module from an array in which the solar module is surrounded by other modules. Thus, when the upper portion **2056** is removed, so as to allow a solar module to be removed from the array, the coupler **2050** can remain securely engaged with an adjacent solar module because the lip **2082** remains fixed relative to the lower lip **2060**. Thus, the solar module **12** which is removed and/or reinstalled can rest against the lower lips **2058** of the coupler **2050**, during the reinstallation process.

While at least one exemplary embodiment has been presented in the foregoing detailed description, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or embodiments described herein are not intended to limit the scope, applicability, or configuration of the claimed subject matter in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing the described embodiment or embodiments. It should be understood that various changes can be made in the function and arrangement of elements without departing from the scope defined by the claims, which includes known equivalents and foreseeable equivalents at the time of filing this patent application.

What is claimed is:

1. A photovoltaic module mounting assembly for securing a photovoltaic module to a mounting surface, the photovoltaic module mounting assembly comprising:

a base portion including a receiver and an opening adapted to receive a fastener to secure the base portion to the mounting surface;

a first threaded member inserted into the receiver, wherein the first threaded member is rotatable relative to the base portion;

a coupling member in communication with the threaded member, the coupling member including:

a lower portion including a first lip extending outwardly from the lower portion,

an upper portion including a second lip extending outwardly from and along an upper edge of the upper portion, and

a second threaded member securing the upper portion to the lower portion;

a third threaded member receiving the first threaded member, the third threaded member being inserted into the coupling member; and

a first photovoltaic module frame captured by the coupling member, wherein the first lip supports a bottom of the first photovoltaic module frame and the second lip engages a top of the first photovoltaic module frame.

2. The photovoltaic module mounting assembly of claim **1** wherein the upper portion is divided into a first portion and a second portion.

3. The photovoltaic module mounting assembly of claim **1** wherein the first lip includes a retention ridge.

4. The photovoltaic module mounting assembly of claim **1** wherein the second lip is hook-shaped.

5. The photovoltaic module mounting assembly of claim **1**, wherein the first threaded member is a jack screw.

6. The photovoltaic module mounting assembly of claim **1**, wherein the third threaded member is fixed relative to the lower portion.

7. The photovoltaic module mounting assembly of claim **1**, wherein the coupling member further includes internal threads that receive the first threaded member.

8. The photovoltaic module mounting assembly of claim **1**, wherein the first threaded member includes a first end and a second end opposite the first end, the first end being inserted into the receiver and the second end including an engagement surface.

9. The photovoltaic assembly of claim **8** wherein the coupling member further includes a height adjustment aperture such that the engagement surface is accessible from a direction opposite from the mounting surface.

10. The photovoltaic module mounting assembly of claim **1** further comprising a second photovoltaic module frame captured by the coupling member, wherein the first lip supports a bottom of the second photovoltaic module frame and the second lip engages a top of the second photovoltaic module frame.

11. The photovoltaic module mounting assembly of claim **1** wherein:

the lower portion further includes a third lip extending outwardly from the lower portion in a direction opposite from the first lip, and

the upper portion further includes a fourth lip extending outwardly from the lower portion in a direction opposite from the second lip.

12. The photovoltaic module mounting assembly of claim 11, further comprising a third photovoltaic module frame captured by the coupling member, wherein the third lip supports a bottom of the third photovoltaic module frame and the fourth lip engages a top of the third photovoltaic module frame.

13. The photovoltaic module mounting assembly of claim 1 wherein the upper portion is the only component of the photovoltaic module mounting assembly that extends above a top surface of the first photovoltaic module frame.

14. A photovoltaic module assembly secured to a mounting surface, the photovoltaic module assembly comprising:

a photovoltaic module including a photovoltaic laminate and a photovoltaic module frame receiving the photovoltaic laminate, wherein the photovoltaic module frame includes:

a first edge with a first proximate end and a first distal end, and

a second edge opposite the first edge with a second proximate end and a second distal end; and

a plurality of photovoltaic module mounting assemblies including a first photovoltaic module mounting assembly, a second photovoltaic module mounting assembly, a third photovoltaic module mounting assembly, and a fourth photovoltaic module mounting assembly, each photovoltaic module mounting assembly including:

a base portion including a receiver and an opening adapted to receive a fastener to secure the base portion to the mounting surface;

a first threaded member inserted into the receiver, wherein the first threaded member is rotatable relative to the base portion;

a coupling member in communication with the threaded member, the coupling member including:

a lower portion including a first lip extending outwardly from of the lower portion,

an upper portion including a second lip extending outwardly from and along an upper edge of the upper portion, and

a second threaded member securing the upper portion to the lower portion; and

a third threaded member receiving the first threaded member, the third threaded member being inserted into the coupling member;

wherein the coupling member of the first photovoltaic module mounting assembly captures the first edge at the first proximate end, the coupling member of the second photovoltaic module mounting assembly captures the first edge at the first distal end, the coupling member of the third photovoltaic module mounting assembly captures the second edge at the second proximate end, and coupling member of the fourth photovoltaic module mounting assembly captures the second edge at the second distal end.

15. The photovoltaic module assembly secured to a mounting surface of claim 14 wherein the first lip of the first photovoltaic module mounting assembly and the first lip of the second photovoltaic module mounting assembly extend out further than the first lip of the third photovoltaic module mounting assembly and the first lip of the fourth photovoltaic module mounting assembly.

16. A method for securing a photovoltaic module to a mounting surface using a photovoltaic module mounting assembly including:

a base portion including an opening and a first threaded member orthogonal to the opening, wherein the first threaded member is rotatable relative to the base portion, and

a coupling member including a lower portion including a first lip extending outwardly from of the lower portion, an upper portion including a second lip extending outwardly from and along an upper edge of the upper portion, and a second threaded member securing the upper portion to the lower portion, and

a third threaded member which receives the first threaded member, the method comprising:

(a) securing the base portion to the mounting surface by inserting a fastener into the opening and penetrating the mounting surface;

(b) attaching the coupling member to the base portion by engaging the coupling member with the first threaded member and by inserting the third threaded member into the coupling member;

(c) tilting the photovoltaic module relative to the coupling member;

(d) engaging the coupling member with the photovoltaic module by contacting the upper lip with a top edge of the photovoltaic module; and

(e) tilting the photovoltaic module downward relative to the coupling member until a bottom edge of the photovoltaic module contacts the lower lip of the coupling member.

17. The method for securing a photovoltaic module to a mounting surface of claim 16 further comprising:

(f) inserting a tool through the coupling member;

(g) engaging the first threaded member using the tool;

(h) rotating the first threaded member relative to the base portion such that a distance between the photovoltaic module and the mounting surface is changed.

18. The method for securing a photovoltaic module to a mounting surface of claim 16 wherein tilting the photovoltaic module downward relative to the coupling member until a bottom edge of the photovoltaic module contacts the lower lip of the coupling member includes engaging a retention ridge of the first lip.

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