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(54) Title: PHOTOVOLTAIC ARRAY MOUNTING STRUCTURE

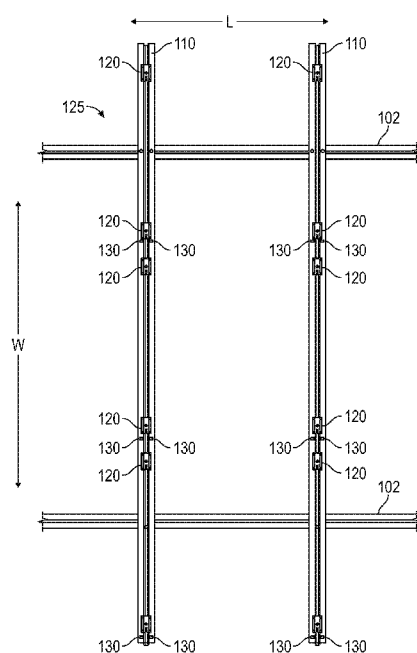


FIG. 3

(57) Abstract: A photovoltaic mounting structure (100) includes a frame (125) for holding a photovoltaic array including a plurality of widthwise channels (110) so as to permit photovoltaic modules (105) to be easily slid between pairs of the channels (110), the photovoltaic modules (105) resting upon flanges (115) of the channels (110). In various embodiments, domed protrusions (140) are disposed on lateral sides of the channel (110) to prevent kinking of the modules (105) and reduce friction, retention teeth (130) are formed on upper surfaces of the flanges (115) to position the modules (105); locator teeth (180) are formed on lower surfaces of the flanges (115) to guide the channels (125) to predetermined spacing; and pre-installed mounting clips (120) are attached to a top surface (118) of the channel (110). The mounting clips (120) each include an anti-rotation tab oriented downwardly and partially disposed in a corresponding hole (127) in a top surface of the channel so as to prevent rotation of the mounting clip (120) when a bolt of the mounting clip (120) is rotated.



PHOTOVOLTAIC ARRAY MOUNTING STRUCTURE

BACKGROUND OF THE INVENTION

1. Field of the Invention

5 [0001] The present invention relates to a photovoltaic array mounting structure, particularly useful for large-scale electric power generation systems.

2. Description of the Related Art

10 [0002] A photovoltaic module includes numerous photovoltaic cells that are packaged into a single unit. The photovoltaic cells are electrically connected in series or parallel, to produce higher voltages and current. Photovoltaic modules can be electrically connected and arranged on various mounting structures to form a photovoltaic array. For large-scale commercial or utility electricity generation, the photovoltaic modules are
15 often arranged on long frames elevated from a ground surface and tilted at a desired angle. These photovoltaic mounting structures are typically laid row upon row, and may take up many acres of outdoor space.

[0003] However, installation of photovoltaic array mounting structures and particularly mounting the photovoltaic modules onto the mounting
20 structures is time-consuming and labor intensive. The high labor costs reflect the difficulty and requisite skills needed to install these systems. Additionally, installation can be problematic from a quality assurance perspective and current techniques often raise safety concerns as well.

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SUMMARY OF THE INVENTION

[0004] The present disclosure relates to a novel photovoltaic mounting

structure that includes various features to markedly reduce installation effort and ensure a proper construction. In an embodiment, the photovoltaic mounting structure includes a frame for holding a photovoltaic array, the frame having a width and a length sufficient to accommodate the photovoltaic array. The frame includes a plurality of widthwise “top hat” channels spaced substantially evenly and in parallel so as to permit photovoltaic modules of the photovoltaic array to be easily inserted between pairs of the channels, the photovoltaic modules resting upon outwardly extended flanges of the channels. Additionally, the frame further comprises a plurality of lengthwise beams spaced substantially perpendicular to the widthwise channels. In an embodiment, the channels include downwardly oriented locator teeth to guide the channels along predetermined spacing across the lengthwise beams. The photovoltaic mounting structure also includes supports attached to the lengthwise beams that can include ground posts and bracing, for example, to elevate the frame from a ground surface. The supports may also allow the frame to be tilted at a desired angle.

[0005] In an embodiment, the top hat channels include a top surface, a pair of lateral sides extending downwardly, and a pair of flanges extending outwardly. The lateral sides of the channels are substantially flat (and smooth) except for having occasional dome-shaped protrusions that are added to reduce friction and eliminate kinking of the modules as they are inserted. Additionally, the flanges of the channels include upwardly oriented retention teeth structured and arranged so as to permit retention of the photovoltaic modules in predetermined positions, and at the same time permit the photovoltaic modules to be slid past the teeth during installation prior to being clamped down.

[0006] In an embodiment, a plurality of pre-installed mounting clips is disposed on the channels, the mounting clips capable of clamping the photovoltaic modules. To reduce installation effort, each of the pre-installed mounting clips is initially connected to a channel by partially-

screwed bolting into pre-drilled holes, the mounting clips elevated using a nylon retaining washer or the like. Advantageously, this arrangement allows the photovoltaic modules to be inserted between pairs of the channels during installation, and then the mounting clips can be clamped
5 onto the photovoltaic modules by simply tightening the bolting. Additionally, the pre-installed mounting clips each include an anti-rotation tab oriented downwardly and partially disposed in a corresponding hole in a top surface of a respective channel so as to prevent rotation of the mounting clip when the bolt of the mounting clip is rotated.

10

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 illustrates a front view of an exemplary photovoltaic mounting structure, according to an embodiment;

15 [0008] FIG. 2 illustrates a side view of the photovoltaic mounting structure;

[0009] FIG. 3 illustrates a close-up view of a section of the frame of the photovoltaic mounting structure;

[0010] FIG. 4 illustrates a top plan view of an exemplary mounting clip on the frame;

20 [0011] FIGs. 5 and 6 illustrate side views of the mounting clip;

[0012] FIG. 7 illustrates a cutaway side view of the mounting clip;

[0013] FIG. 8 illustrates a perspective view of a photovoltaic module installed on the frame;

25 [0014] FIG. 9 illustrates a perspective view of multiple photovoltaic modules installed on the frame;

[0015] FIG. 10 illustrates a side view of an exemplary lengthwise beam of

the frame; and

[0016] FIGs. 11 and 12 illustrate exemplary locator teeth used for spacing the channels along a lengthwise beam.

5

DETAILED DESCRIPTION OF THE INVENTION

[0017] Referring to FIG. 1, an exemplary photovoltaic mounting structure 100, according to an embodiment, is illustrated. The photovoltaic mounting structure 100 includes a frame 125 for holding a photovoltaic array. For illustrative purposes, the photovoltaic array is shown only partially built. In particular, only a single column of photovoltaic modules 105A-C is installed. In general, the frame 125 has a width W and a length L sufficient to accommodate the desired size of the photovoltaic array. Accordingly, the spacing and arrangement of the components may be varied from those shown to accommodate different sizes, thicknesses, and quantities of photovoltaic modules. As illustrated, the frame 125 includes a plurality of widthwise top hat channels 110 spaced substantially evenly and in parallel. As will be described in greater detail, the novel design permits photovoltaic modules, such as the modules 105A-C, to be easily slid between pairs of the channels 110 and held firmly in place. Additionally, the frame 125 comprises lengthwise beams 102 spaced substantially perpendicular to the widthwise channels 110, to provide structural stability and support to the frame 125. Although the illustrated embodiment shows two such beams 102, it is to be understood that the actual number of beams 102 may be different. The frame 125 is raised from the ground using a plurality of exemplary supports 170 which are connected to the lengthwise beams 102.

[0018] Referring to FIG. 2, a side view of the photovoltaic mounting structure 100 is illustrated including an exemplary support 170. As shown, support 170 includes a post 172 secured to the ground surface, bracing 174 to provide additional support, and a support beam 175. As depicted, the

lengthwise beams 102 are attached to an upper surface of beam 175 and the widthwise channels 110 are attached to pairs of the lengthwise beams 102. Although the illustrated support 170 can be used in conjunction with the frame 125, it is to be understood that various other types of suitable ground support structures could be used. In some embodiments, the posts will be anchored to concrete slabs, dual posts will be employed, additional or different bracing will be present, etc.

[0019] Referring to FIG. 3, a close-up view of a section of the frame 125 is illustrated. As shown, the widthwise channels 110 are arranged on top of and substantially parallel to the lengthwise beams 102. As will be described in greater detail, photovoltaic modules can be inserted between pairs of the channels 110, the photovoltaic modules resting upon outwardly extended flanges of the channels 110. Additionally, the flanges of the channels include upwardly oriented retention teeth 130 structured and arranged so as to permit retention of the photovoltaic modules in predetermined positions forming a grid (array), and at the same time permit the photovoltaic modules to be slid past the retention teeth 130 during installation prior to being clamped down. As shown in FIG. 3, three photovoltaic modules could be inserted between the pair of channels 110 shown in this figure. Although the illustrated embodiment shows columns of three photovoltaic modules, it is to be understood that the frame 125 may be constructed so as to accommodate a different number of photovoltaic modules. In this case, the number of retention teeth 130 would vary from the illustration.

[0020] Referring to FIG. 4, a top plan view of an exemplary mounting clip 120 installed on a channel 110 is illustrated. As shown, the mounting clip 120 fits onto a top surface 118 of the channel 110. The mounting clip 120 includes flanges 105 that are parallel to flanges 115 of the channel 110. As can be seen, bolt 103 secures the mounting clip 120 onto the top surface 118. Additionally, an anti-rotation tab 125 extends downwardly into a corresponding hole 127 in the top surface 118 so as to prevent rotation of

the mounting clip 120 as the bolt 103 is turned. The hole 127 can be formed by punching or another suitable fabrication process. The anti-rotation tab 125 and the retention teeth 130 can be formed by cutting or punching flaps (which are then bent at an appropriate angle) or by another suitable fabrication process. In other embodiments, the retention teeth will be have a different structure from the illustrated structure but will achieve substantially the same function.

[0021] Referring to FIGs. 5 and 6, side views of the mounting clip 120 are illustrated. As shown, the retention teeth 130 extend at an acute angle relative to the respective flanges 115. FIG. 5 shows the mounting clip 120 in its initial configuration. Initially, the mounting clip 120 will be pre-installed on the channel 110 using partially-screwed bolting into pre-drilled holes. FIG. 6 shows the mounting clip 120 fully bolted onto the channel 110, done in the field as the photovoltaic array is constructed. Also shown are domed protrusions 140 disposed on relatively smooth lateral sides 116 of the channel 110 to prevent kinking of the modules and reduce friction as the modules are inserted. It is to be understood that the protrusions 140 can assume a different shape from the illustrated “dome” shape without departing from the spirit or scope of the present invention.

[0022] Referring to FIG. 7, a cutaway side view of the mounting clip 120 is illustrated. In this view, the mounting clip 120 is in its initial configuration (similar to FIG. 5). The bolt 103 is already inserted through a hole in the top surface 118 of the channel 110, and partially threaded into a nut 105 or the like. The mounting clip 120 is elevated and held in place using a retaining washer 104 or the like. In an embodiment, the retaining washer 104 is a nylon or rubber retaining washer. In other embodiments, a different type of retaining device may be used, such as a push nut. Once the photovoltaic modules are inserted along sides of the channel 110, bottom corners of the photovoltaic modules will rest upon respective lateral sides 116 and flanges 115 of the channel 110. The bolt 103 will then be tightened such that the mounting clip 120 acts a clamp to hold in place the

photovoltaic modules. Advantageously, the anti-rotation tabs 125 ensure that the mounting clip 120 will not rotate as the bolt 103 is turned.

[0023] Referring to FIG. 8, a perspective view of a photovoltaic module 105 installed on the frame 125 is illustrated. Note that the mounting clip 120 overlaps the photovoltaic module 105 so as to hold the photovoltaic module 105 firmly. FIG. 9 illustrates a perspective view of multiple photovoltaic modules 105A, 105B installed on the frame 125.

[0024] Referring to FIG. 10, a side view of an exemplary lengthwise beam 109 of the frame 125 is illustrated. As shown, the lengthwise beam 102 is a “C-beam” but other types of beams or the like may suffice. As mentioned, the lengthwise beams 102 are substantially perpendicular to the channels 110. As depicted, a lengthwise beam 102 is shown fastened (using a bolt 109 / nut 104 combination) to a widthwise channel 110. It is to be understood that many such channels 100 would be fastened to the lengthwise beam 102 along the length of the frame 125 (see FIG. 1).

[0025] Referring to FIGs. 11 and 12, a pair of exemplary locator teeth 180 used for spacing the channels 110 along lengthwise beam 102 is illustrated. More particularly, each of the channels 110 includes several such pairs of downwardly-oriented teeth 180 on an underside disposed at locations where the channels 110 and the lengthwise beams 102 are to intersect. The teeth 180 greatly facilitate constructing the frame 125 in the field since it is not necessary to measure where to position the channels 110 along the lengthwise beams 102. All that is required is for a worker to lay the channels 100 such that the locator teeth 180 align with the beams 102, an example shown. The locator teeth 180 can be formed by punching or cutting a flap in the flanges 115 of the channel 110, then bending the flap downwardly at an acute angle, for example, or by another suitable fabrication process. In other embodiments, the locator teeth will be have a different structure from the illustrated “tooth” structure but will achieve substantially the same function.

[0026] While this invention has been described in conjunction with the various exemplary embodiments outlined above, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, the exemplary embodiments of the invention, as set
5 forth above, are intended to be illustrative, not limiting. Various changes may be made without departing from the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. A channel structure, comprising:

a rigid beam including a top surface extending horizontally, a
5 pair of lateral sides extending downwardly, and a pair of flanges
extending outwardly and horizontally;

wherein the rigid beam includes:

a plurality of protrusions disposed on the lateral sides;

a plurality of upwardly oriented teeth disposed on upper
10 surfaces of the flanges;

a plurality of downwardly oriented locator teeth disposed on
lower surfaces of the flanges; and

at least one pre-installed mounting clip attached to the beam
using bolting.

- 15
2. The channel structure of claim 1, wherein the pre-installed
mounting clip includes an anti-rotation tab oriented downwardly and
partially disposed in a corresponding hole in a top surface of the
beam so as to prevent rotation of the mounting clip when a bolt of
20 the mounting clip is rotated.

3. The channel structure of claim 1, wherein the protrusions are dome-shaped.
4. The channel structure of claim 1, wherein the retention teeth are
5 punched from the beam.
5. The channel structure of claim 1, wherein the locator teeth are
punched from the beam.
- 10 6. A channel structure, comprising:

a rigid beam including a top surface extending horizontally, a
pair of lateral sides extending downwardly, and a pair of flanges
extending outwardly and horizontally;

wherein the rigid beam includes:

15 a plurality of protrusions disposed on the lateral sides;

a plurality of upwardly oriented retention teeth disposed on
upper surfaces of the flanges;

a plurality of downwardly oriented locator teeth disposed on
lower surfaces of the flanges; and

a plurality of pre-installed elevated mounting clip attached to the beam using bolting;

wherein each of the pre-installed mounting clips include an anti-rotation tab oriented downwardly and partially disposed in a corresponding hole in a top surface of the beam so as to prevent rotation of the mounting clip when a bolt of the mounting clip is rotated; and

wherein the bolt of the mounting clip is not fully bolted into a corresponding threaded hole.

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7. A photovoltaic array mounting structure, comprising:

a frame for holding a photovoltaic array, the frame having a width and a length sufficient to accommodate the photovoltaic array, the frame including a plurality of widthwise channels spaced substantially evenly and in parallel so as to fit photovoltaic modules of the photovoltaic array between pairs of the channels, the photovoltaic modules resting upon flanges of the channels; and

15

a plurality of supports for elevating the frame.

20

8. The photovoltaic array mounting structure of claim 7, further comprising a plurality of pre-installed mounting clips disposed on the channels, the mounting clips capable of clamping the photovoltaic modules; and

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9. The photovoltaic array mounting structure of claim 7, wherein each of the channels includes a top surface extending horizontally, a pair of lateral sides extending downwardly, and a pair of flanges extending outwardly and horizontally.

10

10. The mounting structure of claim 9, wherein the lateral sides of the channels are substantially flat except for having occasional protrusions.

15

11. The mounting structure of claim 10, wherein the protrusions are dome-shaped.

20

12. The photovoltaic array mounting structure of claim 7, wherein the flanges of the channels include upwardly oriented retention teeth structured and arranged so as to permit retention of the photovoltaic modules in predetermined positions.

13. The photovoltaic array mounting structure of claim 12, wherein the retention teeth permit the photovoltaic modules to be slidably moved past the teeth during installation.

5 14. The photovoltaic array mounting structure of claim 7, wherein the pre-installed mounting clips are attached to the channels prior to installation.

15. The photovoltaic array mounting structure of claim 14, wherein the pre-installed mounting clips are attached to the channels using
10 bolting elevated using retaining washers to allow the photovoltaic modules to be slidably moved between pairs of the channels during installation without interference.

16. The photovoltaic array mounting structure of claim 14, wherein the
15 pre-installed mounting clips are each attached to the channels using bolting elevated using a retaining washer.

17. The mounting structure of claim 7, wherein the pre-installed mounting clips each includes an anti-rotation tab oriented
20 downwardly and partially disposed in a corresponding hole in a top surface of a respective channel so as to prevent rotation of the mounting clip when a bolt of the mounting clip is rotated.

18. The mounting structure of claim 7, wherein the frame further
comprises a plurality of lengthwise beams spaced perpendicular to
the channels.

5

19. The mounting structure of claim 18, wherein the supports are
attached to the lengthwise beams.

20. The mounting structure of claim 18, wherein the channels include

10 downwardly oriented locator teeth to guide the lengthwise beams to
predetermined spacing across the length of the frame.

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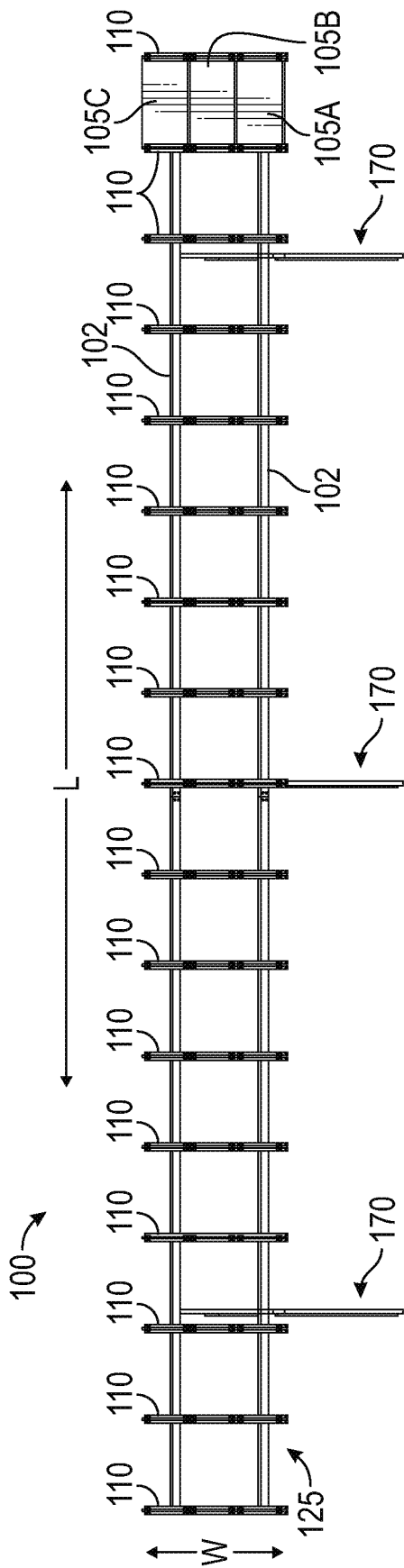


FIG. 1

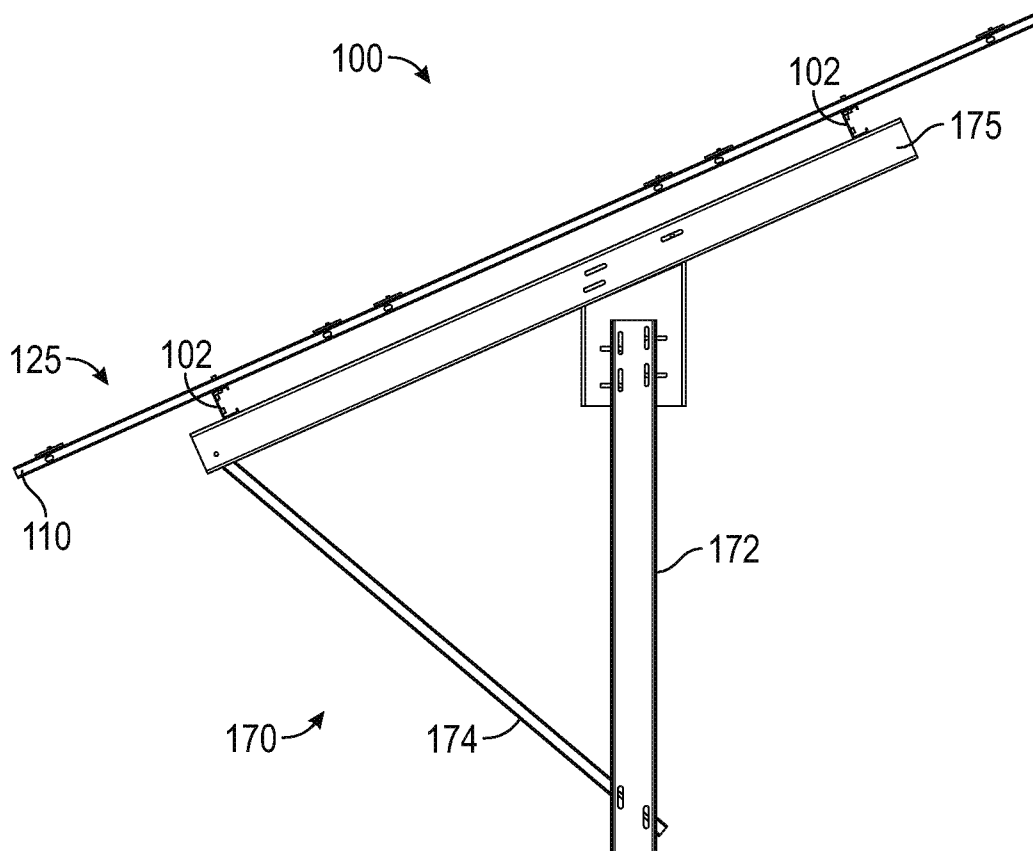


FIG. 2

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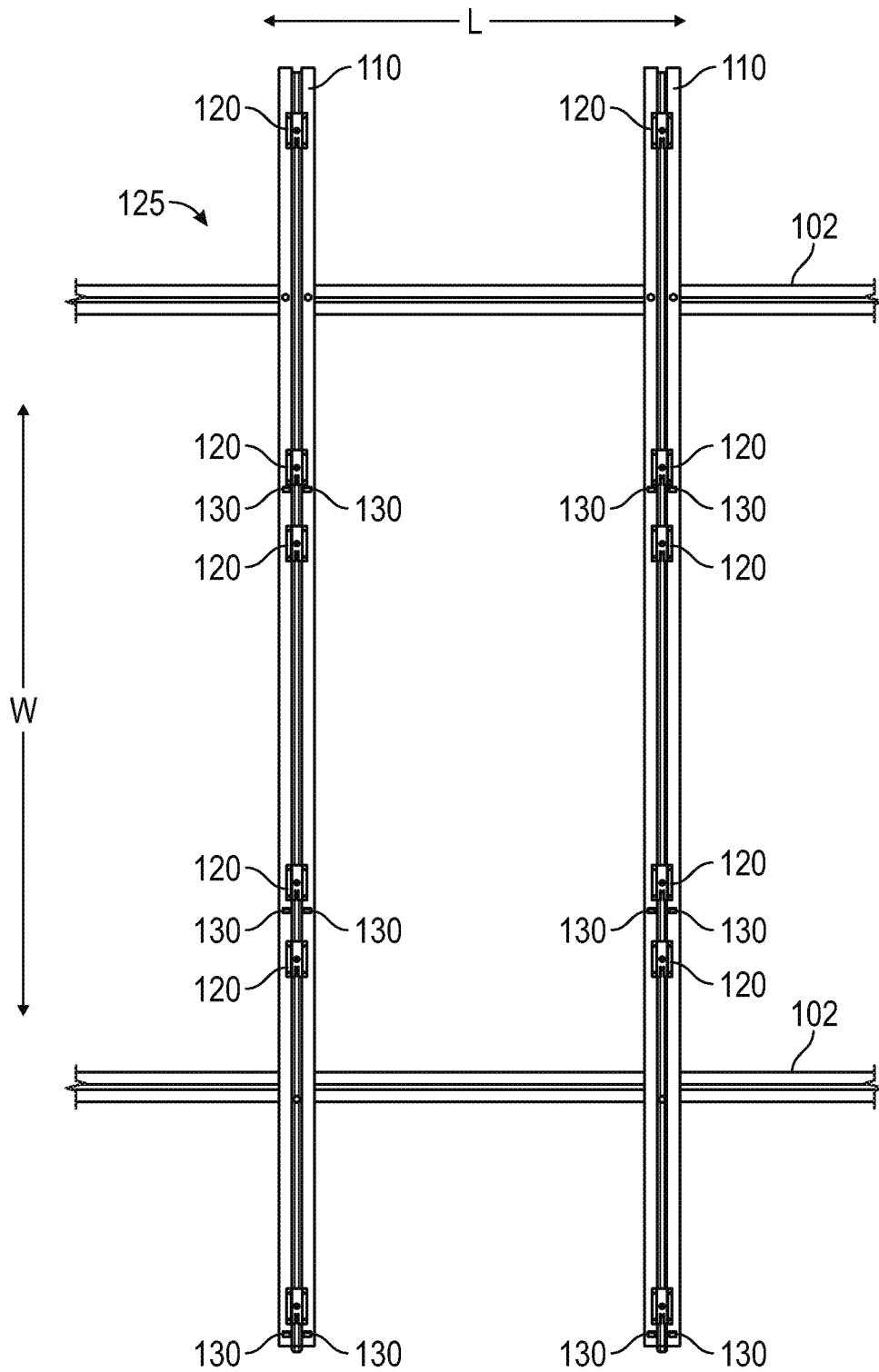


FIG. 3

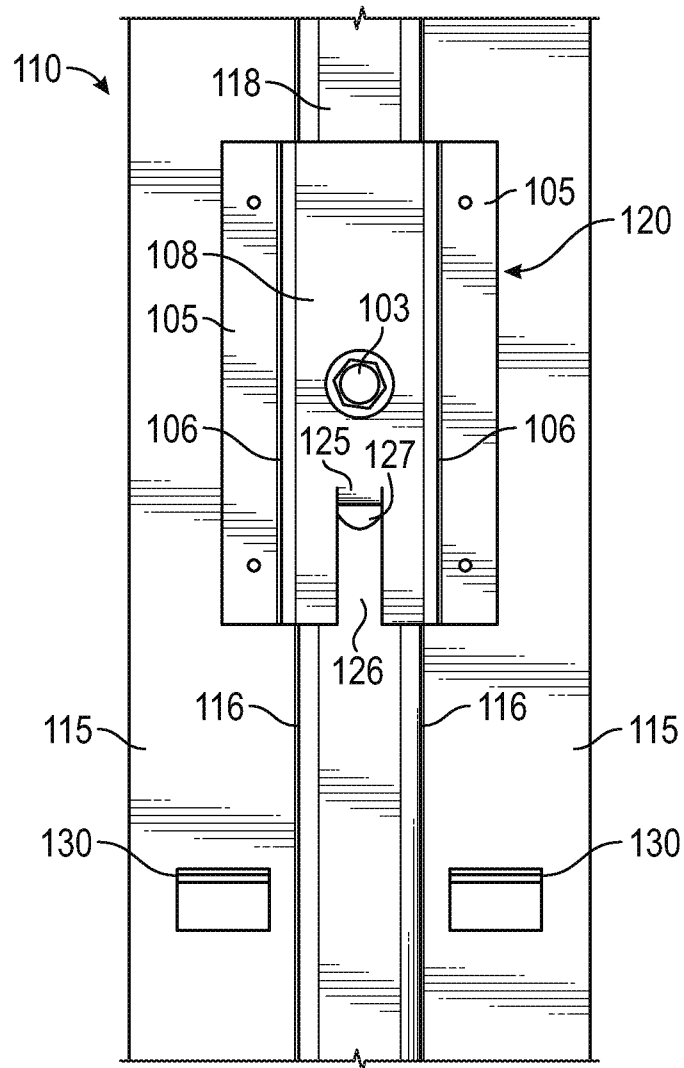


FIG. 4

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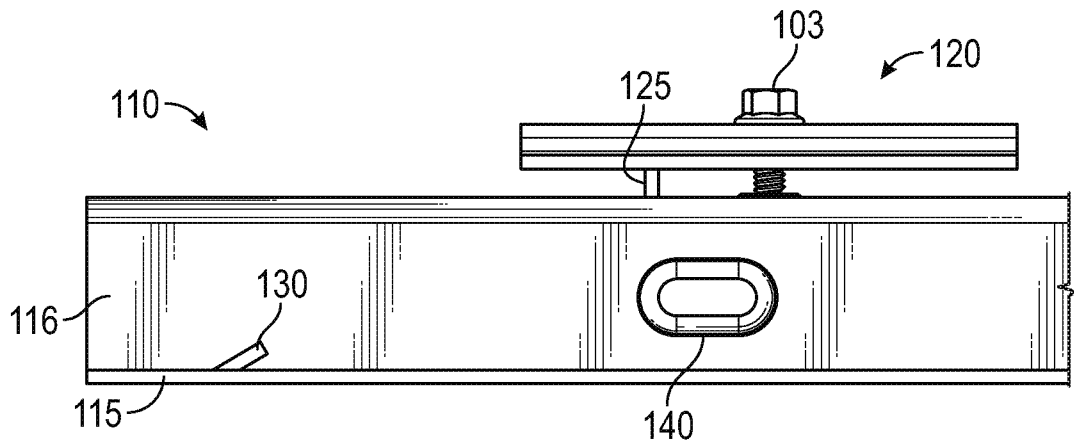


FIG. 5

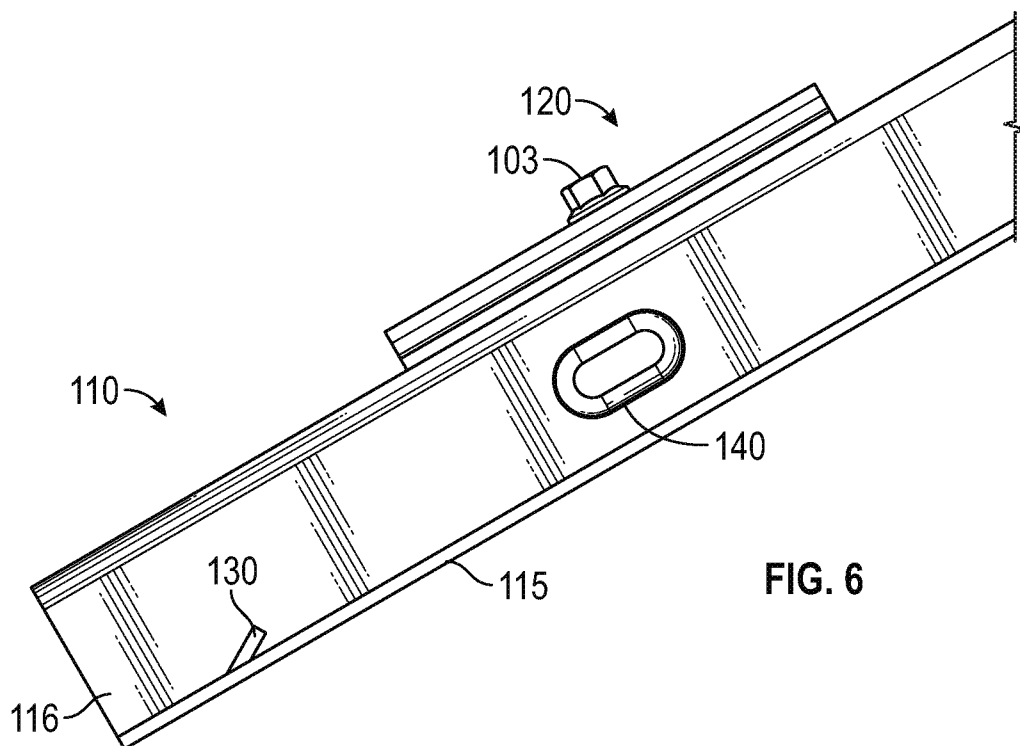
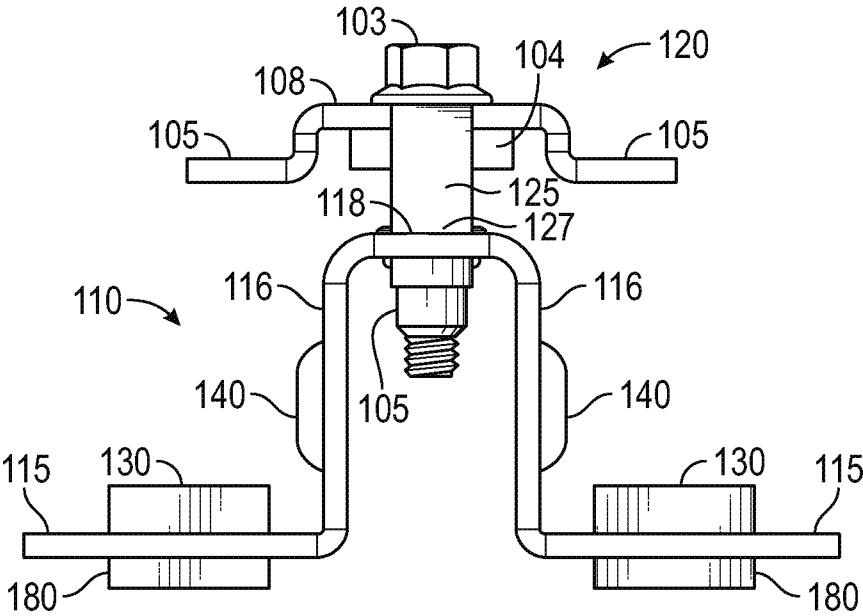


FIG. 6



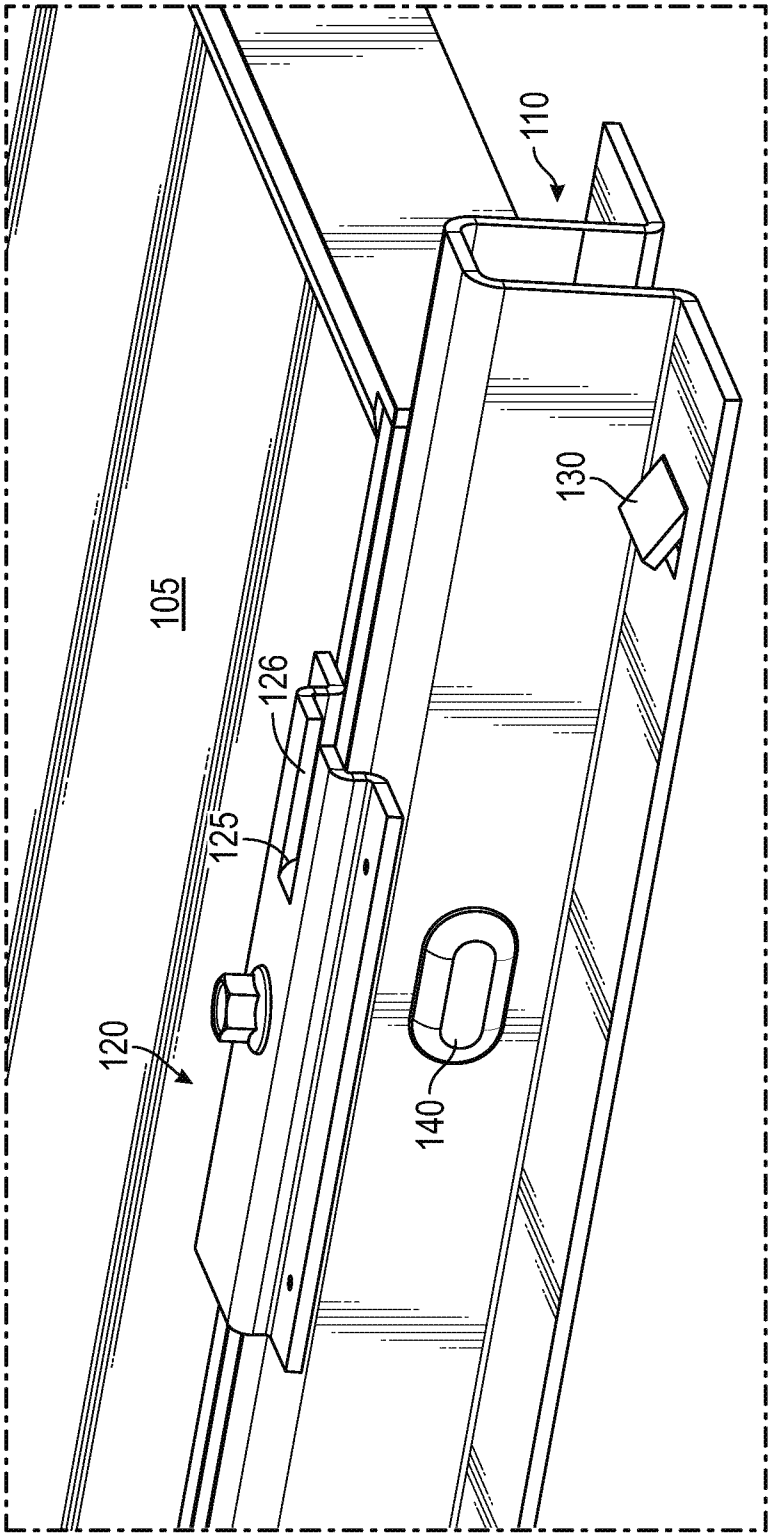


FIG. 8

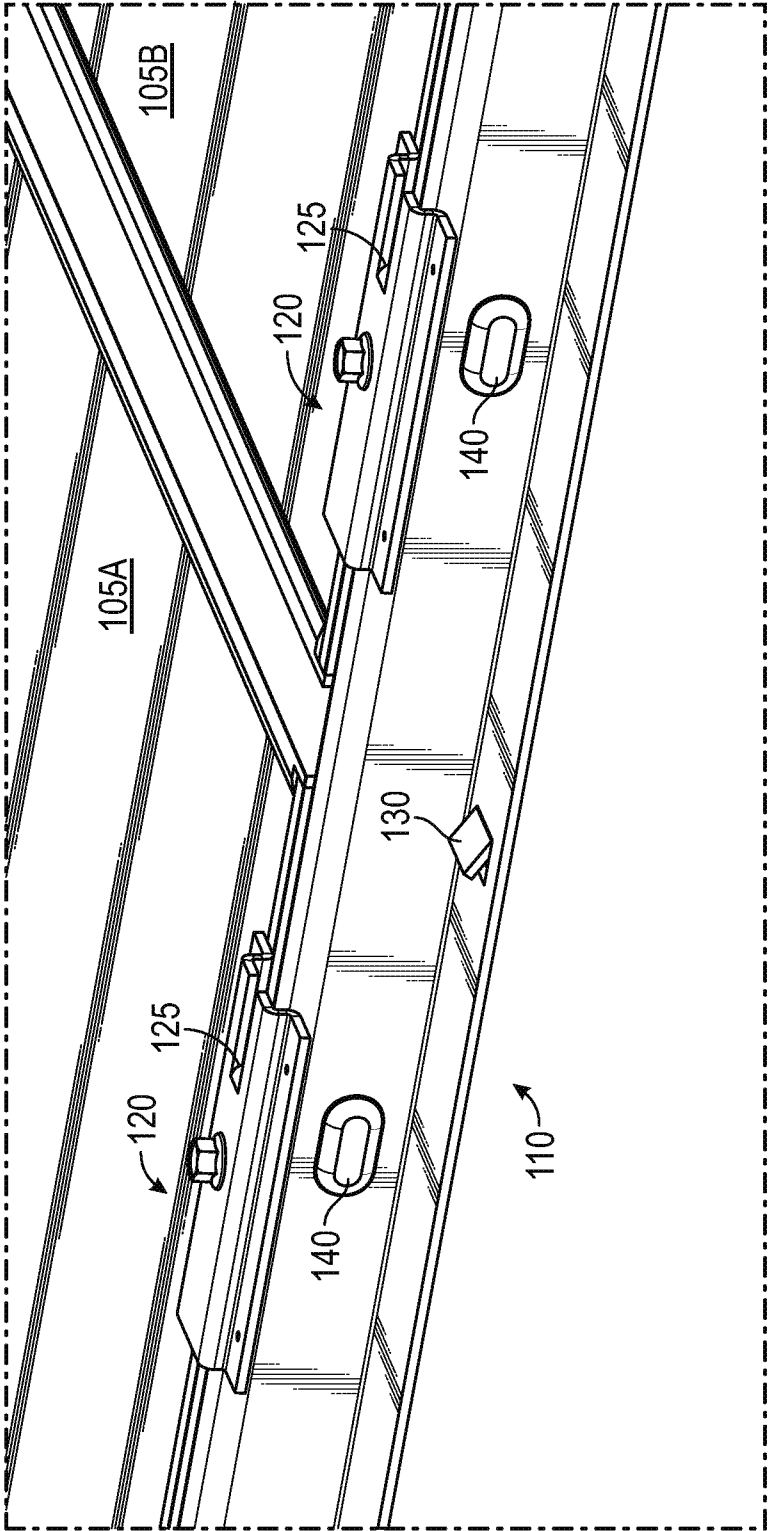


FIG. 9

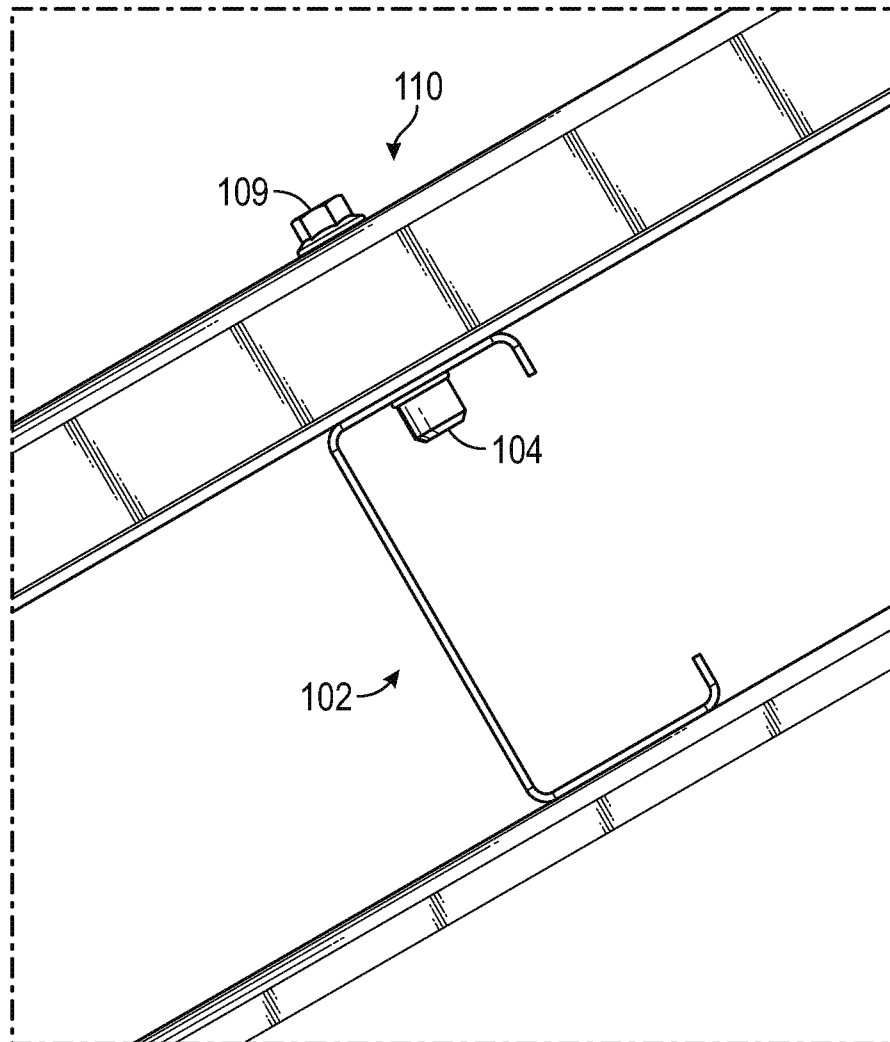


FIG. 10

10/10

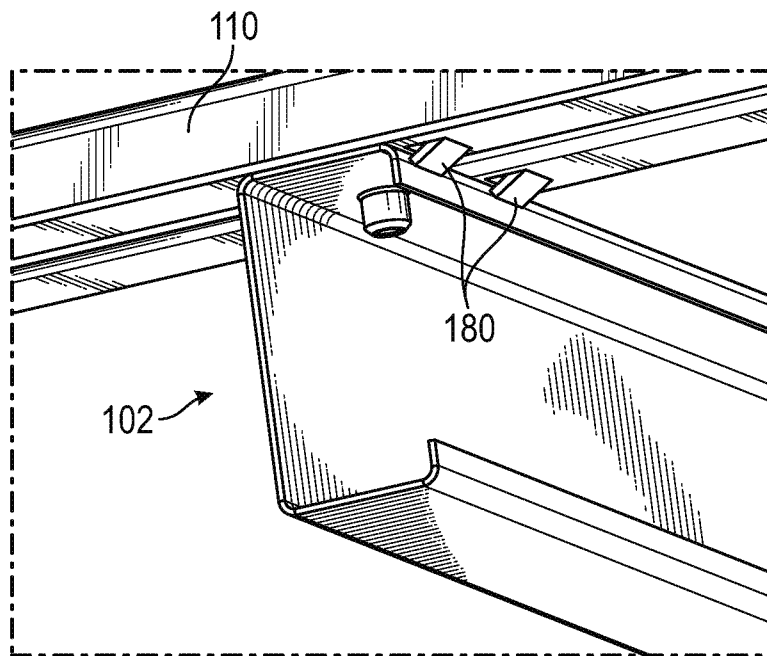


FIG. 11

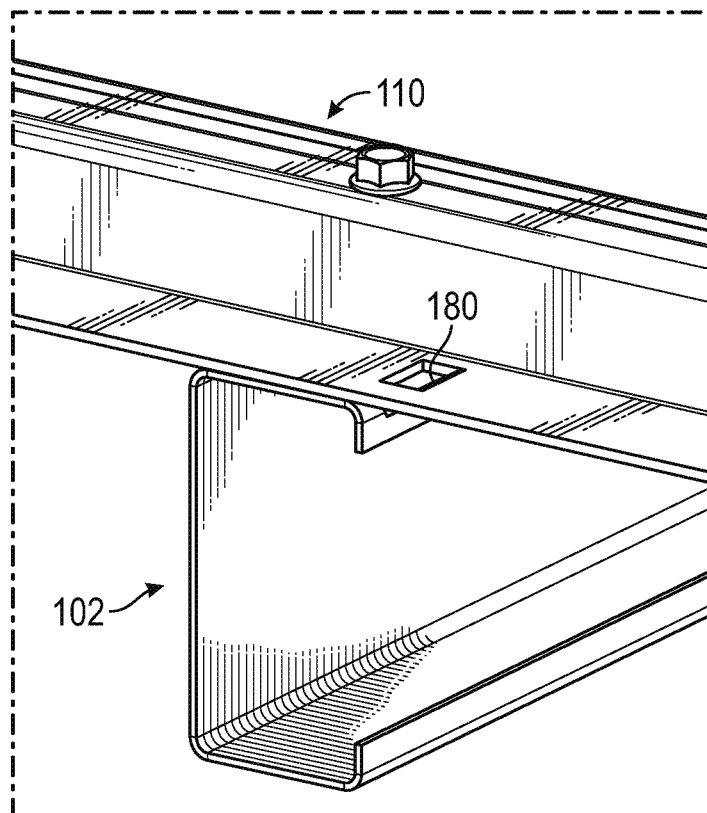


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US16/41680

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F24J 2/52, 2/46; H02S 20/20 (2016.01)

CPC - F24J 2/5203, 2/5254; H02S 20/20

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) Classifications: H02S 20/00, 20/20; F24J 2/46, 2/52 (2016.01)

CPC Classifications: F24J 2/46, 2/52, 2/5201, 2/5243, 2/5252, 2/5254, 2/5203, 2/5211; H02S 20/00, 20/20; Y02E 10/47

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

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

PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, Other Countries (INPADOC), RU, AT, CH, TH, BR, PH); Google Patent, Google Scholar, IEEE, Orbit, EBSCO

Keywords: channel, rigid, beam, protrusion, flanges, teeth, pre-installed, bolt, mounting clip, anti-rotation, tab, hole

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y --- A	US 2012/0325761 A1 (KÜBSCH, M et al.) December 27, 2012; figures 1, 2, 13-15, paragraphs [0050], [0051], [0056], [0058], [0067], [0069], [0083]	1-3 --- 4-6
Y --- A	US20110179606 A1 (MAGNO, J., JR et al.) July 28, 2011; figure 1, 2b, 2c, 6b, paragraphs [0021], [0025], [0030], [0040], [0070]	1-3 --- 4-6
Y --- A	US 2001/0004099 A1 (ONISHI, M) June 21, 2001; figures 3-a, 3-c, 13-a, paragraphs [0112], [0114], [0119], [0122], [0127], [0135], [0136], [0142]	2 --- 6
Y	US 2013/0240466 A1 (SPONSELLER, G) September 19, 2013; figures 32 & 33, paragraph [0077]	4 & 5
A	US 2013/0193297 A1 (FIRST SOLAR, INC) August 01, 2013; figure 2a, 3c, 3d, 4a-5a, paragraph [0027], [0031], [0035]-[0038]	1-6
A	US 2010/0294340 A1 (CUNNINGHAM, D et al.) November 25, 2010; entire document	1-6



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

06 September 2016 (06.09.2016)

Date of mailing of the international search report

10 NOV 2016

Name and mailing address of the ISA/

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-8300

Authorized officer

Shane Thomas

PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US16/41680

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

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

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

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See extra sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-6

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US16/41680

---Continued from Box III: Observations where unity of invention is lacking---

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fee must be paid.

Group I: Claims 1-6 are directed toward a channel structure.

Group II: Claims 7-20 are directed toward a photovoltaic array mounting structure.

The inventions listed as Groups I-III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I include, a channel structure, comprising: a rigid beam including a top surface extending horizontally, a pair of lateral sides extending downwardly, and a pair of flanges extending outwardly and horizontally; wherein the rigid beam includes: a plurality of protrusions disposed on the lateral sides; a plurality of upwardly oriented retention teeth disposed on upper surfaces of the flanges; a plurality of downwardly oriented locator teeth disposed on lower surfaces of the flanges; and a plurality of pre-installed elevated mounting clip attached to the beam using bolting; wherein each of the pre-installed mounting clips include an anti-rotation tab oriented downwardly and partially disposed in a corresponding hole in a top surface of the beam so as to prevent rotation of the mounting clip when a bolt of the mounting clip is rotated; and wherein the bolt of the mounting clip is not fully bolted into a corresponding threaded hole, which are not present in Group II.

The special technical features of Group II include, a photo voltaic array mounting structure, comprising: a frame for holding a photovoltaic array, the frame having a width and a length sufficient to accommodate the photovoltaic array, the frame including a plurality of widthwise channels spaced substantially evenly and in parallel so as to fit photovoltaic modules of the photovoltaic array between pairs of the channels, the photo voltaic modules resting upon flanges of the channels; and a plurality of supports for elevating the frame, which are not present in Group I.

The common technical features shared by Groups I-II are a channel structure.

US 2010/0294340 A1 to Cunningham, D. et al. (hereinafter "Cunningham") discloses a channel structure (connection channel 40 (a channel structure); figure 4, paragraph [0067]).

Since the common technical features are previously disclosed by Cunningham, these features are not special and Groups I & II lack unity.