

DOCUMENT MADE AVAILABLE UNDER THE PATENT COOPERATION TREATY (PCT)

International application number:	PCT/US2019/042763
International filing date:	22 July 2019 (22.07.2019)
Document type:	Certified copy of priority document
Document details:	Country/Office: US
	Number: 62/718,780
	Filing date: 14 August 2018 (14.08.2018)
Date of receipt at the International Bureau:	28 September 2019 (28.09.2019)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a),(b) or (b-bis)

1023798

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

September 27, 2019

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.

APPLICATION NUMBER: *62/718,780*

FILING DATE: *August 14, 2018*

RELATED PCT APPLICATION NUMBER: *PCT/US19/42763*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US62/718,780*



Certified by

Anders Ivarsson

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	PPA7
		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.)
--------------------------	---

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				

Correspondence Information:

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA7
		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.**

Name 1	Ojjo, Inc.	Name 2	
Address 1	47 Mark Drive		
Address 2			
City	San Rafael	State/Province	CA
Country ⁱ	US	Postal Code	94903
Phone Number	415-786-4685	Fax Number	
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	PPA7	Small Entity Status Claimed	☒
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	6	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:

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	PPA7
	Application Number	
Title of Invention	Foundation piers for axial solar arrays and related systems and methods	

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)
Prefix	Given Name	Middle Name	Family Name	Suffix	Remove			
	Phillip		Mancini					
Registration Number	46743							
Additional Representative Information blocks may be generated within this form by selecting the Add button.								

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)
Additional Foreign Priority Data may be generated within this form by selecting the Add button.			

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA7
		Application Number	
Title of Invention	Foundation piers for axial solar arrays and related systems and methods		

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

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.
--

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA7
		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.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA7
		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.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA7
		Application Number	
Title of Invention	Foundation piers for axial solar arrays and related systems and methods		

Assignee Information including Non-Applicant Assignee 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.

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. ☐									
Prefix	Given Name	Middle Name	Family Name	Suffix					
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.									

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA7
		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

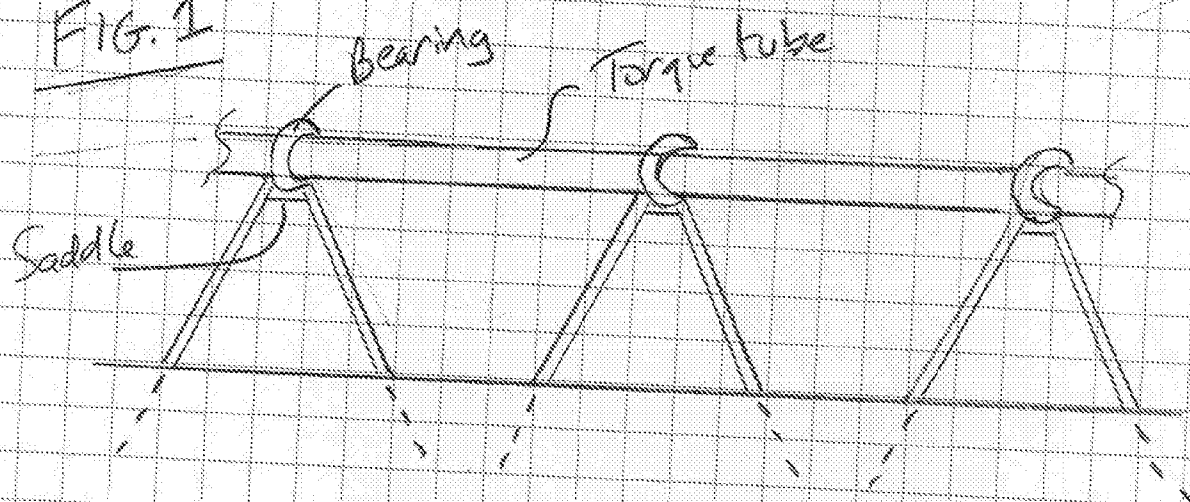


FIG. 2

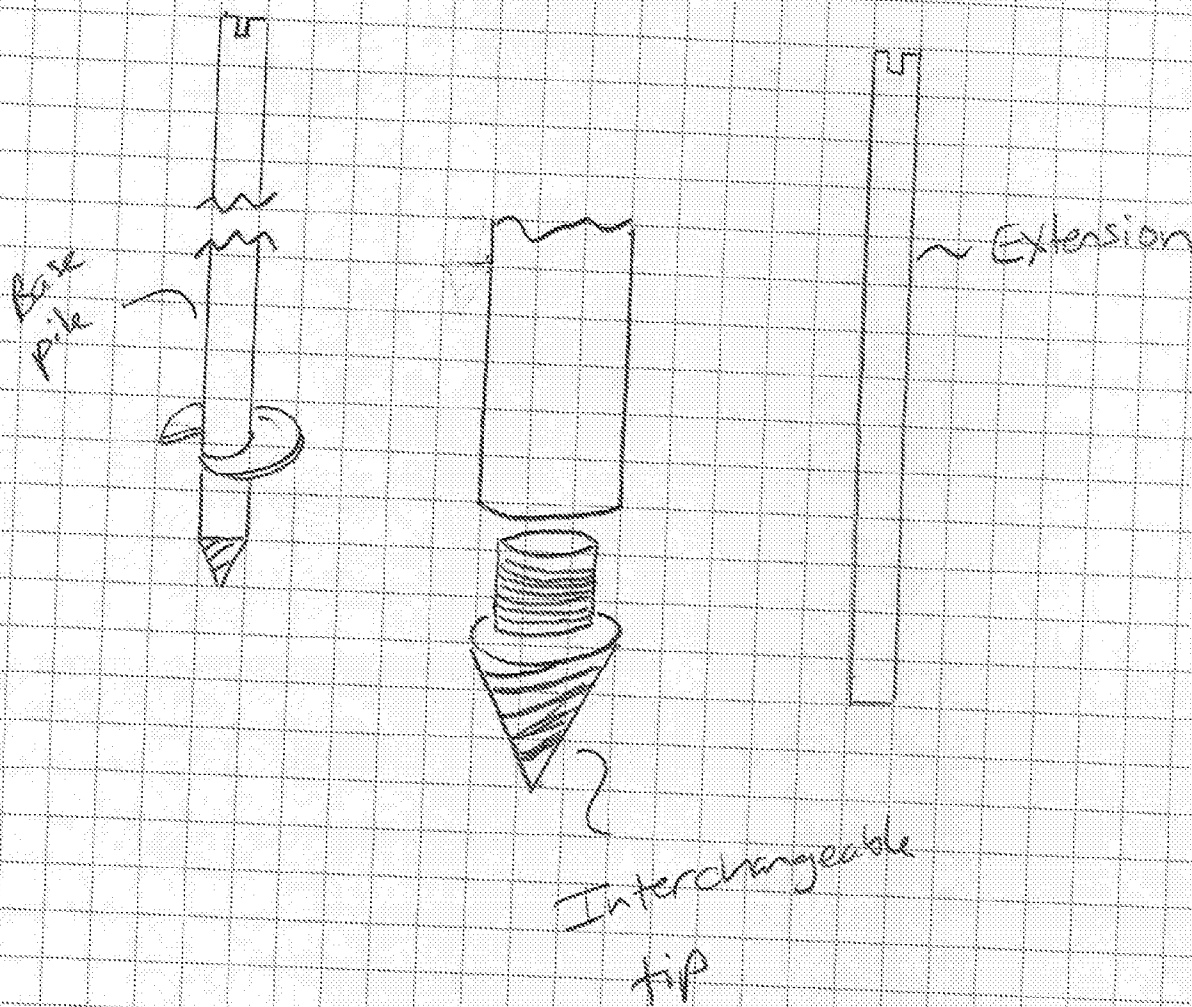


FIG. 3

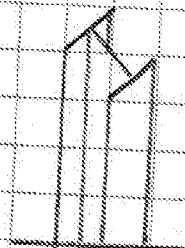
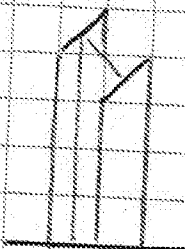
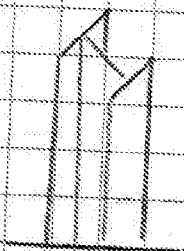
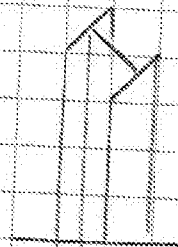
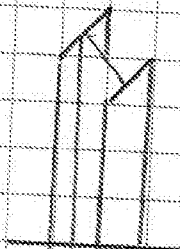
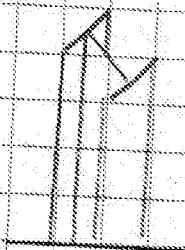
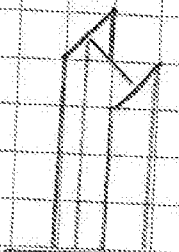
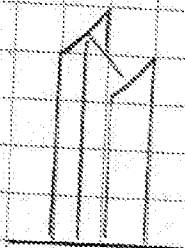
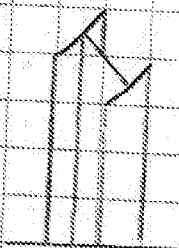
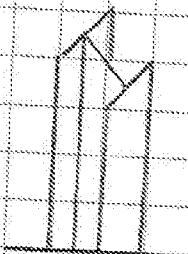
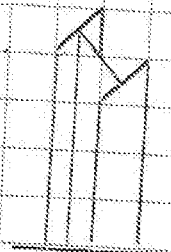
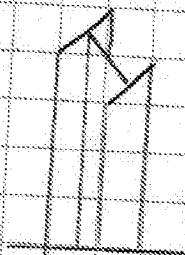
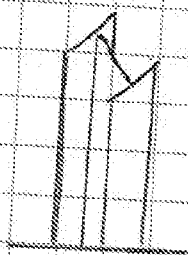


FIG. 4

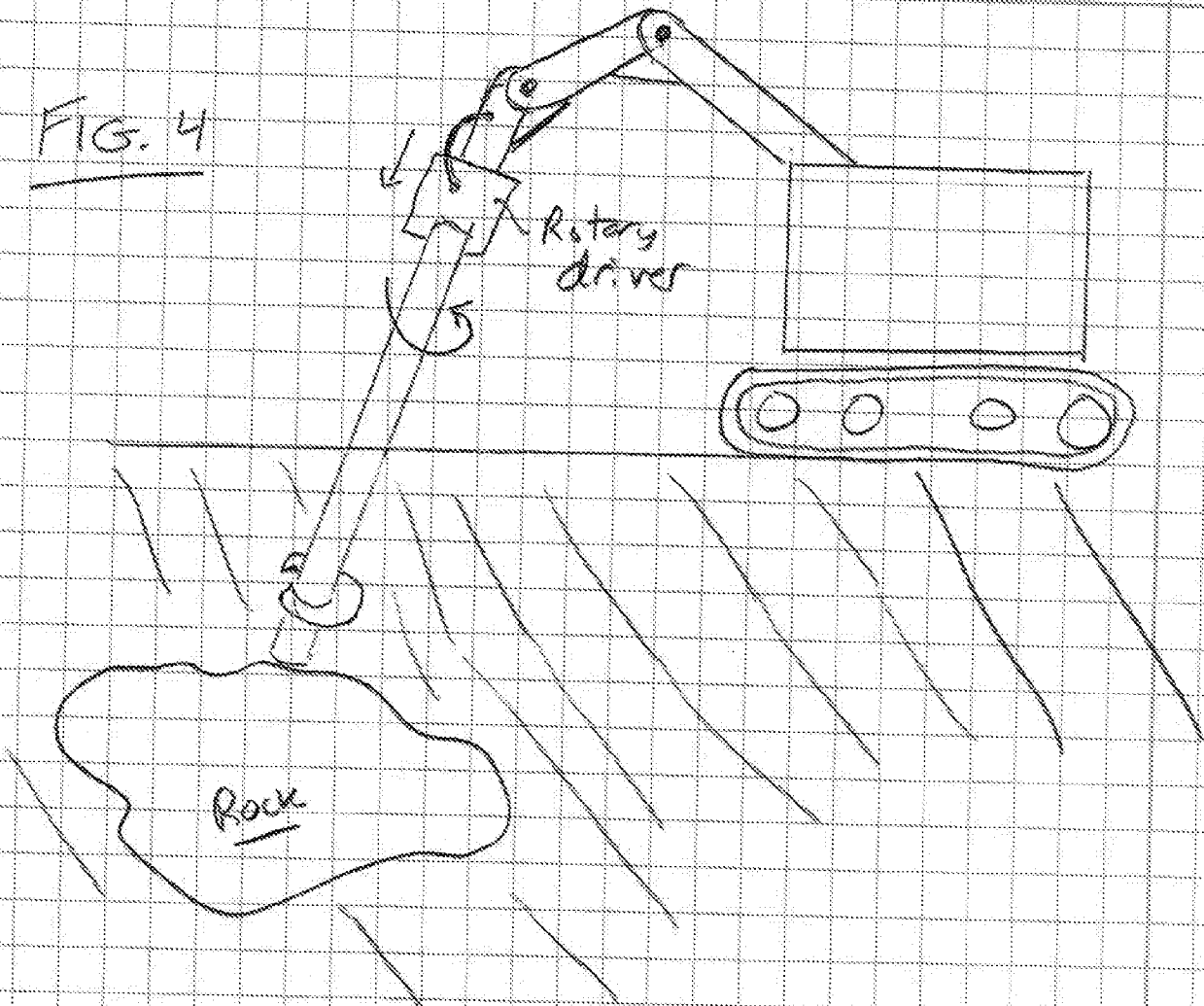


FIG. 5

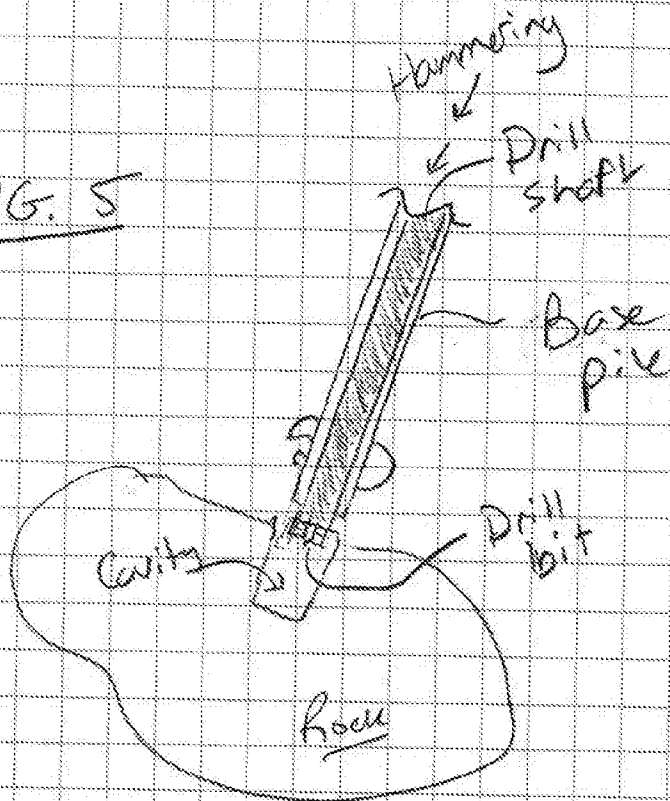


FIG. 6

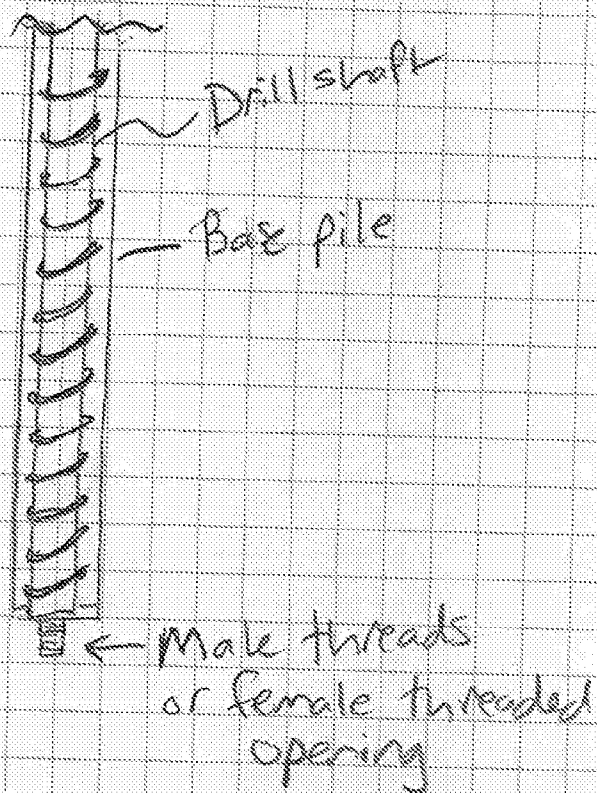


FIG. 7



FIG. 8

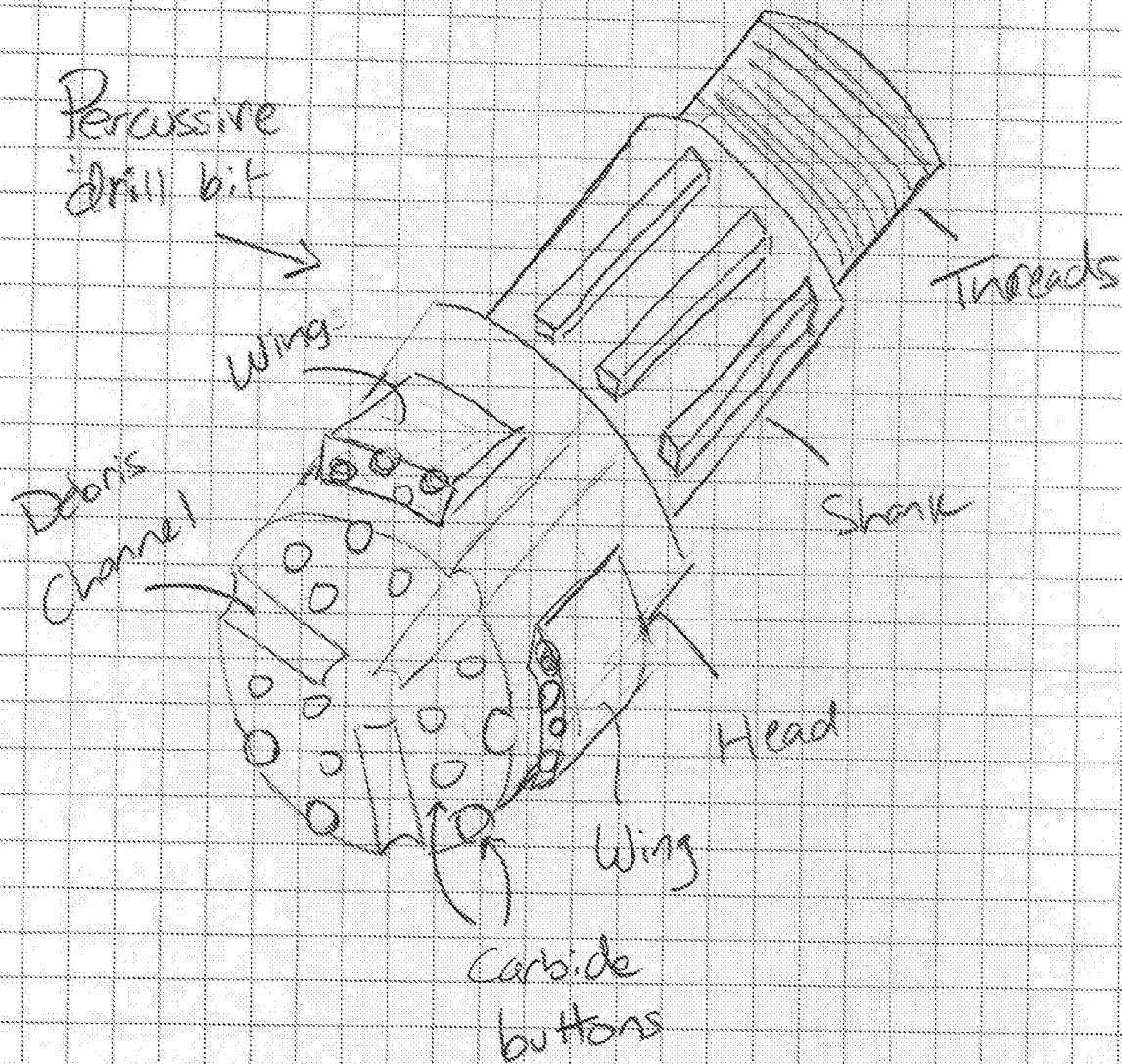
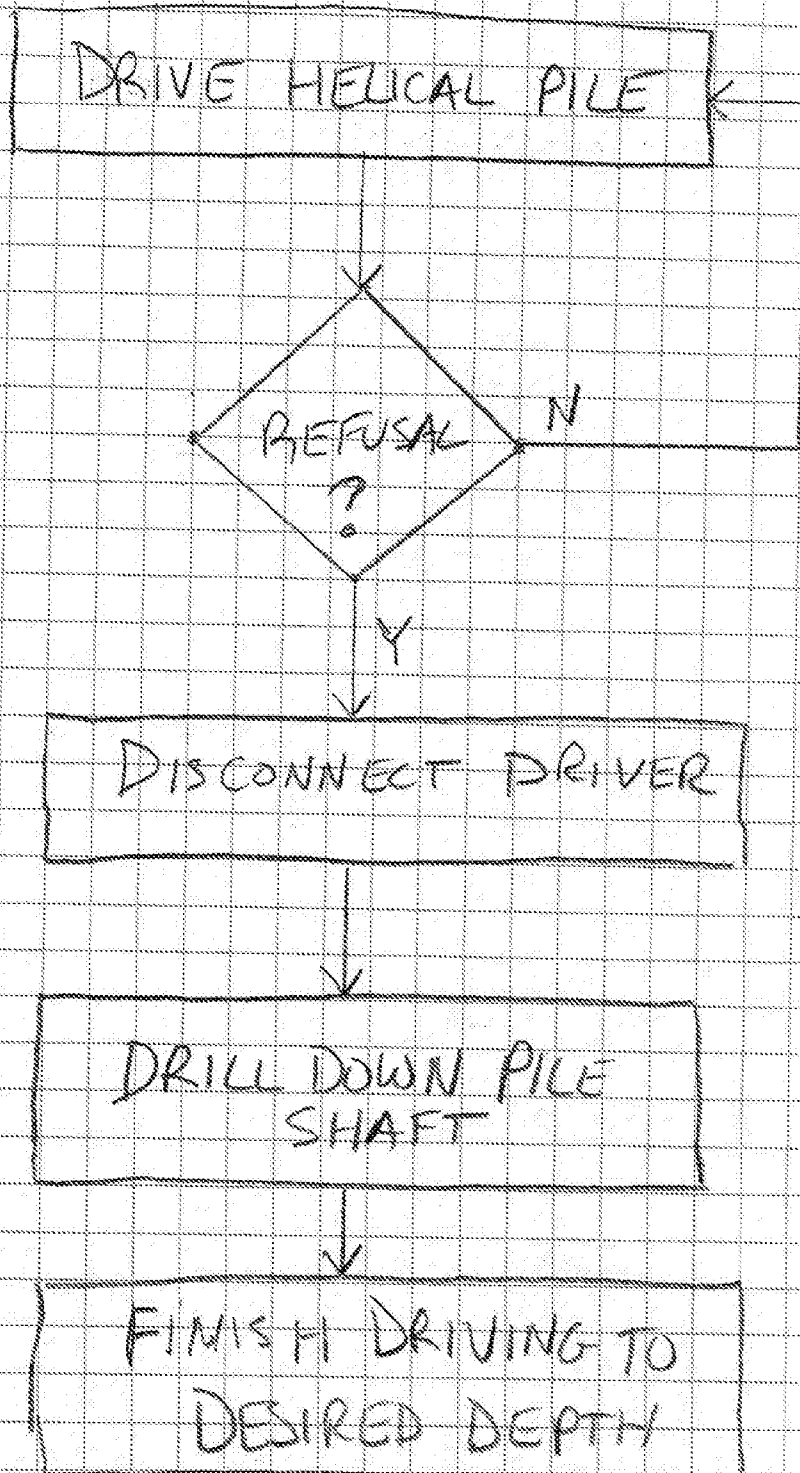


FIG. 9



Electronic Acknowledgement Receipt	
EFS ID:	33467513
Application Number:	62718780
International Application Number:	
Confirmation Number:	2491
Title of Invention:	Foundation piers for axial solar arrays and related systems and methods
First Named Inventor/Applicant Name:	Jack West
Correspondence Address:	Ojjo, Inc. - 47 Mark Drive - San Rafael CA 94903 US 415-786-4685 pmancini@ojjo.com
Filer:	Phillip Mancini
Filer Authorized By:	
Attorney Docket Number:	PPA7
Receipt Date:	14-AUG-2018
Filing Date:	
Time Stamp:	17:48:25
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$ 140

RAM confirmation Number		081518INTEFSW17493100			
Deposit Account					
Authorized User					
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	128920	no	8
			bd1afdc2d0c51591176ef29f8c37bac6570dee34		
Warnings:					
Information:					
2	Specification	PPA7.pdf	113573	no	11
			222406465b3ff2eb8706c91a4fd553b5d2cf4c28		
Warnings:					
Information:					
3	Drawings-only black and white line drawings	PPA70001.pdf	1181342	no	6
			42a6f43203ba960bec96f8397318f36bdc15cf94		
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	29524	no	2
			a77691020fd8e7d4e234c0afb0c31256aee0d8d		
Warnings:					
Information:					
Total Files Size (in bytes):			1453359		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

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

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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, with an A-frame style foundation lateral wind forces tend to pull out the windward frame member and to compress or buckle the leeward frame member. Therefore, increasing resistance to pull out and compression in such arrays can allow installations to go less deep into the ground relative to H and I pile foundations, saving money in steel and other materials as well as time.
- [007] FIG. 1 shows a portion of an axial solar array, in this example, a single axis tracker array with a plurality of A-frame supports, each terminating in a saddle which in turns supports a torque tube and bearing collar. Once panels are installed on the torque tube, the supports need to be able to withstand not only the weight of the materials but

also the lateral forces caused by wind striking the array. Due to the relatively large surface area of solar panels on the torque tube, even a single row of panels can generate relatively large wind forces on the support piers holding up the torque tube.

- [008] FIG. 2 shows components of a foundation pier for an axial solar array according to various embodiments of the invention. The system includes a base pile member that consists of a tubular section of rounded pipe in a pre-cut length. In various embodiments, the pile will have a helix formed near the end that is driven into the ground. The helix may be welded on or otherwise attached to the base pile allowing the pile to be rotated into the ground with a rotary driver attachment to a piece of standard equipment or a specialized single-purpose rotary driving machine.
- [009] In various embodiments, the end of the pile entering the ground will be open, allowing the pipe to be driven like a cookie cutter through the earth with minimal resistance. Typically, with this type of driving, as the pile is rotated in, a plug of dirt will build up inside of it. In dense soils such as regular clay or sandy/silty clay, the open end of the pile will work well, striking a balance between ease of driving and providing sufficient resistance to pull out and compression.
- [010] In certain types of soil, for example, cobble or mixed dirt and gravel, driving an open-ended pile may be more problematic. In these conditions, having a tip on the end of the pile may make driving easier as the tip will break through and/or displace small rocks and gravel allowing the pile to continue to be rotated in. FIG. 2 shows one such tip that could be used in these types of soils. In various embodiments, to accommodate the tip, the open end of the pile nearest the helix may be threaded, allowing it to be easily spun on. In other embodiments, the tip may be attached with a bolt, screw, or other mechanical fastener.
- [011] The tip may take difference shapes depending on the type of soil encountered. Because the tip is consumed in the driving process, that is, it is left in the hole (L.I.T.H) after the pile is driven, relatively simple and/or inexpensive tip designs may be preferred over a rock bit or other known more expensive drill bit tip. Generally speaking, the tip will not be able to easily grind through solid rock as well as a special-purpose rock bit, but it

should be able to cut more effectively through gravel and cobble than the open end of the pile. Although the tip may take on any of a plurality of known shapes, the conical shape shown in FIG. 2 has the advantage that it focuses all the driving force on a relatively small area (i.e., the tip of the cone), and provides a ramped surface to help push minor obstructions (e.g., small rocks, cobble, etc.) out of the way of the pile.

[012] As shown, the free or above-ground end of the pile, that is the end opposite to the helix, may have one or more notches or other shapes formed in it to allow it to receive the rotary driving tool. Also, this same end may be configured to receive another section of base pile, labeled as an extension in FIG. 2. In various embodiments, the extension may be attached to the free end of the pile to be driven, either before driving or after the base pile has been partially driven into the ground. This may be useful in very loose soils where a deeper pile depth is required to achieve the necessary resistance to lateral forces causing axial pull-out and compression.

[013] Referring now to FIG. 3, this figure shows an portion of an axial solar array at an interim installation point. For ease of illustration, the height of the piers is reduced. Typically they will project four or five feet above the ground with as many as 6-12 feet buried below. The piers, in this case H-beams, are set out across the array field at the location where they will be driven. Then, the pile driving rig goes down every row in the array attempting to drive each H-pile to the desired depth. If the desired depth cannot be achieved, that is, the pile hits a rock or submerged structure and will not go down further (i.e., a refusal occurs), the installation point is marked and the rig is moved to the next installation spot. Typically a flag, stick or other marker is put in the ground at the refusal site so that that next installation team can find it. This continues until an attempt has been made to drive every pier in the array. After pile driving is complete, a drill and grout crew comes to the array site and installs the piles at each rejection point using drilling or a combination of drilling and grouting. Having an extra crew to deal with refusals increases installation costs and installation time required to build the array.

- [014] Referring now to FIG. 4, this figure shows an installation of a base pile for an axial solar array according to various embodiments of the invention. As discussed above, in various embodiments a rotary drive is used to spin the base pile into the ground. In this case, a rotary drive unit has been attached to an excavator, however, in various other embodiments, a special-purpose driver or other equipment may be used.
- [015] In the example of FIG. 4, a base pile has been rotated into the ground until a refusal has occurred preventing it from reaching the desired depth. This is detected by an operator when continued rotation fails to drive the pile further into the earth. An audible noise may also indicate a refusal depending on the depth at which it occurs. Once refusal happens, the rotary driver may be uncoupled from the machine and an impact drill used in its place. In various embodiments, the drill may be attached to the same machine used to drive the piles. In other embodiments, a different machine may be used.
- [016] At this point, a rock drill may be inserted into the open end of the base pile and driven through the pile, that is, inside the rounded pipe making up the base pile. In various embodiments, because of earth plugging in the pile, it will be necessary to remove dirt from the pile as the drill bit is driven in. In various embodiments, this is accomplished with an auger-like pattern of threads on the drill shaft that will pull the dirt plug out of the pile as the drill rotates in.
- [017] In various embodiments, the drill will use percussion as well as rotation to break through the rock to create a cavity to continue driving the pile into. In various embodiments, after the drill has rotated in sufficiently deep, the drill is withdrawn and the pile is either driven with impact or again rotated until it becomes embedded in the submerged rock. In various embodiments, and as shown in greater detail in FIG. 9, the drill bit may make an opening that is equivalent to or even slightly larger than the outside diameter of the base pile. In various embodiments, it may not be necessary to drive the pile to the original optimal depth (assuming no rock) if the pile is able to be anchored in the rock or bedrock. In various embodiments, after drilling, the pile may only be driven until the helix reaches the rock. The distance between the helix and the end of the pile may be optimized to insure that at least six inches of the pile may be

embedded in the rock. Any portion of the pile remaining above ground may be cut off with a saw or grinder to be even with the adjacent pile and any other piles on the same row. Also, though not shown, it may be necessary or desirable to shoot pressurized ground down the pile shaft after drilling. This is greatly facilitated by removal of the dirt plug by the drill bit and shaft.

- [018] FIGs. 5 – 7 show the details of the rock drill and related processes. As seen in FIG. 5, the bit and shaft travel down the inner diameter of the pile until the bit emerges from the far end. Threads on the shaft, seen in FIG. 6, pull any dirt plug up and out of the pile. Once the bit emerges from the underground end of the pile, it immediately engages rock. Rotation and percussion cause the bit to break-up the rock. In some embodiments, the drill may be used to create a cavity all the way down to the original desired depth, that is not just the known distance between the pile end and the helix. If the rock is solid bedrock, the drill will simply create a deep cavity within the rock, part of which will remain empty or be filled with grout. Otherwise, if the rock is simply a small to medium-size boulder, the drill bit will break-up the rock possibly causing it to crumble. When driving is resumed, if the rock is solid bedrock or a large boulder, the pile will drive into the rock until the helix reaches the rock at which point another refusal will occur. Otherwise, if the rock was successfully crumbled, the pile will continue to rotate until the desired depth is achieved.
- [019] FIG. 7 shows a variety of different drill tips that may be used with various embodiments of the invention. The first bit is a cross rock bit. It consists of four raised chisel-type blades oriented in a cross pattern. This type of bit is typically made of steel with the blades coated with titanium or made from hardened steel or carbide. The next bit shown in FIG. 7 is percussion type hammer bit. The hammer bit is not sharp and does not use cutting as its primary mechanism. Rather, a series of hardened carbide buttons are embedded in the face of the bit. During rotation, a shank beats against an anvil or strike surface inside the bit head causing the buttons to crush the rock they come into contact with while rotation sweeps the debris out of the way so that the next impact

will again strike hard rock. Compressed air or other pneumatic or hydraulic techniques may be used to generate the hammering action of the drill.

- [020] The third bit shown in FIG. 7 is known as a tri-cone bit. The tri-cone bit consists of three rotating cone-shaped wheels attached to a stationary head via a bearing connection. Each cone is covered in carbide cutting teeth. As the drill shaft is rotated, the cutting teeth on each cone break through the rock. Downward pressure on the drill bit facilitates the cutting. Such bits are commonly used in water, gas and oil exploration and extraction.
- [021] As discussed herein, in certain situations where drilling is required, it may be desirable to drill a cavity that has a slightly larger outside diameter than the base pile. To that end, referring now to FIG. 8, this figure shows a drill bit that is capable of drilling a larger diameter hole than the pipe it is inserted in. The bit shown in FIG. 8 is a hammer bit with a number of individual carbide buttons embedded in the cutting surface. During drilling, the drill shank bangs into the drill head transferring the impact into the rock via the embedded buttons. Rotation sweeps the debris out of the way so that subsequent impacts strike rock and not the debris.
- [022] As drawn, this bit may be particularly well suited to the various embodiments of the invention because it includes one or more deployable features (i.e., wings in) that expand the cutting diameter of the bit once the bit is free of the pile. When the bit and shaft are inserted into the pile, the one or more wings are recessed flush with the outside diameter of the bit. This can be done mechanically or by an operator compressing them from behind as the bit is inserted into the pile. When the bit emerges from the other end the wings extend, either under spring action via another deployment mechanism, thereby increasing the cutting diameter of the bit. In various embodiments, additional carbide buttons may be formed on the cutting surface of the wings (e.g., the surface that is normal to the direction of drilling). In various embodiments, if the wings are spring loaded, the resistance from the rock will tend to keep them out, that is in the cutting orientation. Once the desired depth has been achieved and the bit and shaft are drawn back into the pile, pressure against the back fo

the one or more wings from the mouth of the pile will push them back in to the recessed position, reducing the outside diameter of the bit, allowing it to be drawn up and out of the pile.

[023] FIG. 9 is a flow chart detailing the steps of a method for installing a foundation pier for an axial solar array according to various embodiments of the invention. The method begins with driving the base pile into the ground using a rotary driver. As shown, the base pile includes a helix near the bottom end. As discussed above, rotary drivers are known in the art as either purpose-built machines or attachments for conventional equipment (e.g., excavator, backhoe, tractor, etc.). According to the method, If the pile is able to be driven to the desired depth, then this step is repeated with the next pile, either adjacent to the first or at the next driving point in the array.

[024] Otherwise, if a refusal occurs, driving is stopped. In various embodiments, the rotary driver will be uncoupled from the base pile so that a drill bit and shaft can be driven through the pile to reach the sub-surface obstruction. In other embodiments, drilling may be performed while the pile is still coupled to the rotary driver. The particular drill bit chosen may be selected based on historical drilling information for the specific site or region where the array is being installed.

[025] As the drill is activated within the pile, any dirt plugged up on the pile will be ejected by coil formed on the drill shaft. Once the drill bit exits the bottom of the pipe, it will engage the submerged rock, busting through the rock until the drill reaches the maximum depth. In various embodiments, the drill is then withdrawn and driving resumes. In various embodiments, the rotary driver will be hooked back up to the top of the pile so that it can be driven down at least to the point where the helix strikes the rock. As discussed above, in various embodiments, pressurized grout may be pumped into the cavity either when drilling is complete or after driving resumes. By addressing refusals in line, that is during the ordinary driving process, costs and installation time should be reduced relative to bringing in a separate drill and grout crew after the all the remaining piles are driven to handle the pile refusals.

CLAIM SET 1:

1. A foundation system for an axial solar array comprising:
 - first and second hollow base piles;
 - at least one helix formed proximate to a first end of each of the first and second base piles; and
 - a saddle interconnecting a second end of each of the first and second base piles to form an A-frame support structure.
2. The system according to claim 1, further comprising first and second hollow extension piles configured to attach to the second end of each first and second base piles to increase a length thereof, prior to attaching the saddle.
3. The system of claim 1, further comprising a rotary driver for driving each of the first and second base piles into the ground.
4. The system according to claim 1, further comprising a detachable drill bit portion coupled to the first end of each of the first and second base piles.
5. The system according to claim 1, further comprising an rotary impact driver.
6. The system of claim 5, further comprising a rock drill bit connected to a drill shaft, the drill bit and shaft dimensioned to fit inside an open end of either the first or second base piles and to extend to through an opposing end thereof, to drill through any obstruction preventing driving of the first or second base piles when driven by the rotary driver.
7. The system of claim 6, wherein the drill bit comprises at least one deployable portion that enables the bit to have a first diameter at a first position and a second relatively larger diameter at a second position.
8. The system of claim 7, wherein the deployable portion is spring loaded so as to fit inside either of the first or second base piles when in the first position and to expand to the second position when exiting either of the first or second base piles.
9. A method of installing a foundation for an axial solar array comprising:
 - driving a first base pile into the ground with a mechanical driver until the pier encounters a rigid surface;

disconnecting the mechanical driver and inserting a drill bit and shaft into an open end of the first base pile;

driving the drill bit through base pile and into the rigid surface to create a recess;

removing the drill bit and shaft from the pier;

reattaching the mechanical driver; and

resume driving the base pile until a desired depth is achieved.

10. The method of claim 9, further comprising shooting grout into the recess via the pile.

11. The method of claim 9, wherein the first base pile comprises a hollow round metal tube.

12. The method of claim 9, wherein the first base pile comprises a helix portion formed proximate to an end of the first base pile driven into the ground.

13. The method of claim 9, wherein inserting a drill bit and shaft into the first base pile comprises placing the drill bit into a first position having an outside diameter smaller than an inside diameter of the pile to fit it into the pile and pushing the drill bit through the pile until it comes out the other end whereupon the drill bit deploys to second position having a diameter larger than an outside diameter of the base pile.

14. The method of claim 9, further comprising pulling the drill bit back into the base pile causing it to return to the first position.

15. A system comprising:

first and second base pile members;

a helix formed on a first end of each of the first and second base pile members;

first and second drill bit tips detachably coupled to the first and second base pile members at the first end; and

a saddle interconnecting second ends of first and second base pile members remaining above ground after driving.

16. The system according to claim 15, further comprising a rotary drive machine for simultaneously driving each of the first and second base pile members adjacent to one another to form an A-frame structure with the saddle.

17. The system according to claim 15, further comprising first and second extension members configured to selectively couple to a second end of respective first and second base pile members.
18. A machine for installing a foundation for an axial solar array comprising:
 - a main body portion;
 - a pair of parallel rotary drivers attached to the main body portion for simultaneously driving a pair of adjacent base pile members; and
 - a percussion drill unit attached to the main body portion, for driving a drill bit and drill shaft through a partially driven base pile if a refusal occurs during driving.
19. The machine according to claim 18, further comprising:
 - a propulsion system for moving the main body portion; and
 - a steering system for orienting the main body portion.
20. The machine according to claim 18, further comprising a container holding a plurality of base piles.
21. The machine according to claim 20, further comprising a feeder mechanism connected to the container for feeding base piles to the pair of parallel rotary drivers.