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1021169

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September 15, 2019

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APPLICATION NUMBER: 62/727,456

FILING DATE: *September 05, 2018*

RELATED PCT APPLICATION NUMBER: *PCT/US19/49275*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US62/727,456*



Certified by

Anders Iversen

Under Secretary of Commerce
for Intellectual Property
and Director of the United States
Patent and Trademark Office

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA9
		Application Number	
Title of Invention	Foundation piers for axial solar arrays and related systems and methods		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
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Inventor Information:

Inventor 1				
Legal Name				
Prefix	Given Name	Middle Name	Family Name	Suffix
	Jack		West	
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service				
City	San Rafael	State/Province	CA	Country of Residence ⁱ US
Mailing Address of Inventor:				
Address 1	612 Point Gallinas Road			
Address 2				
City	San Rafael	State/Province	CA	
Postal Code	94903	Country ⁱ	US	
Inventor 2				
Legal Name				
Prefix	Given Name	Middle Name	Family Name	Suffix
	David		Mar	
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service				
City	Berkeley	State/Province	CA	Country of Residence ⁱ US
Mailing Address of Inventor:				
Address 1	1932 Thousand Oaks Blvd.			
Address 2				
City	Berkeley	State/Province	CA	
Postal Code	94707	Country ⁱ	US	
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button. Add				

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA9
		Application Number	
Title of Invention	Foundation piers for axial solar arrays and related systems and methods		

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence information of this application.**

Customer Number	157339		
Email Address	pmancini@ojjo.com	Add Email	Remove Email

Application Information:

Title of the Invention	Foundation piers for axial solar arrays and related systems and methods		
Attorney Docket Number	PPA9	Small Entity Status Claimed	☐
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	4	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	157339		

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA9	
		Application Number		
Title of Invention	Foundation piers for axial solar arrays and related systems and methods			

Prefix	Given Name	Middle Name	Family Name	Suffix	Remove
Registration Number					

Prefix	Given Name	Middle Name	Family Name	Suffix	Remove
Registration Number					

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Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX) the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)

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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA9
		Application Number	
Title of Invention	Foundation piers for axial solar arrays and related systems and methods		

This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.



NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA9
		Application Number	
Title of Invention	Foundation piers for axial solar arrays and related systems and methods		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA9
		Application Number	
Title of Invention	Foundation piers for axial solar arrays and related systems and methods		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

☐ Assignee	☐ Legal Representative under 35 U.S.C. 117	☐ Joint Inventor
☒ Person to whom the inventor is obligated to assign.	☐ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name

Mailing Address Information For Applicant:

Address 1	47 Mark Drive		
Address 2			
City	San Rafael	State/Province	CA
Country ¹	US	Postal Code	94903
Phone Number	415-786-4685	Fax Number	
Email Address	pmancini@ojjo.com		

Additional Applicant Data may be generated within this form by selecting the Add button.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA9
		Application Number	
Title of Invention	Foundation piers for axial solar arrays and related systems and methods		

Assignee Information including Non-Applicant Assignee Information:

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Assignee 1				
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.				
If the Assignee or Non-Applicant Assignee is an Organization check here. ☐				
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Mailing Address Information For Assignee including Non-Applicant Assignee:				
Address 1				
Address 2				
City		State/Province		
Country i		Postal Code		
Phone Number		Fax Number		
Email Address				
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.				

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA9
		Application Number	
Title of Invention	Foundation piers for axial solar arrays and related systems and methods		

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Philip Mancini/			Date (YYYY-MM-DD)	
First Name	Phillip	Last Name	Mancini	Registration Number	46743
Additional Signature may be generated within this form by selecting the Add button.					

FIG. 1

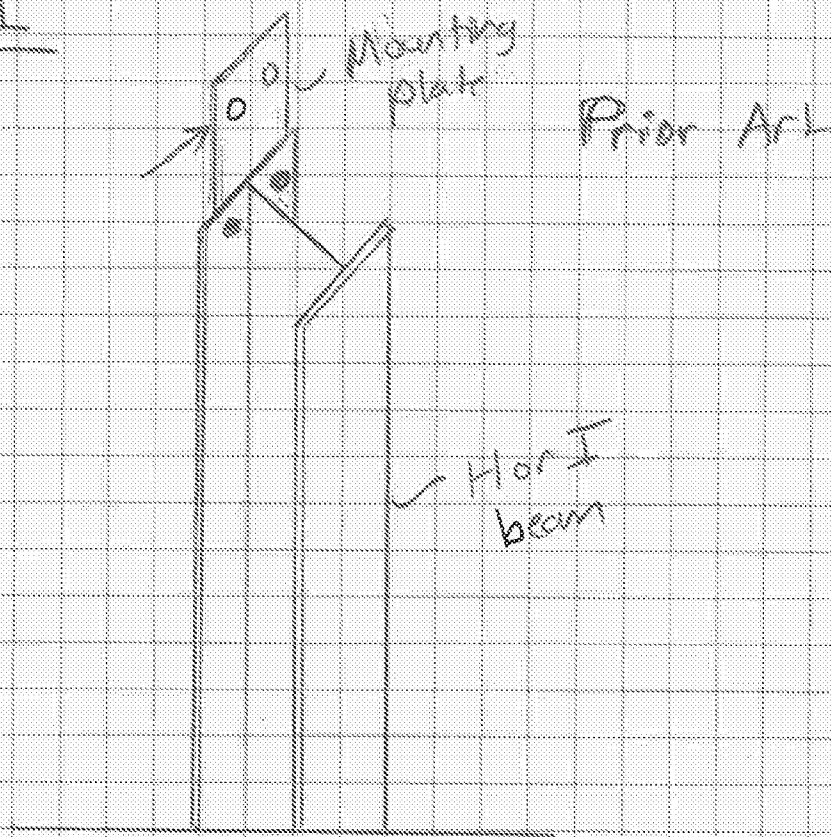


FIG. 2

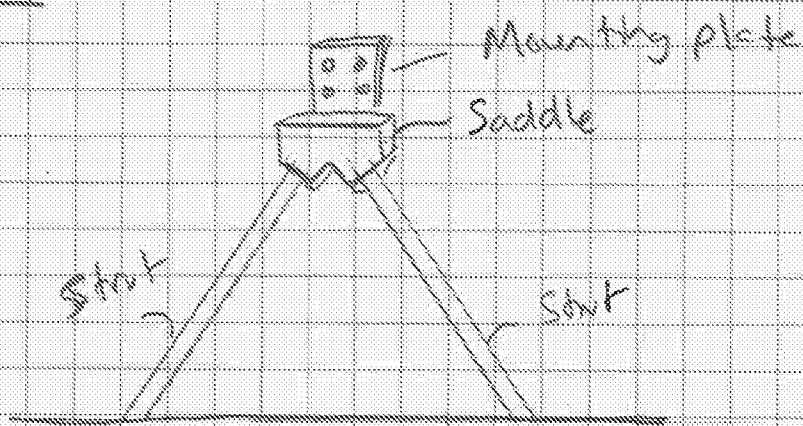


FIG. 3A

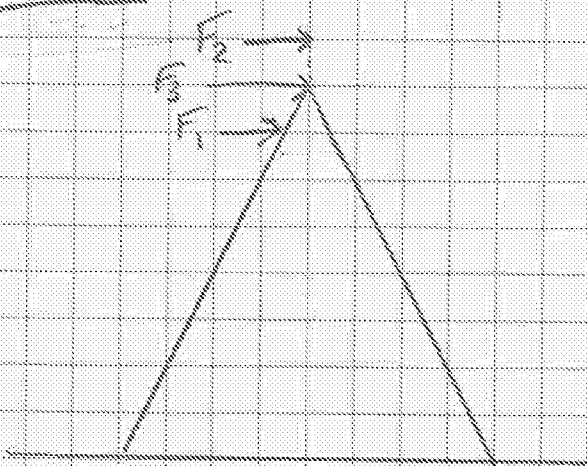


FIG. 3B

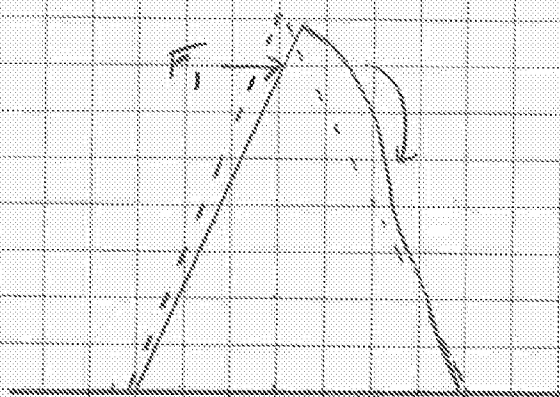


FIG. 3D

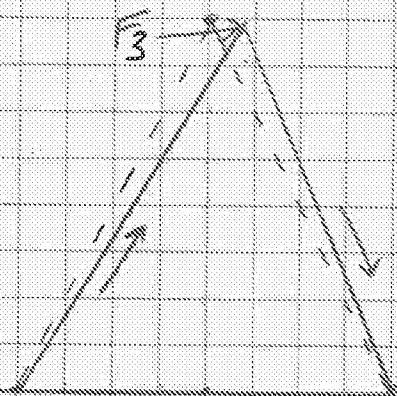


FIG. 3C

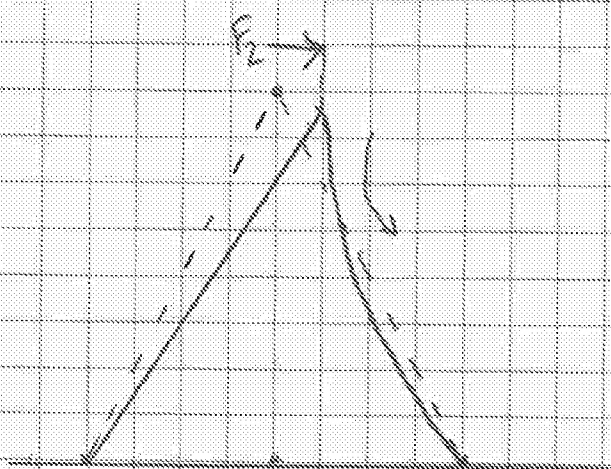


FIG. 4

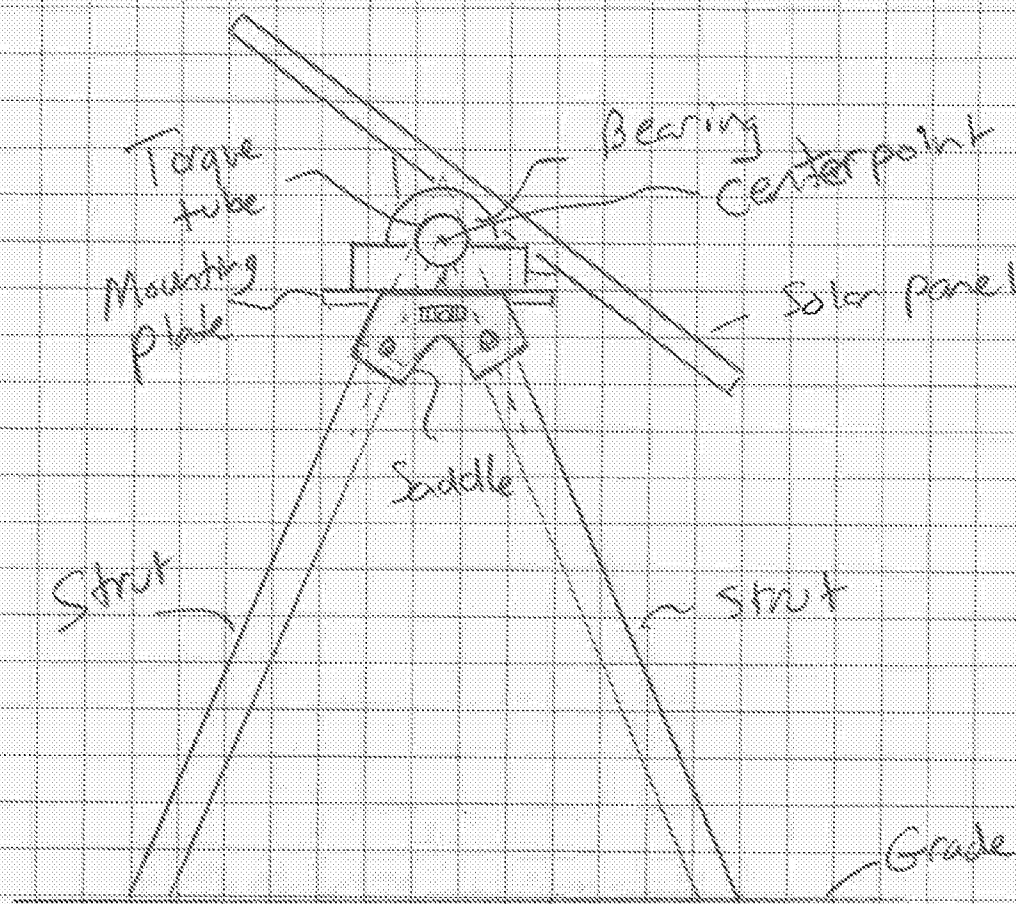


FIG. 5

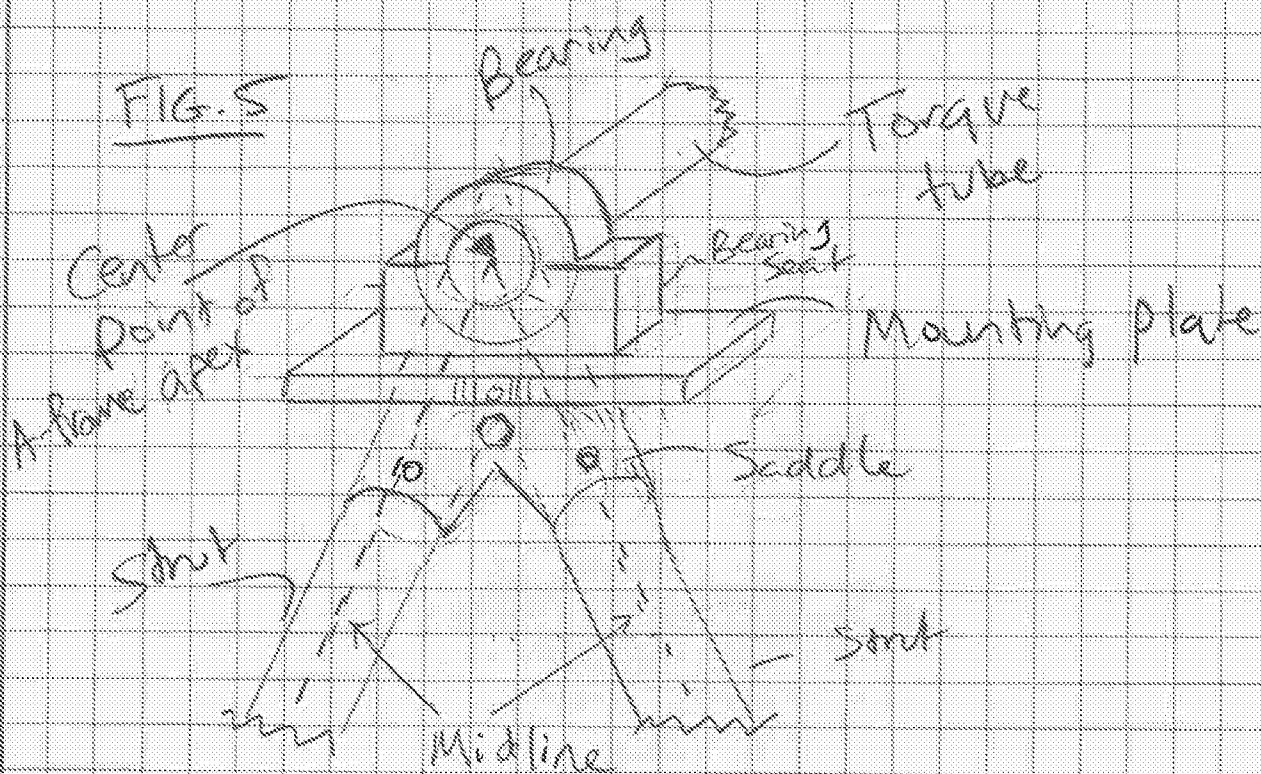


FIG. 6

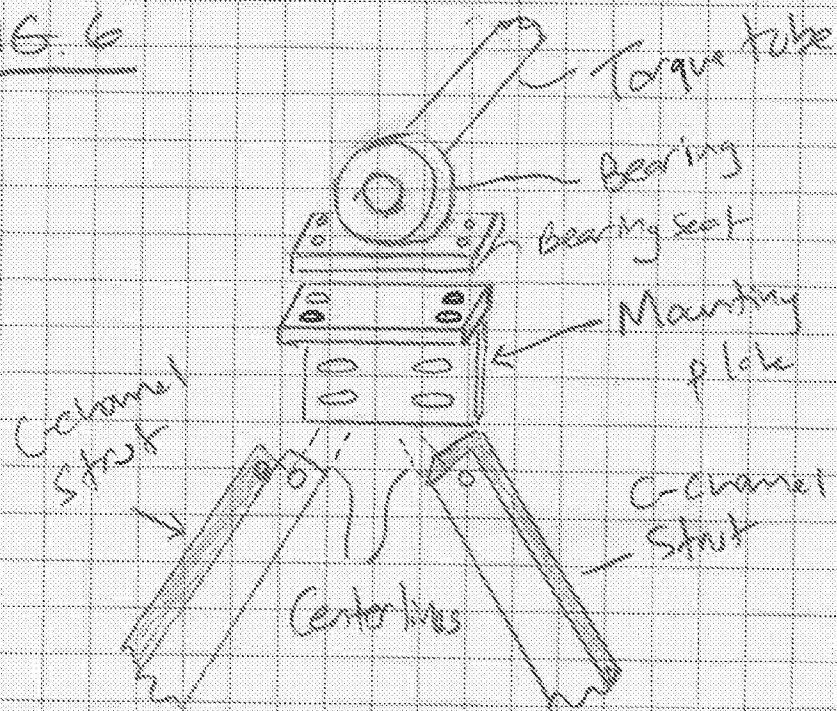
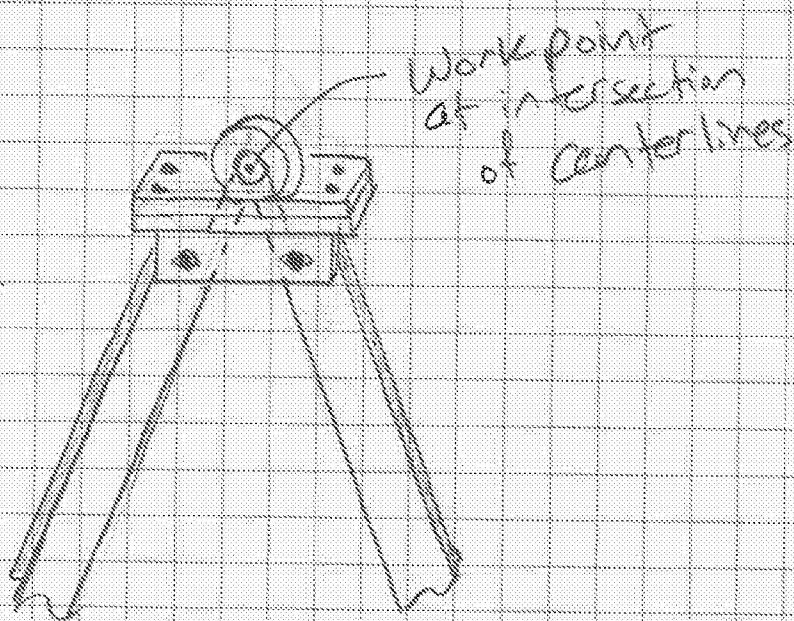


FIG. 7



Electronic Acknowledgement Receipt

EFS ID:	33637619
Application Number:	62727456
International Application Number:	
Confirmation Number:	7773
Title of Invention:	Foundation piers for axial solar arrays and related systems and methods
First Named Inventor/Applicant Name:	Jack West
Customer Number:	157339
Filer:	Phillip Mancini
Filer Authorized By:	
Attorney Docket Number:	PPA9
Receipt Date:	05-SEP-2018
Filing Date:	
Time Stamp:	19:12:53
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$ 140
RAM confirmation Number	090618INTEFSW19135300
Deposit Account	
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The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	WebADS.pdf	127210	no	8
			ca670269b11bf238e5aee7e9540a3af979e9a07c		
Warnings:					
Information:					
2	Specification	PPA9.pdf	109321	no	11
			fc61242e265e258a6d4b9f32bd3781ae557b31c3		
Warnings:					
Information:					
3	Drawings-other than black and white line drawings	PPA9_DrawingFigures.pdf	649841	no	4
			23c59479806f84241926d2b43131609a5b1196a		
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	29610	no	2
			28cd34a70d6ec5ca32709de97ef9e4dcc5acc107		
Warnings:					
Information:					
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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

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SCORE Placeholder Sheet for IFW Content

Application Number: 62727456

Document Date: 09/05/2018

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FOUNDATION PIERS FOR AXIAL SOLAR ARRAYS AND RELATED SYSTEMS AND METHODS**BACKGROUND**

- [001] Solar energy is one of the world's largest source of untapped energy. At sea level, the usable energy density is approximately 250 watts per square meter. Using a two-dimensional model to approximate the earth, $250 \text{ watts/square meter} * \pi * 6,371,000 \text{ meters}^2$ yields about 32,000 terra (trillion) watts of energy that strikes the earth at any particular moment. Given that the sun will continue to supply this energy for billions of more years, the survival of human life will ultimately depend on harnessing this essentially unlimited, clean energy source.
- [002] As in any industry, achieving scale is critical to maximizing the competitiveness of solar relative to other energy sources. This economic reality militates in favor of large-scale (multi-megawatt to multi-gigawatt) solar power plants over residential solar, although there is room for both modalities in the market place. Large-scale solar power plants are predominantly configured as either fixed-tilt or single-axis tracker arrays. Fixed-tilt arrays are arranged as East-West oriented rows of panels tilted South at an angle dictated by the latitude of the array site. By contrast, single axis trackers are rows of solar panels arranged on a rotating North-South axis called a torque tube that sweeps through an East to West rotation through the course of the day, following the sun's progression through the sky. For purposes of this disclosure, both fixed-tilt and single axis trackers will be referred to collectively as axial solar arrays.
- [003] Many large-scale solar projects are funded with so-called power purchase agreements (PPAs), whereby a customer agrees to purchase the power generated by the array at a predetermined megawatt hour rate (e.g., \$25-35 per megawatt hour at today's prevailing rates). Knowing the lifetime of the array (e.g., 35-40 years), a bank or other investor will be comfortable financing such a project given the predictable stream of revenue the array will generate over its lifetime.
- [004] Excluding land acquisitions costs, overall project costs typically include site preparation (road building, leveling, grid and water connections etc.), foundation piers, tracker hardware or fixed-tilt hardware, photovoltaics, inverters and electrical (conduit, wiring,

trenching, etc.). Inherent in all of these are also labor costs. At today's prevailing rates, this totals about \$1 per watt of energy. So, building a 100-megawatt solar power plant today would cost approximately \$100,000,000 dollars.

- [005] Many of these system component costs have dropped over the past few years, in particular solar panels and solar mounting hardware, however, one area that has been mostly overlooked is the cost associated with foundation piers. These structures physically couple solar trackers or fixed-tilt solar arrays to the earth. Typically, after the site has been prepped, a grid of H-piles or other structures are driven into the ground at regular intervals and other components are subsequently attached to those piles. In a conventional, large-scale single-axis tracker array, these piers will typically represent 5-7 percent of the cost of installing an array. Despite this relatively small share of the total array cost, any savings in steel and labor associated with foundation piers will amount to a significant amount of money over a multi-gigawatt portfolio of solar power plant projects. This is particular true in the solar power plant business because many of these deals are locked in years before the installation costs are incurred. Therefore, the savings will be in addition to profits already factored in the calculations that supported the PPA. Reducing steel and associated labor costs used in foundation piers is the object of this application.

DESCRIPTION

- [006] Contrary to conventional single H or I pile foundations used in most axial solar array installations, A-frame style foundations may provide similar resistance to vertical loads and lateral wind forces while using far less steel and being driven less deep. Experimentation has shown that resistance to lateral forces by an A-frame foundation formed from two adjacent angled struts driven into the ground is dictated by soil friction on the windward leg, buckling of the above-ground portion of the leeward leg, and compression (sinking) of the leeward leg. Because of the soil's large pressure on the submerged legs, buckling does not typically occur underground in such foundations occur other than in the first few inches of loose topsoil. Therefore, pulling out of the windward leg is typically the first failure point. So, structures that increase the surface

area or outside diameter of the strut normal to its axis will provide greater resistance to lateral forces than uniform struts. This explains why helical anchors are often used in applications where large weights need to be supported (retaining walls, building foundations, etc.) or where massive resistance to pull-out is required (e.g., securing communication towers and utility poles).

- [007] Referring now to FIG. 1, this figure shows a conventional support for an axial solar array using an H or I beam. Typically, when a large single axis tracker array is being constructed, a series of beams are driven into the ground with a pile driver along multiple rows, one for each torque tube. These rows will support the torque tubes making up the array. The beams may have holes pre-drilled in them so that a mounting plate or other structure can be attached. Then, motors, torque tube bearings and other structures are attached to each mounting plate.
- [008] H and I beams provide a robust platform for supporting tracker components but are not optimized from a cost or materials usage perspective. Beams are good at handling loads but less good at dealing with lateral (bending) forces. As a result, they are often oversized and driven very deep, with as much as two-times the amount of material below ground as above ground. Also, pile driving to those depths takes time, leads to more refusals, and generates a great deal of noise.
- [009] Referring now to FIG. 2, by contrast the system shown in FIG. 1, this figure shows an A-frame foundation pier system for an axial solar array according to various embodiments of the invention. Each A-frame support consists of a pair of adjacent struts (round tubes) that are driven into the ground at an angle with respect to normal. In this example, the pair is capped off with a saddle and mounting plate. The saddle completes the A-frame structure, making it a rigid triangle and the provides a platform on which to attach the bearing, a torque motor, or other equipment. The torque tube rotates within the bearing to allow solar panels to track the sun's East-West progression throughout the day.
- [010] In the example of FIG. 2, the mounting plate is shown as being attached vertically to the saddle. In various other embodiments, the mounting plate may sit atop the saddle at a

horizontal orientation. In further embodiments, the saddle may be replaced with a mounting plate having a vertical portion for joining the adjacent struts and a horizontal portion for supporting the bearing (see, e.g., FIGS. 6 and 7). Also, in this image, although it appears that the struts join in a common plane, in some embodiments, the struts may be staggered in two parallel planes. This may make it possible to drive both struts simultaneously without one strut being in the driving path of the other.

- [011] Referring now to FIGS. 3A-D, these figures are force diagrams showing the various forces and their effects on an A-frame-type foundation pier. With an A-frame foundation, lateral forces (wind) applied to the torque tube will tend to pull up on the windward leg of the A-frame while compressing the leeward leg. However, the point of application of the force will determine the A-frame's ability to resist such forces without failure as well as the particular failure mode.
- [012] FIG. 3A shows three different lateral forces, F_1 , F_2 and F_3 applied at three different points on the A-frame. The different locations of the points correspond to different attachment points of the torque tube to the A-frame. Force F_1 and its corresponding force diagram at 3B show that a force applied below the work point or apex of the 3B will hasten the buckling of the leeward leg of the A-frame. As the magnitude of the lateral force increases, the frame will tend to buckle above ground somewhere between the apex and the approximate point where the leeward leg enters the ground. Similarly, Force F_2 , positioned above the work point or apex of the A-frame will tend to act as a lever, hastening the failure of the leeward leg as shown in 3C. As F_2 moves above the apex, the force will gain a mechanical advantage on the A-frame, making it more progressively more vulnerable to failure.
- [013] Lateral force F_3 is applied right at the apex or work point of the A-frame. As seen in 3D, the force applied at this point will have the least tendency to prematurely buckle the leeward leg because it is being applied to the strongest point on the frame. If the magnitude of F_3 is large enough the A-frame will still fail but by locating the force at the work point, it should resist failure to a greater extent than forces F_1 or F_2 allowing the strut to relatively smaller than if the force is applied elsewhere on the frame.

- [014] In an axial solar array wind incident upon the solar panels is transferred to the torque tube which in turn transfers it to the structure supporting it. To provide optimal resistance to this force, it is important that the torque tube attachment point coincides with the work point or apex of the A-frame. To that end, FIGS. 4 and 5 show a portion of an axial solar array where the saddle, mounting plate and bearing orient the cross-sectional center of the torque tube at the work point of the A-frame. In this case, because the struts terminate in the saddle, prior to contacting one another, the work point is represented by the axial dotted lines running through the center of each strut that intersect at the cross-sectional center of the torque tube. If the diameter of the torque tube is known, this can be accomplished by controlling spacing between the free ends of the struts, the position of the saddle and/or the depth of the recesses formed in the saddle that receive the struts, and the dimensions of the mounting plate, or bearing seat, or combinations of these variables. If the desired spacing between the free ends is known, then the other components can be dimensioned so that the torque tube is centered about the apex when it is seated in the bearing. In various embodiments, it may be necessary to cut off the end of one or both struts after they are driven to them fit in the saddle.
- [015] Taking the simple case of the struts driven into the ground at plus or minus 60 degrees, if the struts are level with respect to one another, or if the saddle can be adjusted to make them level, then once the spacing between their center lines is known, say for example, 12 inches apart, the center of the torque tube should be 10.39 inches above that because in a 30-60-90 triangle, if the horizontal distance between the center lines is 12 inches, then each triangle has a base or 6 inches or $x=6$. In that case, the additional distance along the axis of the strut (the hypotenuse) is 12 inches or $2x$ and the additional vertical height to get to the apex is $x\sqrt{3}$ or 10.39 inches. Therefore, in this case, the mounting plate should be adjusted so that the bearing and/or bearing seat holds the torque tube so that its center point is exactly 10.39 inches above the imaginary line intersecting the free ends of the adjacent struts. Depending on the desired angle of the struts and distance between them, trigonometry can be used to

accurately determine the optimal center point for the torque tube to maximize the A-frame's resistance to lateral forces.

- [016] Referring to FIGS. 6 and 7, these figures show exploded and perspective views respectively of a foundation system for an axial solar array according to various other embodiments of the invention. As seen in FIG. 6, the system consists of a pair of adjacent struts oriented at angles with respect to vertical. In this example, the struts are C-channel struts instead of rounded tubes. This changes the position of the apex from that of the rounded of tube. C-channels are open on one side, so the apex is the intersection of an imaginary ribbon running along the spine (bottom of the C) of each adjacent strut up to the point where the ribbons would intersect.
- [017] In the exploded view of FIG. 6, the next element above the struts is the mounting plate. As drawn, the plate consists of a vertical portion and a horizontal portion. The vertical portion is a flange with pre-drilled holes for attaching to the above-ground free end of each adjacent strut pair. Although drawn as a single flange that attaches to one of the sides of the C-channel, in various embodiments, the mounting plate may have two vertical flanges that fit around both sides of the C-channel. In either case, the vertical portion may have enlarged openings to allow for some adjustment in either the horizontal or vertical directions, or in some cases, in both directions. This allows for micro adjustments of the mounting plate height and orientation so that it can be aligned with the other mounting plates in the same row. The mounting plate also consists of a horizontal portion that provides a seat for the bearing.
- [018] A bearing assembly sits atop the mounting plate and is connected via pre-drilled holes in both structures. In various embodiments, the bearing assembly will consist of a seat, that is, a relatively flat portion that sits on the horizontal flange of the mounting plate, and a bearing. The bearing receives the torque tube and allows it to rotate under the power of the drive motor. Typically, one or more of the supports holding up the torque tube will support a drive motor that applies a rotational force to the tube according to a control algorithm.

- [019] FIG. 7 shows the exploded elements of FIG. 6 in an assembled state according to various embodiments of the invention. After the adjacent C-channel strut pair has been driven into the ground, the mounting plate is bolted on. Then, the bearing assembly is seated on the mounting plate. In various embodiments, the bearing assembly and mounting plate will be oriented on the adjacent strut pair so that a cross-sectional center of the torque tube projecting through the bearing coincides with the intersection of the centerline of each adjacent strut. By focusing lateral forces applied to the torque tube to this point, the struts can be relatively smaller than if the torque tube is offset from this point as seen and discussed in the context of FIGS. 3A-D.
- [020] It should be appreciated that although the figures and specification show and describe only round and C-channel struts, that the various embodiments of the invention are compatible with other strut types as well. The cross-sectional geometry of the strut will determine the ideal point to center the torque tube on.

CLAIM SET 1:

1. A foundation system for an axial solar array comprising:
 - a pair of adjacent struts installed in supporting ground at reciprocal angles with respect to normal;
 - a saddle interconnecting above-ground ends of the adjacent struts to form a rigid A-frame structure; and
 - a mounting plate portion on the saddle;
 - a torque tube bearing portion supported by the mounting plate portion; and
 - a torque tube surrounded by the bearing portion above the mounting plate portion, wherein the bearing portion holds the torque tube so that its cross section is centered at an apex of the A-frame structure via the mounting plate portion.
2. The foundation system according to claim 1, wherein the bearing portion comprises a bearing and a bearing seat.
3. The foundation system according to claim 1, wherein at least one of the saddle portion and mounting plate portion comprises an integrated level.
4. The foundation system according to claim 1, wherein the saddle comprises a pair of recesses, each recess dimensioned to capture one of the above-ground ends of the adjacent struts.
5. The foundation system according to claim 1, wherein the mounting plate portion includes a lateral adjustment feature to allow adjustment of the bearing portion in the East and West directions with respect to the mounting plate.
6. A method of installing a foundation for an axial solar array comprising:
 - driving multiple pairs of adjacent struts at angles to one another along a North-South oriented row;
 - joining above-ground ends of each adjacent strut pair with a saddle to form a rigid A-frame structure;
 - leveling each saddle before securely attaching it to the adjacent strut pair;
 - installing a bearing assembly above each saddle; and

- capturing a section of a tracker torque tube with the bearing so that a cross sectional center of the torque tube coincides with an apex of each A-frame structure.
7. The method of claim 6, wherein driving the pair of adjacent struts at angles to one another comprises using a rotary driver to drive each strut into the ground.
 8. The method of claim 6, wherein joining the above-ground ends of the adjacent struts with a two-piece saddle, the two-piece saddle combining to define a pair of angled recesses capturing the above-ground ends of the adjacent struts.
 9. The method of claim 8, wherein leveling the saddle comprises adjusting a depth of each above-ground end in the recess before rigidly attaching each strut to the saddle.
 10. The method of claim 6, wherein each wherein installing a bearing assembly comprises adjusting a position of the bearing assembly with respect to the saddle in the East and West directions.
 11. A single axis tracker comprising:
 - a plurality of adjacent strut pairs spaced apart in a North-South oriented row;
 - a plurality of saddles, one interconnecting each adjacent strut pair, to form a row of rigid A-frame structures;
 - a plurality of bearing portions, each bearing portion installed on one of the plurality of saddles; and
 - a torque tube spanning the length of the row, the torque tube rotating within the plurality of bearing portions, the bearing portions and saddles orienting the torque tube at the apex of each A-frame structure.
 12. The single axis tracker of claim 11, further comprising a mounting plate between each saddle and bearing portion, the mounting plate supporting the bearing portion.
 13. The single axis tracker of claim 11, wherein each saddle comprises a two-piece structure that captures a free end of each adjacent strut pair to form a pair of adjacent angled recesses.
 14. The single axis tracker of claim 13, wherein the saddle comprises a leveling mechanism to control the depth of each adjacent strut within each recess.
 15. A foundation for an axial solar array comprising:

a pair of adjacent struts installed in supporting ground at reciprocal angles with respect to normal;

a saddle portion interconnecting above-ground ends of the adjacent struts to form a rigid A-frame structure; and

a mounting plate portion on the saddle portion;

a torque tube bearing portion supported by the mounting plate portion; and

a section of torque tube surrounded by the bearing member above the mounting plate portion, wherein the bearing portion and mounting plate support the torque tube with respect to the A-frame structure so that lateral wind forces incident on PV modules supported by the torque tube are translated to the rigid A-frame structure at its strongest point.

16. The foundation according to claim 15, wherein each saddle portion comprises a leveling mechanism to compensate for any difference in height between the adjacent struts.

17. The foundation according to claim 15, wherein the mounting plate portion includes a lateral adjustment feature to allow adjustment of the bearing portion with respect to the mounting plate in the East and West directions.

18. A foundation system for an axial solar array comprising:

a pair of adjacent C-channel struts driven into supporting ground at reciprocal angles with respect to ground normal so that a length of each struts projects above-ground;

a mounting plate interconnecting the pair of adjacent C-channel struts at their respective above-ground ends;

a bearing attached above the mounting plate and C-channel struts, the bearing plate holding a section of torque tube so that a cross-sectional center of the torque tube coincides with an intersection of respective centerlines of the adjacent struts.

19. A single axis tracker comprising:

a plurality of adjacent strut pairs spaced apart in a North-South oriented row;

a plurality of mounting plates, one interconnecting each adjacent strut pair, to form a row of rigid A-frame structures;

a plurality of bearing portions, each bearing portion installed on one of the plurality of mounting plates; and

a torque tube spanning the length of the row, the torque tube rotating within the plurality of bearing portions, the bearing portions and mounting plates orienting a cross sectional center of the torque tube so that it coincides with an intersection of respective centerlines of the adjacent struts.

20. A method of installing a foundation for an axial solar array comprising:

driving multiple pairs of adjacent struts at angles to one another along a North-South oriented row;

joining above-ground ends of each adjacent strut pair with a mounting plate to form a rigid A-frame structure;

leveling each mounting plate before securely attaching it to an adjacent strut pair; and

installing a bearing above each mounting plate, the bearing capturing a section of a torque tube so that a cross-sectional center of the tube coincides with an intersection of respective centerlines of each adjacent strut pair.