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1021172

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APPLICATION NUMBER: *62/796,020*

FILING DATE: *January 23, 2019*

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 *US62/796,020*



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Anders Ivarsson

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	PPA24
		Application Number	
Title of Invention	Pile caps, adapters and bearing housing assemblies for A-frame foundations		
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:

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Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service				
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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	PPA24
		Application Number	
Title of Invention	Pile caps, adapters and bearing housing assemblies for A-frame foundations		

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	Pile caps, adapters and bearing housing assemblies for A-frame foundations		
Attorney Docket Number	PPA24	Small Entity Status Claimed	☒
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	8	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	PPA24	
		Application Number		
Title of Invention	Pile caps, adapters and bearing housing assemblies for A-frame foundations			

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)

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

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	PPA24
		Application Number	
Title of Invention	Pile caps, adapters and bearing housing assemblies for A-frame foundations		

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	PPA24
		Application Number	
Title of Invention	Pile caps, adapters and bearing housing assemblies for A-frame foundations		

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	PPA24
		Application Number	
Title of Invention	Pile caps, adapters and bearing housing assemblies for A-frame foundations		

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

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Address 2

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94903

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415-786-4685

Fax Number

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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	PPA24
		Application Number	
Title of Invention	Pile caps, adapters and bearing housing assemblies for A-frame foundations		

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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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	PPA24
		Application Number	
Title of Invention	Pile caps, adapters and bearing housing assemblies for A-frame foundations		

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	/Phillip D. 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. 1A

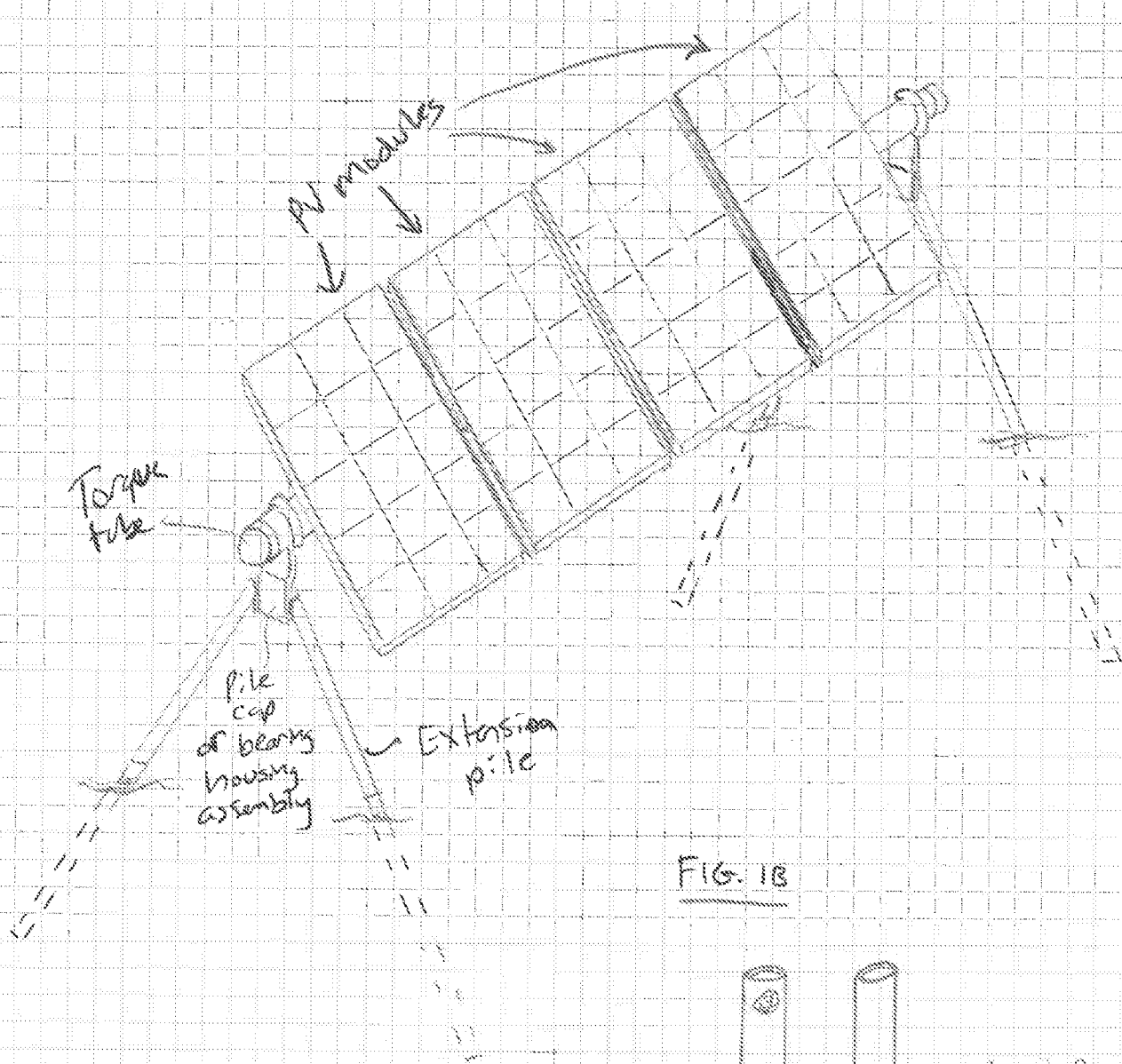


FIG. 1B

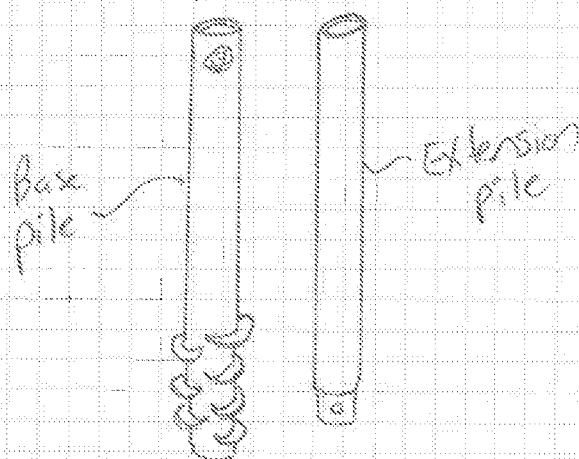


FIG. 2A

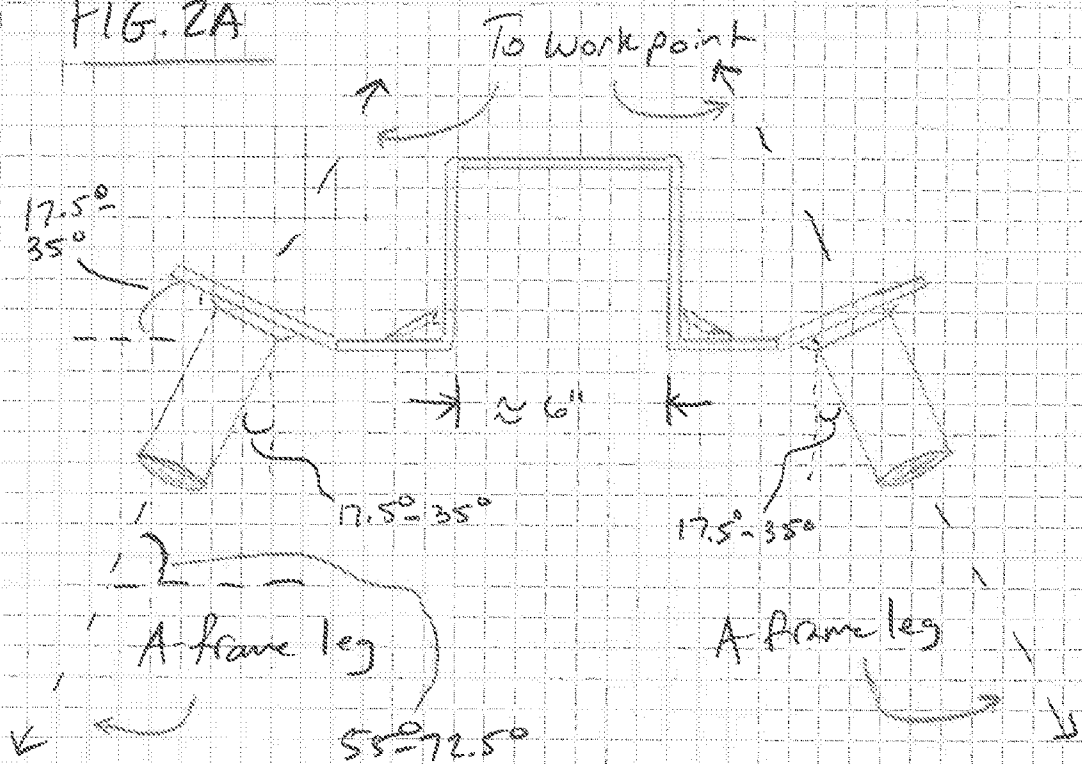


FIG. 2B

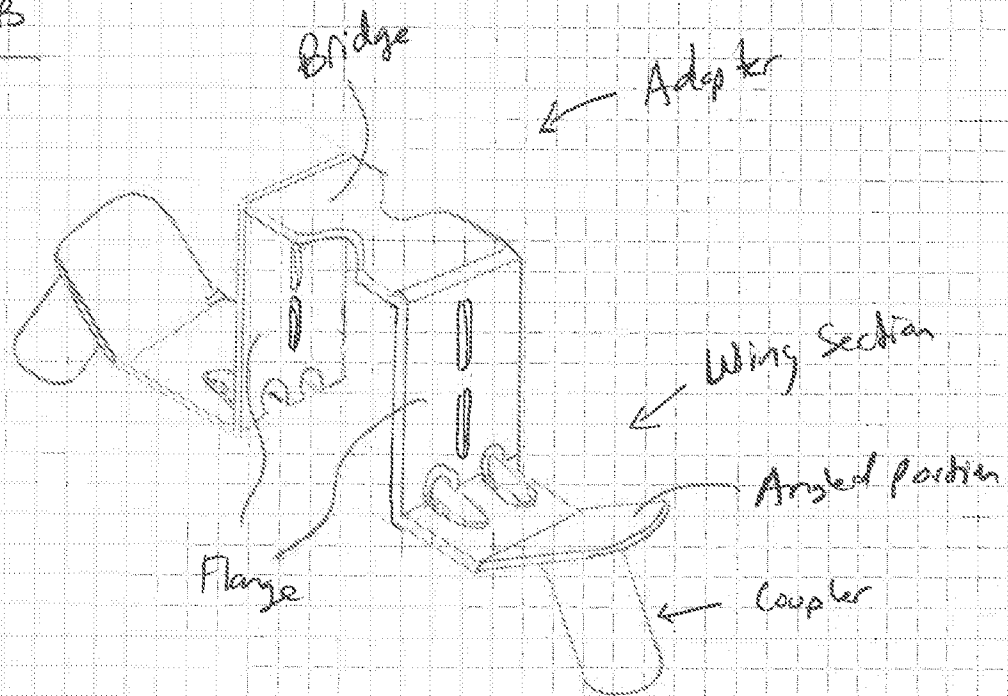


FIG. 2C

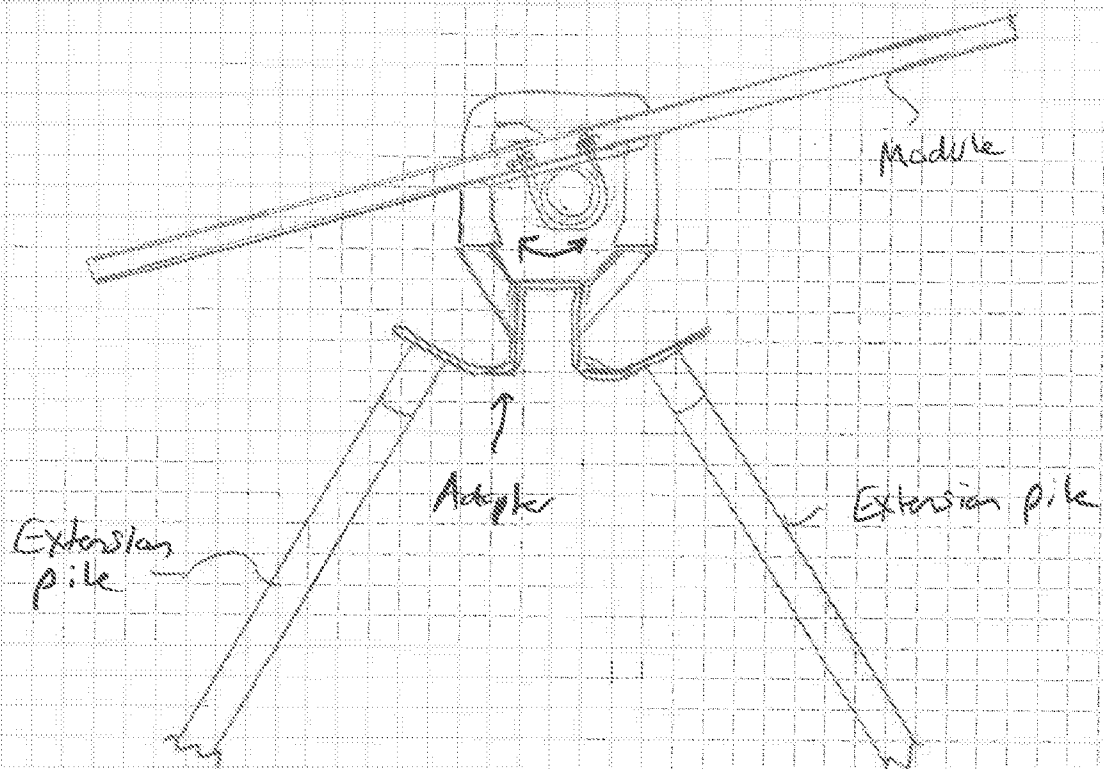


FIG. 2D

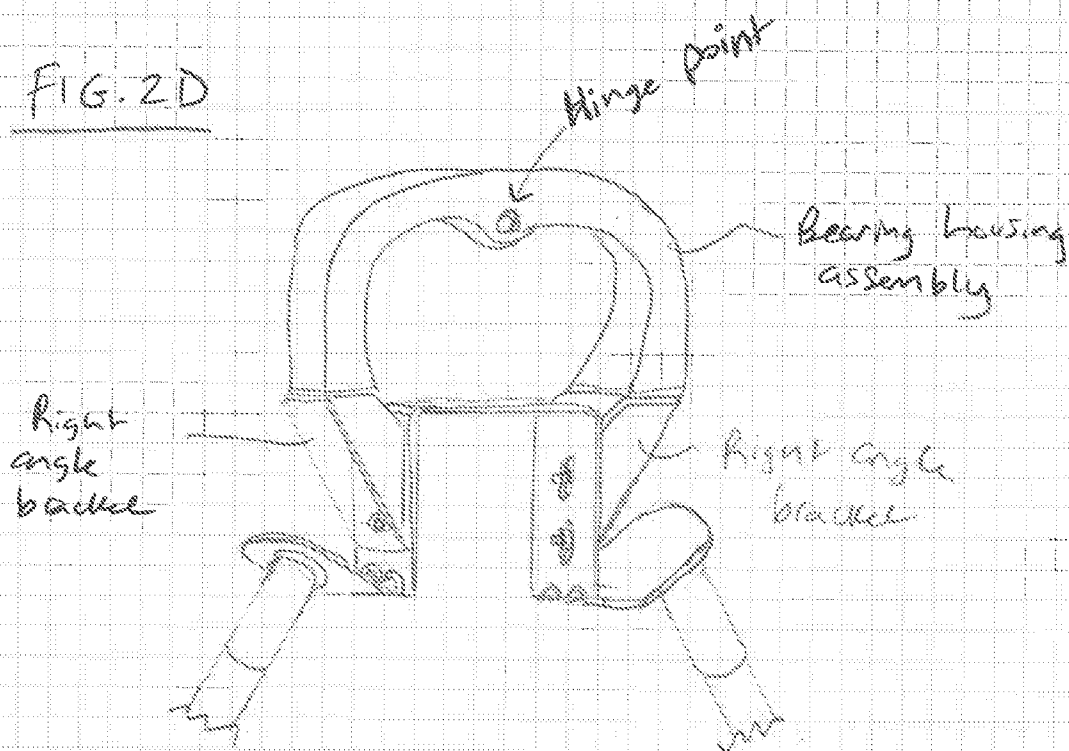


FIG. 3A

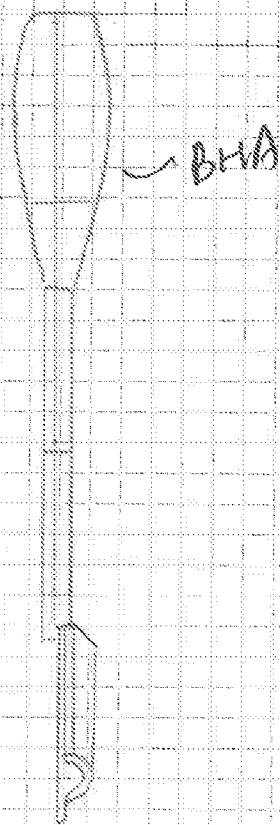


FIG. 3B

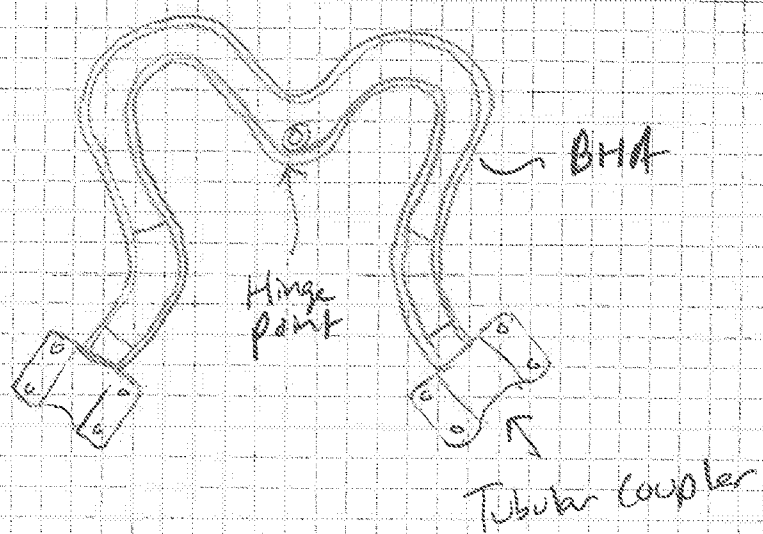


FIG. 3C

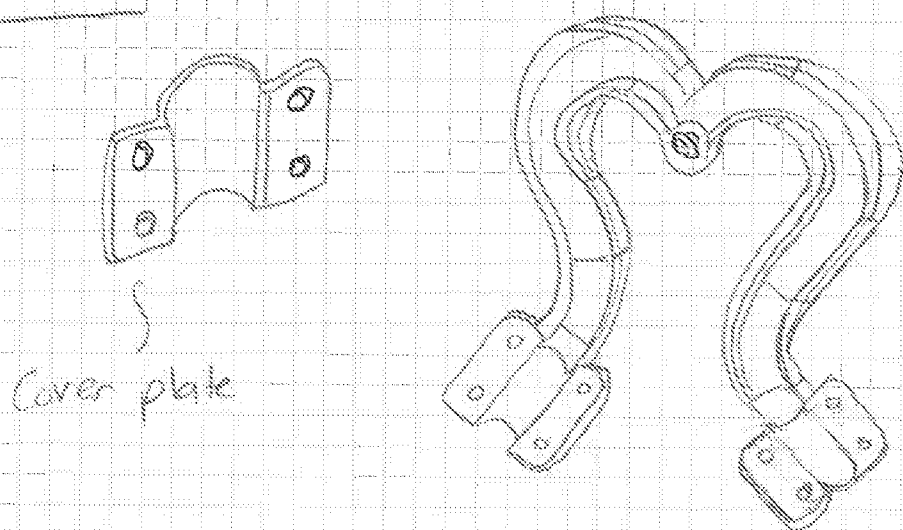


FIG. 3D

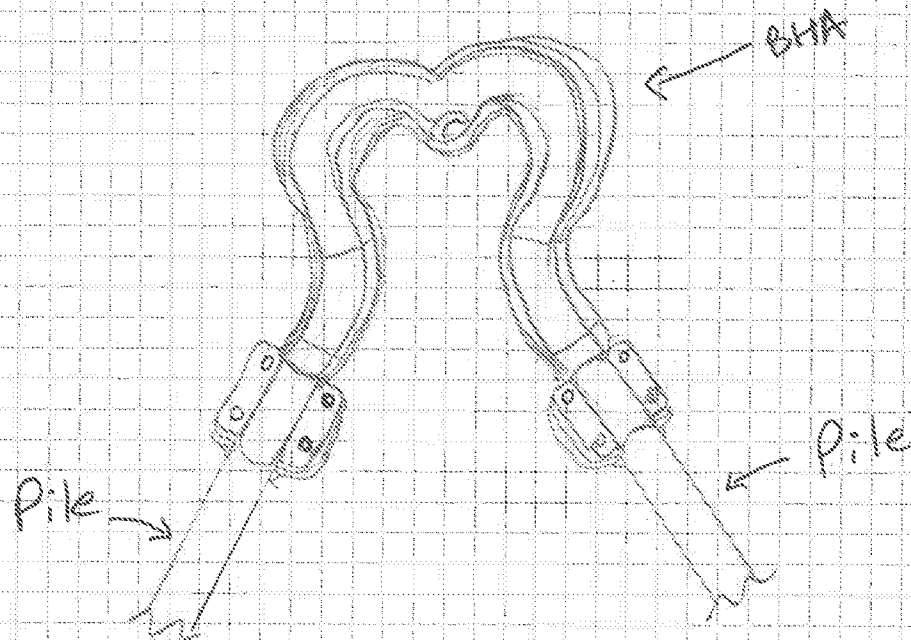


FIG. 3E

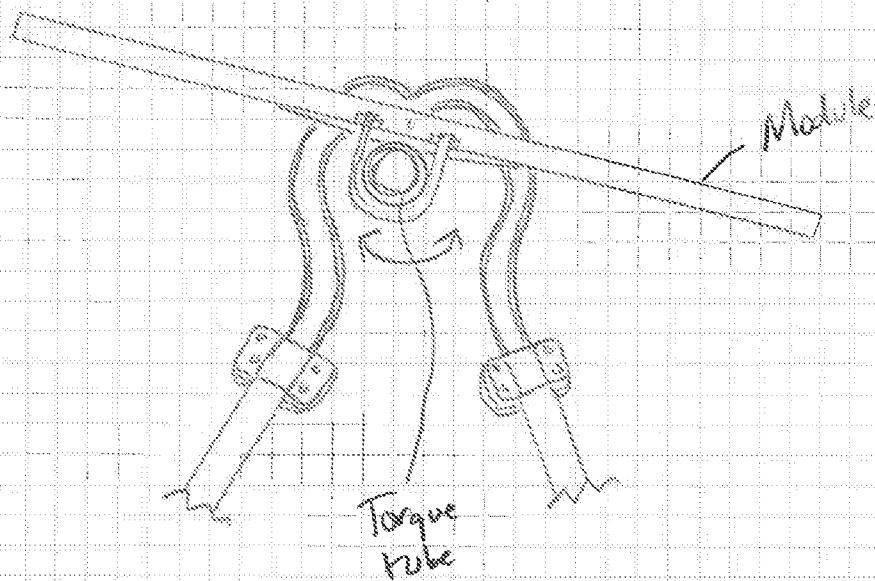


FIG. 4A

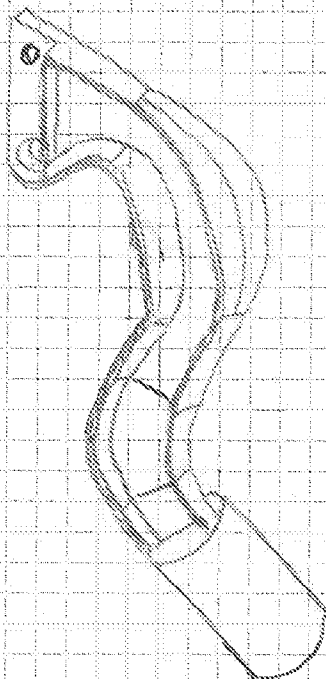


FIG. 4B

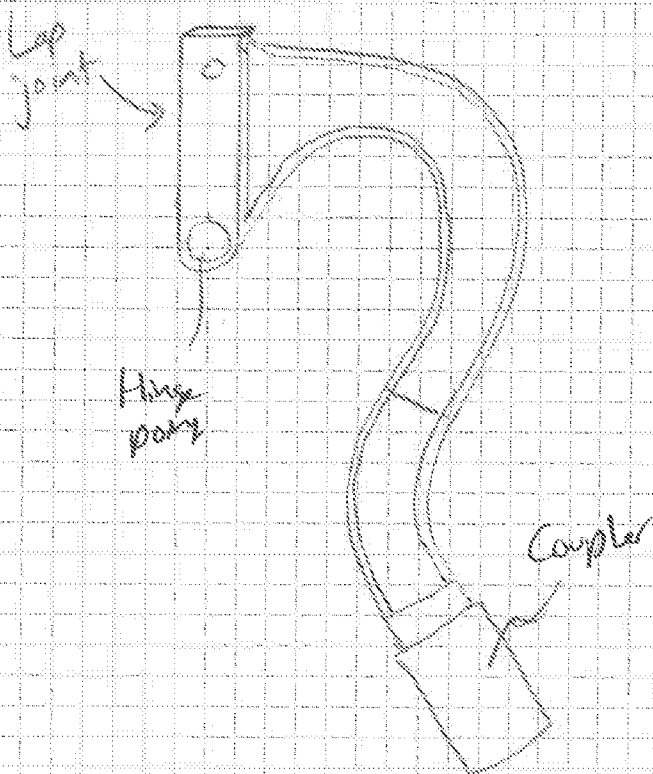


FIG. 4C

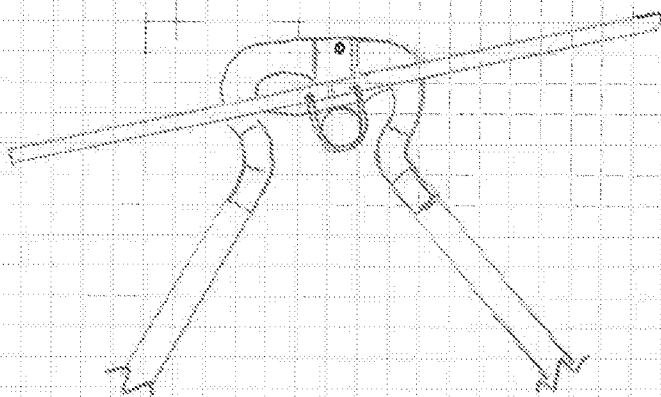


FIG. 4D

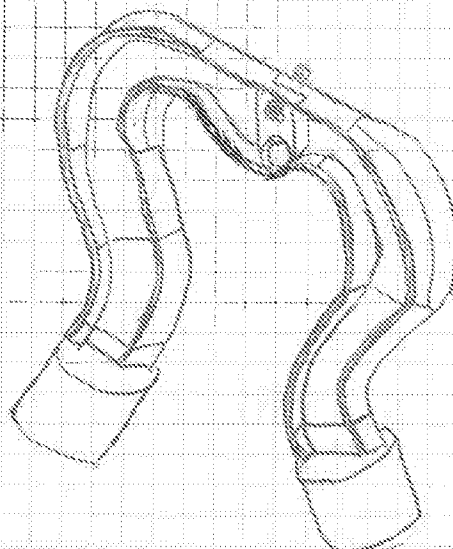


FIG. 5A

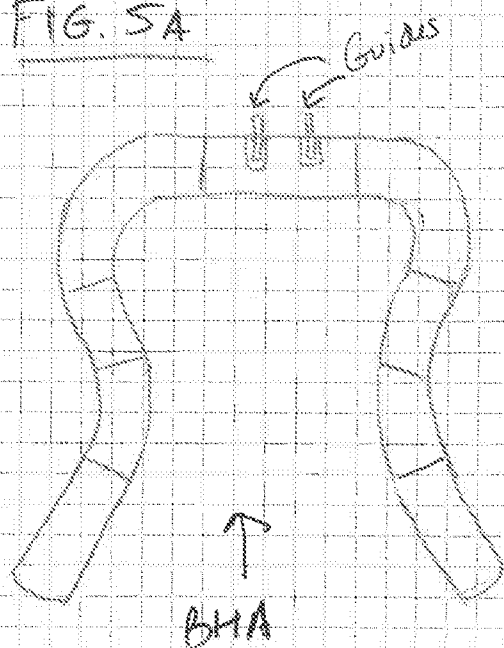


FIG. 5B

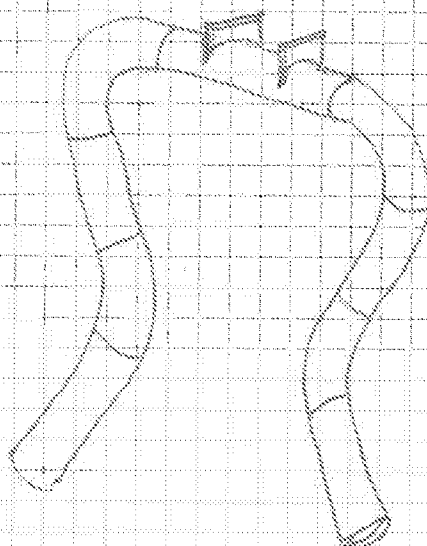


FIG. 5C

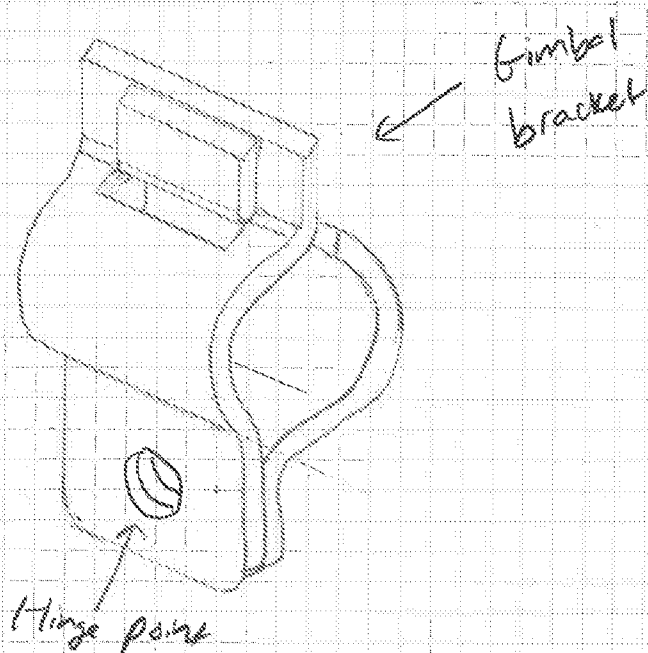


FIG. 5D

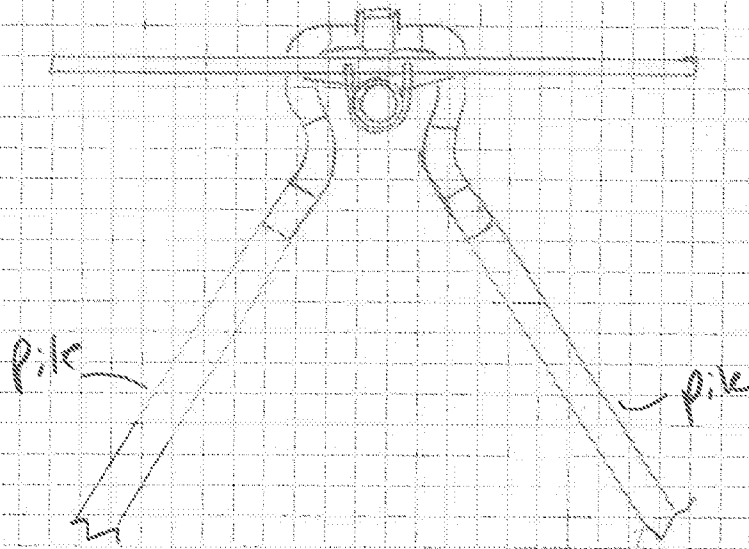
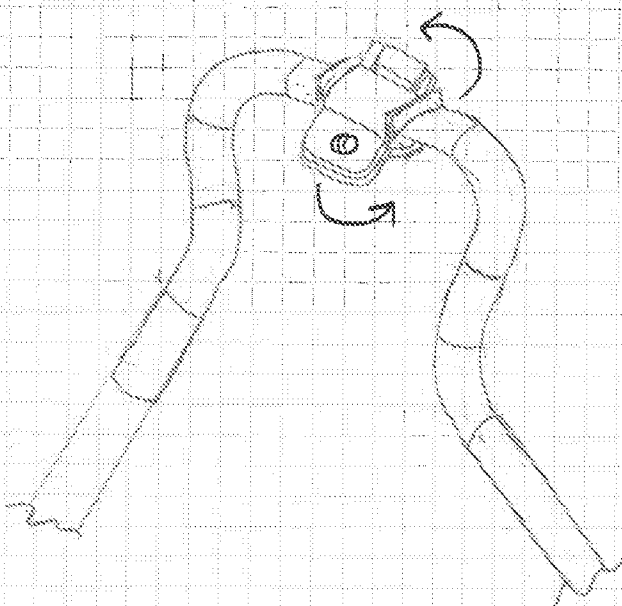


FIG. 5E



Electronic Acknowledgement Receipt

EFS ID:	34942334
Application Number:	62796020
International Application Number:	
Confirmation Number:	9645
Title of Invention:	Pile caps, adapters and bearing housing assemblies for A-frame foundations
First Named Inventor/Applicant Name:	Kathryn Pesce
Customer Number:	157339
Filer:	Phillip Dominick Mancini
Filer Authorized By:	
Attorney Docket Number:	PPA24
Receipt Date:	23-JAN-2019
Filing Date:	
Time Stamp:	20:18:33
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$ 140
RAM confirmation Number	012419INTEFSW20205200
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	127211	no	8
			12f124bdc6484a3f12cce30c78bdce9d50ebbce7e		
Warnings:					
Information:					
2	Specification	PPA24.pdf	128993	no	14
			b3619916926ad46387b9ffce16aedc854137ec0e		
Warnings:					
Information:					
3	Drawings-only black and white line drawings	PPA24_DWGS.pdf	1219412	no	8
			c619c505095b59bd966d81988738e21c197bceddd		
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	29683	no	2
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Total Files Size (in bytes):			1505299		

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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

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.

PILE CAPS, ADAPTERS AND BEARING HOUSING ASSEMBLIES FOR A-FRAME FOUNDATIONS**BACKGROUND**

[0001] Single-axis solar trackers are becoming ubiquitous as the cost of solar panels and power storage equipment continues to drop. However, one part of the utility-scale solar cost stack-up that has been largely ignored is foundations. Single-axis trackers are made from rows of solar panels attached to a rotating torque tube that is oriented along a North-South row. A motor rotates the tube throughout the day so that the panels can follow the position of the sun in the sky from East to West. The torque tube in these systems is supported by rows of monopiles driven into the ground with a pile driver at regular intervals along each torque tube. The bearing housing assembly and/or other intervening hardware is attached to the head of each pile to support the torque tube.

[0002] Single-axis tracker makers use one of two configurations for attaching the torque tube to the monopile foundation. The most common configuration attaches the torque tube support element (e.g., bearing housing, bearing housing support, etc.) to the top, flange or sides of H-pile. The piles have holes or slots formed in the face of each flange so that the torque tube support elements can be quickly attached and adjusted in the vertical direction to align the torque tube with the other piles in the row. One commercially available system using this bottom-up configuration is the DuraTrack HZ single-axis tracker from Array Technologies, Inc. of Albuquerque, NM. In the DuraTrack system, the torque tube rotates directly about its axis within a bearing that sits on the H-pile.

[0003] Although less common than bottom-up, at least one tracker maker uses a top-down configuration where the torque tube hangs from hinge pin that allows the entire tube to swing like a pendulum rather than rotating about its own axis. This system, known commercially as the NX Horizon single-axis tracker from NEXTracker of Fremont, CA, purports to be mechanically balanced, meaning that the amount of torque required to move the torque tube is the same at all panel angles. Bottom-up systems require more torque to resist gravity as the angle of the modules with respect to the ground becomes steeper, but in the balanced system the required torque remains constant. However,

because the torque tube hangs, it swings through an arc rather and therefore needs some clearance in the East-West direction from the structure holding. NEXTracker attaches a pair of right-angle brackets to the outside face of each flanges of the H-pile to provide a horizontal mounting platform with greater width than provided by the H-pile alone. A U-shaped bearing housing assembly is mounted upside on this horizontal platform and the torque tube is hung from a hinge point at the center of the U.

[0004] Contrary to the H-piles currently used to support single-axis trackers, the inventors of this invention have proposed a foundation system that uses an A-frame made of a pair of adjacent piles driven into the ground at reciprocal angles with respect to plumb to support the torque tube. The A-frame allows less steel to be used than with a monopile because the legs of the A-frame only need to resist tension and compression rather than bending. For an A-frame foundation to work with tracker systems designed to sit atop monopiles without compromising the benefits of the A-frame, various novel and non-obvious, pile caps, adapters and bearing housing assemblies will be necessary. Those pile caps, adapter and bearing housing assemblies are the subject of this disclosure.

DESCRIPTION

[0005] The following description is intended to convey a thorough understanding of the embodiments described by providing a number of specific embodiments and details involving pile caps, adapters and bearing housing assemblies for integrating A-frame foundations with conventional single-axis trackers. It should be appreciated, however, that the present invention is not limited to these specific embodiments and details, which are exemplary only. It is further understood that one possessing ordinary skill in the art in light of known systems and methods, would appreciate the use of the invention for its intended purposes and benefits in any number of alternative embodiments, depending upon specific design and other needs.

[0006] Turning to FIG. 1A, this figure shows a portion of a generic single axis tracker system supported by an A-frame foundation system according to various exemplary embodiments of the invention. The portion shown here includes a pair of A-frame foundation supports positioned at either end of a torque tube section with four

photovoltaic modules (PV or solar panels) in between. In such a system, the torque tube is aligned along a North-South axis so that as the tube rotates, the panels stay normal (orthogonal) to the sun's position in the sky.

[0007] In this exemplary system, each leg of the A-frame consists of a base foundation pile and an extension pile. FIG. 1B, shows these components in greater detail. In various embodiments, the base pile includes a partial or full-thread form at one end (bottom end) to facilitate rotary driving and to provide greater resistance to axial forces of pull-out and compression. In various embodiments, after the base pile is rotated into the ground, an extension pile may be joined to it to complete the legs of the A-frame. Then, an adapter, pile cap or other structure is attached to the free end of each adjacent extension pile to add rigidity to the structure and provide a platform for attaching other components. In various embodiments, the adapter or pile cap is dimensioned to orient the torque tube at a work point of the A-frame so that wind on the panels will be converted into pure tension and compression rather than a bending moment. The work-point is at the apex of the A-frame and is the ideal loading point. Rather than make the legs of the A-frame strong enough to resist bending moments – the approach taken with monopiles – the A-frame isolates forces to axial forces which columns are much better at resisting. As a result, the structure can be supported with less material.

[0008] Turning now to FIGS. 2A and 2B, these figures show an adapter for an A-frame foundation system according to various embodiments of the invention. The adapter shown here consists of a piece of stamped metal configured with left and right wings that are symmetrically positioned around a pair of vertical flanges interconnected by a bridge. Each wing consists of an angled portion and a flat portion. The flat portions are generally horizontal in orientation, matching the orientation of the bridge. The angled portions serve as a base for tubular couplers that receive or are inserted into the free ends of two adjacent extension piles to complete the A-frame. In various embodiments, these angled portions will be welded onto the bottom face of the angled portions to project out of their respective surfaces in a downward (ground-facing) direction at an angle that matches the angle of the extension piles and at a spacing that aligns with them.

[0009] In various embodiments, the angled portions are oriented at an angle in a range of 17.5 degrees to 35 degrees and preferably at about 30 degrees with respect to horizontal. This will correspond to a pile angle of 72.5 to 55 degree and preferably about 60 degrees. In various embodiments, the angle of the angled portions will be selected so that the tubular couplers match the desired angle of adjacent A-frame legs (base piles + extension piles) and will be inserted over or into the free ends of two adjacent extension piles without significantly changing their angle. In various embodiments, this will enable the A-frame to present an H-pile interface to the tracker installer so that the installation process for the tracker installer will be identical to that done for H-pile foundations.

[0010] As shown in this example, the connection point between the flat portions and the flanges is reinforced. This is exemplary only. Gussets or other reinforcing members may be added to various points on the adapter to increase rigidity. The flanges are shown with a pair of vertical attachment slots. This is exemplary only. In various embodiments, the flanges may have one or more holes or slots arranged in a different configuration. Slots may be preferred because they allow for greater adjustability than holes. In various embodiments, the flanges are parallel to one another and the bridge portion interconnecting them is orthogonal to each, separating them by the same distance as the distance between a standard W6x9 (wide flange) H-pile – approximately six inches. This will enable a bearing housing assembly or bearing housing support structure, such as the bottom up one used with the Array Technologies DuraTrack single-axis tracker to be bolted directly to the adapter, replicating the H-pile interface.

[0011] As discussed herein, one benefit of an A-frame is that the forces are axial rather than moment. To keep them confined to axial forces, it is important that the point where forces applied by the torque tube translate into the A-frame is collocated with the work point of the A-frame. To that end, in various embodiments, the adapter is dimensioned so that that the axis of rotation for any bottom-up bearing housing assembly is or can be adjusted to be co-located with the A-frame's work point.

[0012] FIGS. 2C and 2D show the same adapter as 2A and B but in these, figures it is used with NextTracker's single-axis tracker. As discussed above, the Horizon is a top-down

system whereby a clamp holding the torque tube hangs from a hinge pin inserted through a pivot point formed at the center of a bearing housing assembly. Instead of rotating about its axis, in this configuration the torque tube swings through an arc as the tube and the clamp holding it rotate about the hinge pin. To make this work, the torque tube curves up at the motor, levels out and then curves back down so that the point along the torque tube connected to the output gear of the torque motor simply rotates, whereas the remainder of the tube on either side of the offset sweeps through an arc. As a result, the bearing housing assembly needs to have clearance relative to a bottom-up system where the tube rotates in place. In various embodiments, the adapter is optimized so that when the NEXTracker bearing housing assembly is seated, the hinge point of the assembly is at the work point of the A-frame.

[0013] As discussed above, because of the required clearance, the NEXTracker system requires a foundation that is wider than the standard 6-inch width of a W6x9 pile. Consequently, when using H-piles, NEXTracker attaches a right-angle bracket to the outside face of each flange widen the pile. The adapter according to various embodiments of the invention provides the same geometry as the top of an H-pile, allowing NEXTracker's right-angle brackets to be attached directly to the slots formed in each flange. The result is that the same NEXTracker parts may be used regardless of whether H-piles or A-frame foundations are used. The attachment slots on the side of the adapter may be used as a mechanism to adjust the height of the hinge point in the NEXTracker bearing housing assembly so that it is aligned with the work point.

[0014] As shown in FIGS. 2A-D, the same A-frame adapter may be used to support either a bottom-up single-axis tracker such as that manufactured and sold by Array Technologies or a top-down single-axis tracker such as that from NEXTracker without requiring any modifications to those systems.

[0015] Turning now to FIGS. 3A-3E, these figures show a cardioid-shaped bearing housing assembly (BHA) specifically adapted for a top-down single-axis tracker such as the NEXTracker Horizon system according to various embodiments of the invention. The BHA according to these embodiments serves at least three functions. First, it unifies the

adjacent legs of the A-frame (base and extension foundation piles) to form a rigid structure. Second, it replaces the bearing housing assembly and right-angle brackets of the Horizon system, providing a hinge point to hang the torque tube and clearance for it to swing through its East-West arc. Finally, it orients the hinge point from which the torque tube hangs with the work point of the A-frame. This is accomplished by controlling the geometry between the legs of the A-frame so that the hinge point aligns with the intersection of the respective axes defined by the legs.

[0016] The BHA shown in these figures is a single cast metal piece, however, other manufacturing techniques may be employed without departing from the spirit or scope of the invention. The cast piece shown here consists of a cardioid-shaped hoop with a cusp and two symmetric S-shaped arms that intersect at the cusp and terminate in respective tubular couplers. The S-shaped members project away from the cusp, then curve back inwards before curving back out to match the desired drive angle of the piles (e.g., 60 degrees). In various embodiments, the desired angle will be known in advance and the BHA will be manufactured to maintain that angle.

[0017] The tubular couplers shown in the example of these figures is shown as a partial tube. In various embodiments, separate cover plates that are also tubular fit over the legs of the A-frame and mate to the tubular couplers on the BHA to capture the legs. Bolts, rivets, or other known mechanical fasteners may be used to secure the cover plates to the BHA's tubular connectors. It should be appreciated that other embodiments may have a complete tube at the end of each S-shaped arm dimensioned to receive or fit inside the free ends of each adjacent A-frame leg. Such modifications are within the scope of the invention.

[0018] FIGS. 3D and 3E show the BHA of FIGS. 3A-C attached to a pair of adjacent foundation piles and supporting a top-down tracker array according to various embodiments of the invention. Together the BHA, and pair of base and extension piles create an A-frame that defines a single plane that at least on flat ground, is substantially orthogonal to the main axis of the torque tube. Orthogonality will keep the A-frame in

tension and compression and minimize bending regardless of the angle of the PV modules attached to the torque tube.

[0019] Turning to FIGS. 4A-D, these figures show a two-piece BHA according to various other embodiments of the invention. The two-piece BHA according to these embodiments is like that of FIGS. 3A-E in that it provides a bearing for the torque tube and also completes the A-frame. This two-piece BHA is made of two substantially identical S-shaped members with a lap joint at one end and a tubular coupler at the other. To form the BHA, the lap joints are overlapped and bolted together to form a partial cardioid. The lap joints have one or more holes for receiving mechanical fasteners to joint them together as well as a hinge point to receive a hinge pin holding the torque tube. When the overlapping portions are joined, the hinge point is approximately aligned at the middle of the partial cardioid. In various embodiments, the two S-shaped members may be joined together with a bolt and nut, rivet or other known mechanical fastener to convert them into a rigid unitary structure. In various embodiments, the hinge point is an opening that passes through each member to form a single axis for a hinge pin supporting the torque tube and/or torque tube bracket. The members are shown in the figures as being made of cast metal, but they could also be manufactured using a different technique. Two smaller members may be advantageous to the single member BHA of FIGS. 3A-E in that they may be less expensive to manufacture and cheaper to ship, but otherwise should be functionally equivalent.

[0020] Though not shown in the figures, each tubular coupler may have one or more holes to for receiving a rivet, bolt or set screw for securely attaching the free end of each pile to the BHA. Also, instead of a tubular coupler, each member could terminate in a partial tubular connector as shown and discussed in the context of the embodiment of FIGS. in 3A-E where a separate cover plate is used to secure the BHA to each pile.

[0021] In some case, developers may desire to install a single-axis tracker on sites that slope in the North-South direction. This may be advantageous because, depending on which end is high (Southern or Northern), the slope can give the panels a slight equatorial tilt that will increase the amount of energy that can be harvested. When building a single-axis tracker on such a site, the should still be installed plumb to avoid being put in bending.

Installing plumb piles along a sloping N-S line can be problematic. If the torque tube is kept level, the piles must increase in length as the ground slopes downward. If the torque tube slopes down with the slope of the land but the piles remain plumb, the BHA must compensate for the slope to accommodate the sloped torque tube. BHA's may have some adjustability to compensate for pitch to adjust for piles that are not perfectly plumb, however, these are not typically designed to accommodate a 10-15-degree slope. Consequently, various embodiments provide a BHA that is gimbaled in the North-South direction to accommodate North-South slope.

[0022] To that end, FIGS. 5A-5E show a gimbaled BHA for an A-frame foundation system according to various other embodiments of the invention. The BHA according to these embodiments consists of a continuous tubular member having two S-shaped portions interconnected by a substantially straight section. Together, these elements form a hoop. The straight section shown in the figures has a pair of guides projecting out of its surface. These guides are positioned on either side of the vertical midline of the hoop. In various embodiments, a two-piece gimbal bracket collars the straight section between the guides. The two-piece gimbal bracket shown here includes a hinge point that receives a hinge pin supporting a torque tube and/or torque tube bracket. The ends of each S-shaped portion are open to receive or fit over free ends of two adjacent piles. As in other embodiments, the BHA according to these embodiments secures the free legs of each foundation pile of the pair to form a rigid A-frame, provides clearance for the top-down torque tube to swing through its rotation arc, and provides a hinge point for the torque tube. The gimbal bracket allows the torque tube to hang along a N-S sloping row without inducing additional stress into the BHA because it is free to rotate in and out of the plane of the BHA. This allows the gimbal bracket to remain orthogonal to the torque tube, even as the torque slopes. In various embodiments, the gimbaled bracket is a stamped piece that comes pre-assembled onto the BHA. In other embodiments, the gimbaled bracket may be assembled by an installer onsite. The hinge may help to hold the two halves of the gimbaled bracket together. Also, though not shown, the open ends of each S-shaped portion may include one or more holes, projections, or other features to enable them to be quickly and securely attached to

the legs of the A-frame (i.e., the foundation piles projecting up out the ground into free space).

[0023] It should be appreciated that the embodiments described and claimed herein are exemplary only. Those of ordinary skill in the art will appreciate modifications and substitutions that retain the spirit and scope of the invention.

CLAIMS

1. A system comprising:

a pair of base foundation piles, each base foundation pile comprising an elongated, hollow, tubular member having a substantially uniform inside diameter and a thread form at a first end;

a pair of upper foundation piles, each upper foundation pile comprising an elongated, hollow, tubular member coupled to a second end of one of the base foundation piles, extending a main axis thereof; and

an A-frame adapter, the A-frame adapter comprising a second pair of tubular couplers, each one of the pair of tubular couplers adapted to mate with a top end of one of the upper foundation piles to form an A-frame, wherein the second pair of tubular couplers are separated by a pair of parallel mounting flanges and a bridge portion interconnecting the pair of parallel mounting flanges, the mounting flanges providing a mounting interface to support a single-axis tracker.

2. The system according to claim 1, further comprising:

a pair of right-angle brackets, each configured to attach to one of the parallel mounting flanges of the adapter and to provide a horizontal mounting surface; and

a U-shaped bearing housing assembly resting on and attached to the horizontal mounting surface of the right-angle brackets while straddling the bridge portion, the bearing housing assembly including a hinge point for hanging a torque tube.

3. The system according to claim 2 wherein the adapter is configured to orient the hinge point of the bearing housing assembly at a work point of the A-frame.

4. An A-frame to H-pile adapter for a mechanically balanced tracker system comprising:

a pair of co-planar tubular couplers for receiving respective adjacent legs of an A-frame foundation;

a pair of parallel mounting flanges each mounting flange connected to one of the tubular couplers; and

a bridge portion connecting the parallel flanges at a spacing of approximately 6 inches, wherein each tubular coupler is oriented at an angle with respect to a closest one of the

pair of parallel mounting flanges in a range of 17.5 degrees to 35 degrees, pointing downward.

5. A bearing housing assembly for a mechanically balanced single-axis tracker supported by an A-frame comprising:

- a cardioid-shaped member with a cusp between a pair of opposing S-shaped arms that curve away from the cusp;

- a hinge point proximate to the cusp;

- a pair of tubular couplers at a terminal end of each S-shaped arm, each tubular coupler angled to match an angle and spacing of free ends of a pair of tubular piles; and

- a pair of cover plates, each cover plate adapted to mate to one of the tubular couplers to couple one of the free ends of the pair of tubular piles to the cardioid-shaped member to complete the A-frame.

6. The bearing housing assembly according to claim 5, wherein the bearing housing assembly defines a first plane and the hinge point is an axial opening orthogonal to the first plane.

7. The bearing housing assembly according to claim 6, further comprising a hinge pin in the axial opening, the hinge pin providing an axis of rotation for a torque tube suspended within the bearing housing.

8. The bearing housing assembly according to claim 5, wherein the hinge point is located at a work-point of the A-frame.

9. A mechanically balanced tracker system comprising:

- a pair of elongated base piles, each base pile driven into supporting ground at a reciprocal angle to the other with respect to plumb;

- a pair of elongated extension piles, each extension pile mated to one of the base piles; and

- a cardioid-shaped bearing housing member with a cusp and a pair of opposing S-shaped arms that curve away from the cusp, the bearing housing member comprising:

- a hinge point proximate to the cusp;

a pair of tubular couplers at a terminal end of each arm, each tubular coupler angled and spaced apart to match an angle and spacing of one of the extension piles; and

a pair of cover plates, each cover plate adapted to couple one of the tubular couplers to a free end of one of the extension piles to the cardioid-shaped member to complete the A-frame.

10. The system according to claim 9, wherein the hinge point is located at a work-point of the A-frame.

11. A bearing housing assembly for a mechanically balanced single-axis tracker with an A-frame foundation comprising:

a cardioid-shaped member formed from a pair of substantially identical S-shaped arms fastened together with a lap joint proximate to a cusp;

a hinge point proximate to the cusp and passing through both arms at the lap joint; and

a pair of tubular connectors at a terminal end of each arm, each tubular connector adapted to receive a free end of a foundation pile making up a leg of the A-frame.

12. The bearing housing assembly according to claim 11, wherein the cardioid-shaped member defines a first plane and the hinge point defines an axial opening orthogonal to the first plane.

13. The bearing housing assembly according to claim 12, further comprising a hinge pin in the axial opening, the hinge pin providing an axis of rotation for a torque tube suspended within the bearing housing.

14. The bearing housing assembly according to claim 11, wherein the hinge point is located at a work-point of the A-frame.

15. A mechanically balanced tracker system comprising:

a pair of elongated base foundation piles, each base foundation pile driven into the ground at reciprocal angles to one another;

a pair of elongated extension piles, each extension pile mated to one of the base foundation piles; and

a cardioid-shaped member formed from a pair of substantially identical S-shaped arms fastened together with lap joint proximate to a cusp comprising:

a hinge point proximate to the cusp and passing through both arms at the lap joint;
and

a pair of tubular connectors at a terminal end of each arm, each tubular connector adapted to receive a free end of one of the extension piles to complete the A-frame.

16. A bearing housing assembly for a mechanically balanced single-axis tracker comprising:

a pair of substantially identical S-shaped tubular members;

a bridge member interconnecting a first end of each S-shaped member to form a hoop;

and

a gimbal bracket collared around the bridge member so as to hinge in and out of the plane defined by the hoop, wherein a second end of each S-shaped member is oriented at an angle relative to plumb to receive an end of one of a pair of adjacent extension piles to form an A-frame foundation for the single-axis tracker, and the hanger comprises a hinge point for supporting a torque tube.

17. The bearing housing assembly according to claim 16, wherein the hinge point defines an axial opening orthogonal to the plane defined by the hoop.

18. The bearing housing assembly according to claim 17, further comprising a hinge pin in the axial opening, the hinge pin providing an axis of rotation for a torque tube suspended from the bearing housing.

19. The bearing housing assembly according to claim 11, wherein the hinge point is located at a work-point of the A-frame.

20. A mechanically balanced tracker system comprising:

a pair of elongated base foundation piles, each base foundation pile driven into the ground at reciprocal angles to one another;

a pair of elongated extension piles, each extension pile mated to an above-ground end of one of the base foundation piles; and

a bearing housing assembly comprising:

a pair of substantially identical S-shaped tubular members each having a first end and an opposing second end;

a bridge member interconnecting the first end of each S-shaped member to form a hoop; and

a gimbal bracket collared attached around the bridge member so as to hinge in and out of the plane defined by the hoop, wherein the second end of each S-shaped member is oriented at an angle with respect to plumb to receive an end of one the pair of extension piles to form an A-frame foundation for the single-axis tracker, and the hanger comprises a hinge point for supporting a torque tube.

21. The system according to claim 20, wherein the hinge point defines an axial opening orthogonal to the plane defined by the hoop.

22. The system according to claim 21, further comprising a hinge pin in the axial opening, the hinge pin providing an axis of rotation for a torque tube suspended from the bearing housing.

23. The system according to claim 22, wherein the hinge point is located at a work-point of the A-frame.