



(51) International Patent Classification:
F24J 2/38 (2014.01)

(21) International Application Number:
PCT/US2014/059087

(22) International Filing Date:
3 October 2014 (03.10.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/887,348 5 October 2013 (05.10.2013) US

(71) Applicant: MAGNA INTERNATIONAL INC.
[CA/CA]; 337 Magna Drive, Aurora, ON L4G 7K1 (CA).

(72) Inventors; and

(71) Applicants (for US only): WERNER, Mark, Francis
[CA/CA]; 5985 Abbot Street, Lasalle, ON N9J 3L6 (CA).
WOLETZ, Mattias, Peter [DE/US]; 851 Grant Avenue,
Clawson, MI 48017 (US). ZUZELSKI, Michael, Gregory
[US/US]; 21690 Meadow Lane, Beverly Hills, MI 48025
(US).

(74) Agents: HURLES, Steven, C. et al.; DICKINSON
WRIGHT PLLC, 2600 West Big Beaver Road, Suite 300,
Troy, MI 48084 (US).

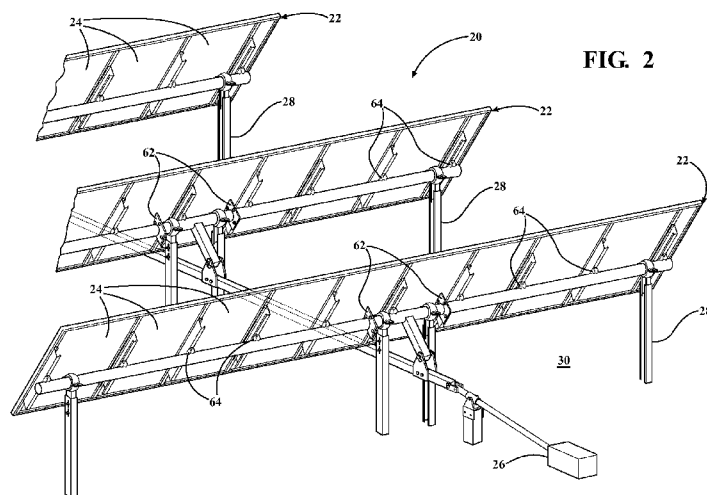
(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: SOLAR PHOTOVOLTAIC SINGLE AXIS TRACKER



(57) Abstract: An improved solar panel assembly is provided. The assembly includes a plurality of sub-assemblies which are spaced from one another. Each sub-assembly has at least two torque tubes and a plurality of laterally spaced rails which are coupled with the torque tubes for supporting a plurality of solar panels or reflectors thereon. Rotation of the torque tubes about the lateral axis rotates the solar panels or the reflectors mounted on the rails. At least one torque arm is joined with and extends transversely away from one of the torque tubes of each sub-assembly. A driveshaft extends longitudinally between the sub-assemblies and is moveable in the longitudinal direction for rotating the solar panels or reflectors via the torque arms, the torque tubes and the rails. The torque tubes are generally cylindrical in shape and adjacent torque tubes of each sub-assembly are co-axially joined in an end-to-end relationship with one another.



SOLAR PHOTOVOLTAIC SINGLE AXIS TRACKER

CROSS-REFERENCE TO PRIOR APPLICATIONS

[0001] This PCT Patent Application claims the benefit of U.S. Provisional Patent Application Serial No. 61/887,348 filed October 5, 2013, entitled “Solar Photovoltaic Single Axis Tracker,” the entire disclosure of the application being considered part of the disclosure of this application and hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates generally to support frame assemblies for solar related devices.

2. Related Art

[0003] Solar trackers are devices which include a plurality of solar panels and (such as, for example, photovoltaic panels, reflectors, lenses or other optical devices) are operable to automatically adjust the orientations of those panels throughout each day to maximize the amount of solar rays captured or reflected by the solar panels. Solar trackers generally have a support frame assembly which engages and supports the solar panels. Typically, each support frame assembly has its own actuator for adjusting orientations of the solar panels.

[0004] Other types of solar trackers have a driveshaft which extends between and is operably connected to a plurality of sub-assemblies, each of which has a support frame assembly and a plurality of solar panels. Each sub-assembly includes a torque tube which supports the solar panels and a torque arm which interconnects the torque tube with the driveshaft. In operation, an actuator moves the driveshaft through a generally arcuate path, and this motion is translated through the torque arms into the torque tubes to rotate solar

panels. As such, the single actuator simultaneously adjusts the orientations of the solar panels of a plurality of sub-assemblies that are spaced from one another.

[0005] There remains a significant and continuing need for a more efficient and less costly solar tracker.

SUMMARY OF THE INVENTION AND ADVANTAGES

[0006] One aspect of the present invention provides for an improved solar panel assembly including a plurality of sub-assemblies which are spaced from one another in a longitudinal direction. Each of the sub-assemblies includes at least two torque tubes which extend in a lateral direction that is generally transverse to said longitudinal direction. Each of the sub-assemblies further includes a plurality of laterally spaced rails which are coupled with the torque tubes for supporting a plurality of solar panels or reflectors thereon.

Rotation of the torque tubes about the lateral axis rotates the solar panels or the reflectors mounted on the rails. At least one torque arm is joined with and extends transversely away from one of the torque tubes of each sub-assembly. A driveshaft extends longitudinally between the sub-assemblies and is moveable in the longitudinal direction for rotating the solar panels or reflectors via the torque arms and the torque tubes and the rails. The torque tubes are generally cylindrical in shape and adjacent torque tubes of each sub-assembly are co-axially joined in an end-to-end relationship with one another.

[0007] The cylindrical shape of the torque tubes allows the torque tubes to be joined with one another with any circumferential alignment which allows for easier assembly of the parts of the solar assembly in the field. The torque tubes may also be formed more cost effectively than torque tubes of other non-cylindrical shapes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] These and other features and advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following

detailed description when considered in connection with the accompanying drawings wherein:

[0009] Figure 1 is a perspective and elevation view of an exemplary solar tracker assembly;

[0010] Figure 2 is an enlarged perspective and fragmentary view of the exemplary solar tracker assembly of Figure 1;

[0011] Figure 3 is an enlarged perspective and fragmentary view of a portion of the exemplary solar tracker assembly of Figure 1;

[0012] Figure 4 is a perspective and elevation view of an exemplary spherical bearing assembly;

[0013] Figure 5 is a perspective, fragmentary and elevation view of the exemplary spherical bearing of Figure 4 showing a pair of races being supported in a lower shell;

[0014] Figure 6 is a perspective and fragmentary view of the exemplary spherical bearing of Figure 4 and showing a single race being supported in the lower shell;

[0015] Figure 7 is a perspective and elevation view of one of the races;

[0016] Figure 8 is a perspective and elevation view of the other of the races;

[0017] Figure 9 is an enlarged and fragmentary view showing the connection between adjacent torque tubes of the exemplary solar tracker assembly of Figure 1;

[0018] Figure 10 is an enlarged and fragmentary view showing the connection between rails and a torque tube in the exemplary solar tracker assembly of Figure 1; and

[0019] Figure 11 is an enlarged and perspective view showing an exemplary braking mechanism for restricting movement of a driveshaft.

DESCRIPTION OF THE ENABLING EMBODIMENT

[0020] Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, an exemplary embodiment of a solar tracker assembly **20** is

generally shown in Figure 1. As shown, the solar tracker assembly **20** includes a plurality of sub-assemblies **22** (nine being shown in the exemplary embodiment) which are spaced from one another in a longitudinal direction. The longitudinal direction could be a north-south direction, an east-west direction or any desirable direction. As best shown in Figure 2, each of the exemplary sub-assemblies **22** has its own array of photovoltaic panels **24**, or cells, for harnessing the potential energy in solar rays and generating electricity. As shown, the arrays of the different sub-assemblies **22** are all arranged to face in the same general direction, and as will be discussed in further detail below, the sub-assemblies **22** are all mechanically connected to one another so that a single driving unit or actuator **26** can simultaneously adjust the orientations of the photovoltaic panels **24** of all of the sub-assemblies **22**. As such, the single actuator **26** is operative to adjust the sub-assemblies **22** such that the photovoltaic panels **24** simultaneously “follow the sun” as it figuratively travels across the sky during each day to increase the total amount of solar rays harnessed and the total amount of electricity generated by the photovoltaic panels **24** each day as compared to stationary/non-moveable photovoltaic panels. Although photovoltaic panels **24** are employed in the exemplary embodiment, it should be appreciated that the sub-assemblies **22** could include mirrors or any suitable type of solar reflecting or collecting in place of or in addition to the photovoltaic panels **24** shown in the exemplary embodiment.

[0021] Referring still to Figure 2, each of the sub-assemblies **22** includes a frame structure **28** which supports the photovoltaic panels **24** above a base **30**, such as the ground, a platform or a roof of a building. Referring now to Figure 3, as will be discussed in further detail below, each of the frame structures **28** includes a plurality of support posts **32** which extend vertically upwardly from the base **30** (shown in Figures 1 and 2), a plurality of bearings **34** which are positioned at the upper ends of the support posts **32**, a plurality of torque tubes **36** which extend between the bearings **34** and a plurality of rails **38** which

support the photovoltaic panels **24**. The bearings **34** allow rotation of the torque tubes **26** which drives rotation of the photovoltaic panels **24** via the rails **38**.

[0022] The support posts **32** of the frame structures **28** are anchored to the base **30**, and the support posts **32** of each subassembly **22** are spaced apart from one another in a lateral direction which is perpendicular to the aforementioned longitudinal direction. The support posts **32** of the exemplary embodiment are made of metal and are generally C-shaped in cross-section, and each support post **32** has a pair of vertically extending slots **40** adjacent their upper ends for attaching the bearings **34** with the support posts **32**.

[0023] Referring now to Figures 4-8, an exemplary one of the bearings **34** is shown. As shown, each of the bearings **34** includes a lower shell **42** and an upper shell **44**, each of which has a semi-spherical outer surface and a semi-spherical inner surface. In the exemplary embodiment, the lower and upper shells **44**, **42** are of identical shape and construction, which allows for reduced manufacturing costs through economies of scale. Each of the lower shells **42** is connected (for example, through welding) to the top of a bearing post **46** which has a plurality of apertures **48** that are spaced vertically from the lower shell **42**. While some of the components of the solar tracker assembly must be assembled in the field, the lower shells **42** may be attached to the bearing posts **46** in a factory setting and shipped as a pre-assembled unit to an installation site. The apertures **48** in the bearing posts **46** are for connecting the bearing posts **46** with the aforementioned support posts **32** (shown in Figure 3) via fasteners, such as bolts. Specifically, the bearings **34** are interconnected with the support posts **32** by aligning the apertures **48** of the bearing posts **46** with the slots **40** in the support posts **32** and inserting fasteners through the aligned apertures **48** and slots **40**. This type of connection is particularly advantageous because it may be established in the field in a very quick manner and without any special equipment. Additionally, the slots **40** in the support posts **32** allow for the heights of the bearings **34**

relative to the base **30** to be established in the field and to be easily adjusted if needed. For bases **30** having uneven terrain, this may be particularly advantageous since it allows the photovoltaic panels **24** of each sub-assembly **22** to be held at generally constant levels. It should be appreciated that the slots could be in the bearing posts **46** in addition to or in lieu of the slots **40** in the support posts **32**.

[0024] Referring now to Figures 5-8, each of the bearings **34** further includes a pair of races **50** which, like the lower and upper shells **42, 44** are also of identical construction with one another. Each of the races **50** has a tongue **54** on one side and a recess **56**, which is shaped similarly to the tongue **54**, on the other side. In the exemplary embodiment, the races **50** lack have any latches or any other features for locking into engagement with one another. However, such features could be included, if desired. The lower and upper shells **42, 44** have radially outwardly extending flanges **58**, and the flanges **58** of the upper shell **44** are connectable to the flanges **58** of the lower shell **42** to trap the first and second races **50** within the confines established by the spherical inner surfaces of the lower and upper shells **42, 44**. In the exemplary embodiment, the flanges **58** of the lower and upper shells **42, 44** are connected together with fasteners. However, any suitable releasable or permanent connection means may alternately be employed.

[0025] The races **50** have generally smooth, continuous, and semi-spherical outer surfaces to provide for low-friction contact surfaces between the races **50** and the semi-spherical inner surfaces of the lower and upper shells **42, 44**. The races **50** also have grids on their inner sides for structural strengthening purposes. The races **50** are preferably made of a self-lubricating and low-friction material, such as Acetal Co-Polymer to provide a low friction contact surface between the shells **42, 44** and the races **50**. In contrast to cylindrical bearings, which are found in many known solar tracker assemblies, the spherical bearings **34** of the exemplary embodiment compensate for some degree in the rotational variations of

the support posts **32** and also may reduce stress at the bearings **34** from wind loading by providing for additional compliance in the joint due to the additional degrees of freedom allowed by the spherical design.

[0026] Referring now to Figure 9, each of the sub-assemblies **22** has a plurality of torque tubes **36** which are attached with one another in a co-axial fashion with adjacent ends of the torque tubes **36** being joined with one another such that all of the torque tubes **36** may rotate simultaneously with one another. In the exemplary embodiment of the solar assembly, the adjacent ends of the torque tubes **36** have generally flat and rectangularly-shaped plates **62** attached to their ends (e.g., through welding in a factory setting), and the plates **62** of adjacent torque tubes **36** are bolted to one another to establish the connection between the adjacent torque tubes **36**. This allows shorter torque tubes **36** to be constructed in a factory setting and shipped out to the field where they may then be quickly connected with one another without any welding or other special equipment. It should be appreciated that other connection means, such as brazing or fasteners, may alternately be employed to secure the plates **62** to the ends of the torque tubes **36**.

[0027] Referring still to Figure 9, in the exemplary embodiment, the torque tubes **36** are generally circular in cross-section, which allows for increased freedom when attaching the plates **62** to the ends of the torque tubes **36** as compared to square torque tubes of other such solar assemblies. As such, a particular rotational alignment between the plates **62** of the opposite ends of the torque tubes **36** relative to one another and to the torque tubes **36** is not required. This allows connection of the torque tubes **36** to be accomplished more simply and at a lower cost than if the torque tubes were non-circular.

[0028] Referring back to Figure 3, the rails **38** of the frame structures **28** are spaced in a lateral direction from one another and are interconnected with the torque tubes **36** via brackets **64**. In the exemplary embodiment, the brackets **64** have a pair of arcuate edges

which are connected to the torque tubes **36** through welding but could be welded or otherwise attached to the torque tubes **36** through any suitable manner. The brackets **64** may be connected with the torque tubes **36** in a factory setting before the torque tubes **36** are shipped to the field. This allows for the brackets **64** to be more precisely positioned and oriented along the torque tube **36**. In the exemplary embodiment, each rail **38** is disposed between a pair of photovoltaic panels **24** and supports the adjacent lateral edges of those panels **24**. In the exemplary embodiment, the photovoltaic panels **24** are mounted in a portrait orientation but could alternately be oriented in a landscape orientation.

[0029] An exemplary process for assembling the sub-assemblies **22** of the exemplary embodiment in the field begins with anchoring the support posts **32** to the base **30** such that the support posts **32** extend generally vertically upwardly from the base **30**. Next, the bearing posts **46**, which are attached to the lower shells **42**, are joined to the support posts **32** with fasteners, such as bolts such that the inner surfaces of the lower shells **42** face upwardly. Then, the races **50** are placed around the torque tubes **36** and set into the upwardly facing spherical inner surfaces of the lower shells **42**. To secure the torque tubes **36** with the bearings **34**, the flanges **58** on the upper shells **44** of the bearings **34** are then secured to the flanges **58** on the lower shells **42**. With this, the torque tubes **36** are supported above the support posts **32** by the bearings **34** and may rotate relative to the base **30**. The races **50** of the bearings **34** may be stationary relative to either the first and second shells **42**, **44** or to the torque tubes **36** during rotation of the torque tubes **36**. The rails **38** may then be secured to the brackets **64** on the torque tubes **36** and the plates **62** on adjacent torque tubes **36** may be secured to one another with, for example, fasteners. All of these steps may be accomplished quickly and without any welding equipment or other special tools.

[0030] Once the photovoltaic panels **24** are installed on the rails **38** of the frame structure **28**, the torque tubes **36** allow them to simultaneously and uniformly rotate relative to the base **30**, thereby allowing the photovoltaic panels **24** to “follow the sun” as it travels across the sky during each day to increase the total amount of solar rays that are harnessed and the total amount of electricity that is generated.

[0031] As shown in Figure 3, each of the sub-assemblies **22** additionally includes a torque arm **60** which is interconnected with a middle torque tube **36a** that is shorter than the other torsion tubes **36b**. The torque arms **60** are preferably attached directly to the middle torque tubes **36** through welding in a factory setting. However, the torque arms **60** could alternately be connected with the middle torque tubes **36** through brazing, adhesives, mechanical fasteners, etc. As discussed in further detail below, the torque arms **60** on the sub-assemblies **22** are mechanically connected to one another through a driveshaft **66** for simultaneously rotating all of the photovoltaic panels **24** of all of the sub-assemblies **22**.

[0032] Referring still to Figure 3, the end of each torque arm **60** opposite of the middle torque tube **36a** is attached via a bracket **64** to an elongated driveshaft **66** which extends in the longitudinal direction between all of the sub-assemblies **22** (see Figure 1). The bracket **64** of the exemplary embodiment is a pair of plates that are generally triangularly shaped when viewed from one side. The bracket **64** is preferably attached to the torque arm **60** with a cleavis pin/cotter pin connection to establish a pivoting connection therebetween and is attached to the driveshaft **66** through a pair of fasteners that are spaced longitudinally from one another. The dispositions of the brackets **64** between the torque arms **60** and the driveshaft **66** is advantageous because it provides for a vertical offset between the bottoms of the torque arms **60** and the driveshaft **66**. This offset ensures a clearance between the lower edges of the photovoltaic panels **24** and the driveshaft **66** during the course of the kinematic motion of driving the system while also reducing the

amount of vertical movement of the driveshaft **66** when rotating the photovoltaic panels **24**. Thus, a “gap” is not required between photovoltaic panels **24** directly above the driveshaft **66** as is included in many other known solar tracking systems. In other words, the exemplary sub-assemblies **22** include a constant row of photovoltaic panels **24** with increased electricity generation and improved aerodynamics, which results in a reduced wind turbulence on the sub-assemblies **22**. The additional photovoltaic panels **24** may be used, for example, to power battery backups or additional electrical equipment for the system.

[0033] As discussed above and shown in Figure 1, the driveshaft **66** extends longitudinally between and interconnects all of the sub-assemblies **22**. The driveshaft **66** is attached to an actuator **26** (such as an electric, hydraulic, or pneumatic motor) which is controlled by a control box (not shown) for moving the driveshaft **66** in a longitudinal direction. Movement of the driveshaft **66** in the longitudinal direction causes the torque arms **60** to pivot about the middle torque tubes **36a**, thereby rotating all of the torque tubes **36a, 36b** of all of the sub-assemblies **22** simultaneously. This re-orientes all of the photovoltaic panels **24** relative to the base **30**. As such, a single actuator **26** is able to simultaneously re-orient the photovoltaic panels **24** of all of the sub-assemblies, thus allowing the photovoltaic panels **24** to “follow the sun” through the sky to maximize the amount of solar rays harnessed by the solar tracker assembly **20** during each day. Although the exemplary solar tracker assembly **20** includes nine sub-assemblies **22**, it should be appreciated that any desirable number of sub-assemblies **22** may be attached to one another through the drive shaft **66**.

[0034] Each of the sub-assemblies **22** is also configured such that the torque arm **60** extends generally perpendicularly relative to the photovoltaic panels **24**. During heavy

winds, this orientation of the torque arm **60** allows it to provide support to the frame structure **28** for resisting wind forces acting on the photovoltaic panels **24**.

[0035] The driveshaft **66**, bracket **64**, torque arm **60**, and middle torque tube **36a** may all be added to an existing solar assembly by cutting gaps into the torque tubes of those assemblies and connecting the middle torque tubes **36a** to the existing torque tubes at the gaps. As such, certain aspects of the present invention may be employed to improve an existing solar tracker assembly.

[0036] Obviously, many modifications and variations of the present invention are possible in light of the above teachings and may be practiced otherwise than as specifically described while within the scope of the appended claims.

CLAIMS

What is claimed is:

Claim 1. A solar panel assembly, comprising:

a plurality of sub-assemblies which are spaced from one another in a longitudinal direction;

each of said sub-assemblies including at least two torque tubes which extend in a lateral direction which is generally transverse to said longitudinal direction and wherein each of said sub-assemblies includes a plurality of laterally spaced rails coupled with said torque tubes for supporting a plurality of solar panels or reflectors thereon and wherein rotation of said at least one torque tube rotates the solar panels or reflectors mounted on said rails;

at least one torque arm joined with and extending transversely away from one of said torque tubes of each sub-assembly;

a driveshaft extending longitudinally between said plurality of sub-assemblies and being moveable in said longitudinal direction for rotating the solar panels or reflectors via said torque arms and said torque tubes and said rails; and

wherein said torque arms are generally cylindrical in shape and adjacent torque tubes of each sub-assembly are co-axially joined in an end-to-end relationship with one another.

Claim 2. The solar panel assembly as set forth in claim 1 wherein adjacent ones of said torque tubes have adjacent longitudinal ends with plates attached to said longitudinal ends and wherein said plates of said adjacent torque tubes are joined together.

Claim 3. The solar panel assembly as set forth in claim 2 wherein said plates of said adjacent torque tubes are joined together with fasteners.

Claim 4. The solar panel assembly as set forth in claim 2 wherein said plates are welded to said longitudinal ends of said torque tubes.

Claim 5. The solar panel assembly as set forth in claim 1 further including a plurality of photovoltaic panels supported on said laterally spaced rails of each of said sub-assemblies.

Claim 6. The solar panel assembly as set forth in claim 5 wherein each of said sub-assemblies includes a photovoltaic panel disposed directly above said driveshaft which extends between said sub-assemblies.

Claim 7. The solar panel assembly as set forth in claim 5 and wherein said torque arms of said sub-assemblies extend generally transversely to said photovoltaic panels.

Claim 8. The solar panel assembly as set forth in claim 1 wherein said rails are joined with said torque tubes via brackets.

Claim 9. The solar panel assembly as set forth in claim 8 wherein each of said brackets has at least one generally arcuate edge that is joined with one of said torque tubes.

Claim 10. The solar panel assembly as set forth in claim 9 wherein each of said brackets has a pair of generally arcuate edges.

Claim 11. The solar panel assembly as set forth in claim 10 wherein said arcuate edges of said brackets are welded to said torque tubes.

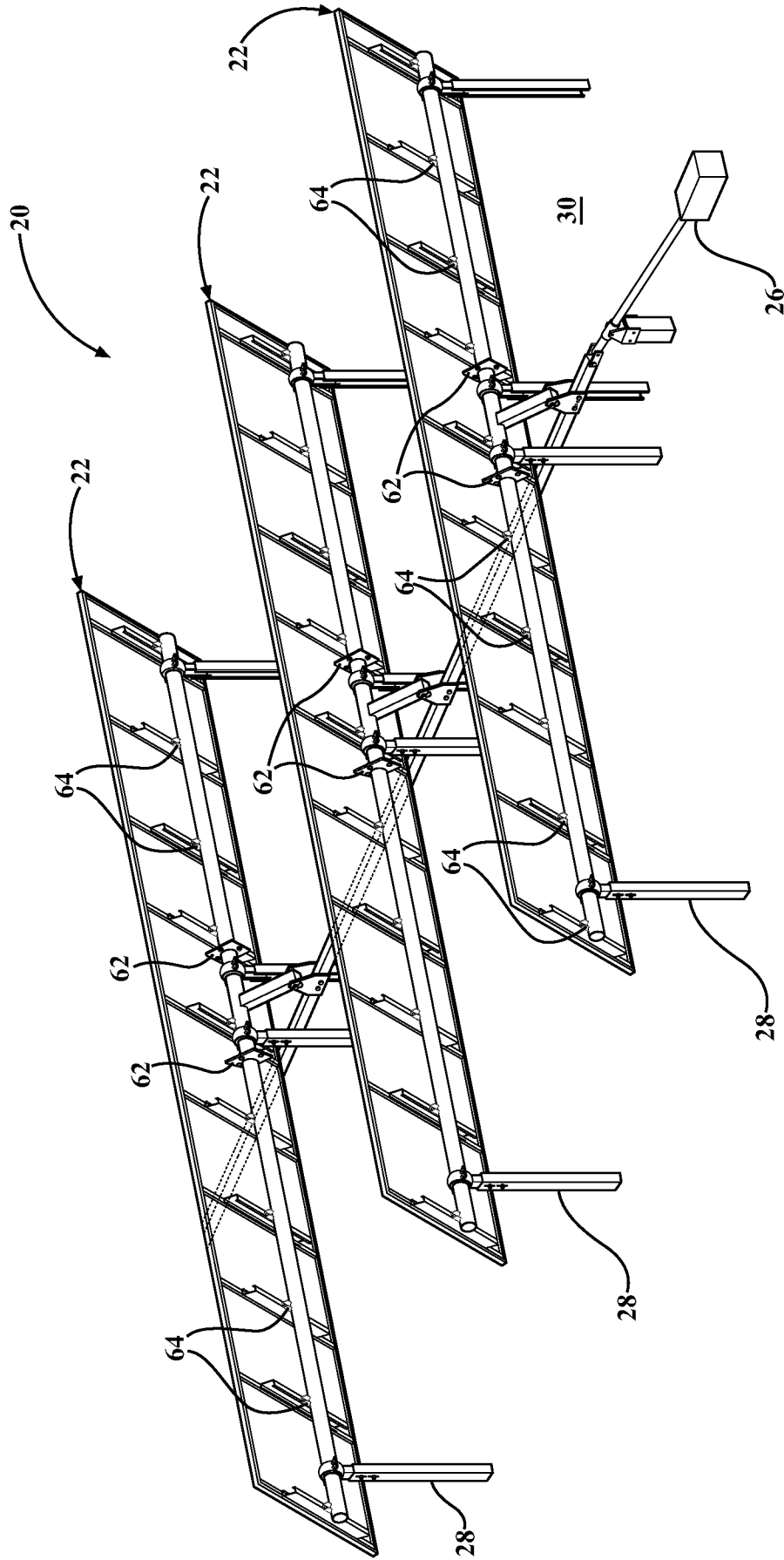
Claim 12. The solar panel assembly as set forth in claim 1 further including a plurality of bearings which rotatably support said torque tubes.

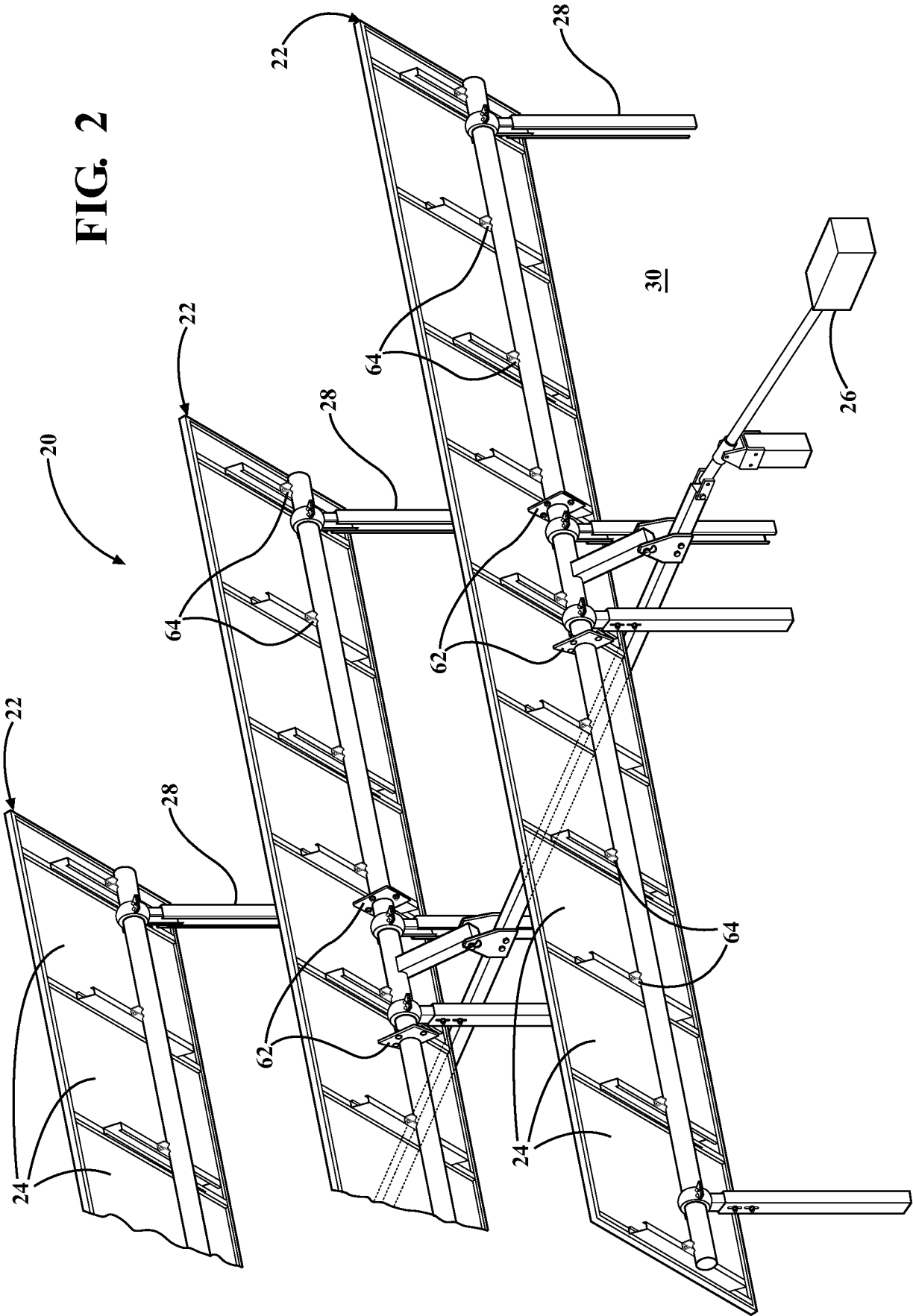
Claim 13. The solar panel assembly as set forth in claim 12 wherein each of said bearings includes a pair of races with generally spherically shaped outer surfaces and a pair of shells with generally spherically shaped inner surfaces and wherein said races are slidably supported within said shells.

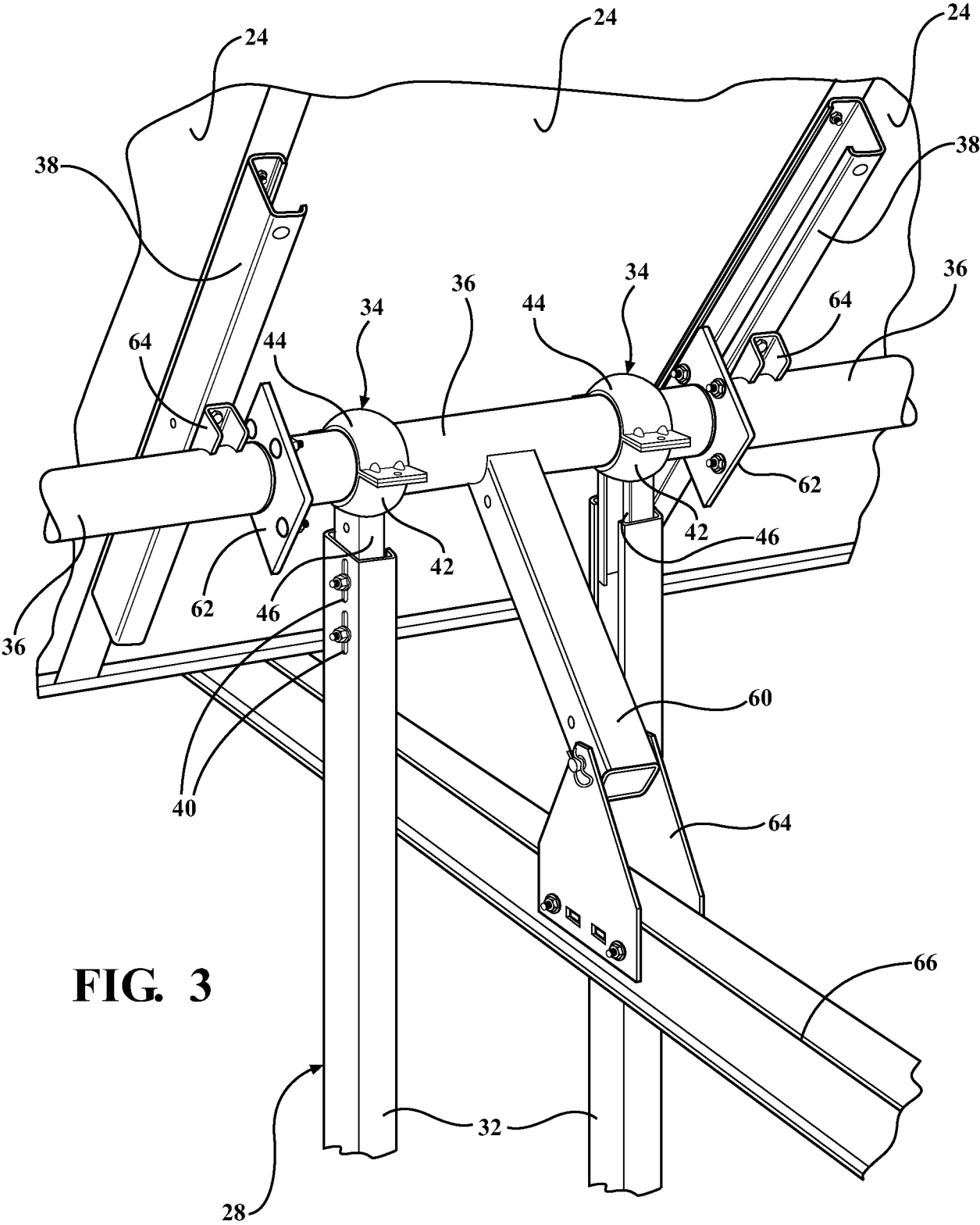
Claim 14. The solar panel assembly as set forth in claim 12 wherein each of said sub-assemblies includes a plurality of support posts which support said bearings.

Claim 15. The solar panel assembly as set forth in claim 1 further including an actuator operably coupled with said driveshaft for moving said driveshaft in a longitudinal direction to simultaneously rotate said torque tubes of said plurality of sub-assemblies through said torque arms.

FIG. 1







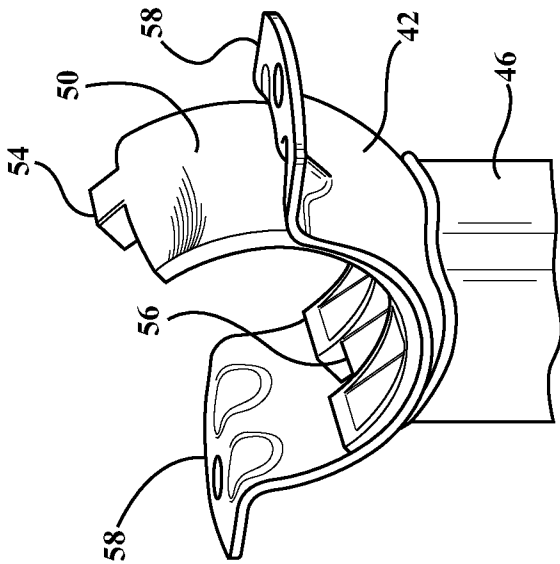


FIG. 6

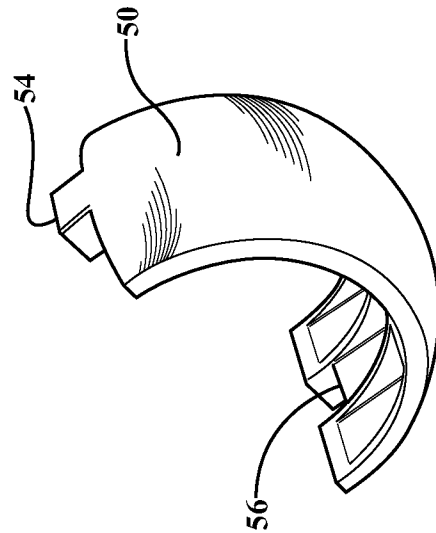


FIG. 8

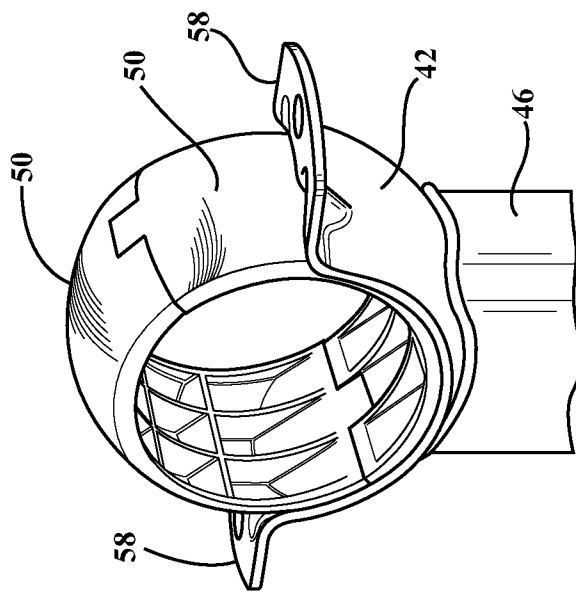


FIG. 5

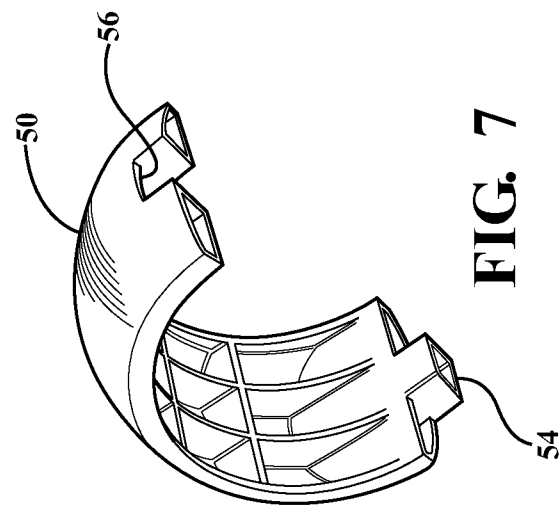


FIG. 7

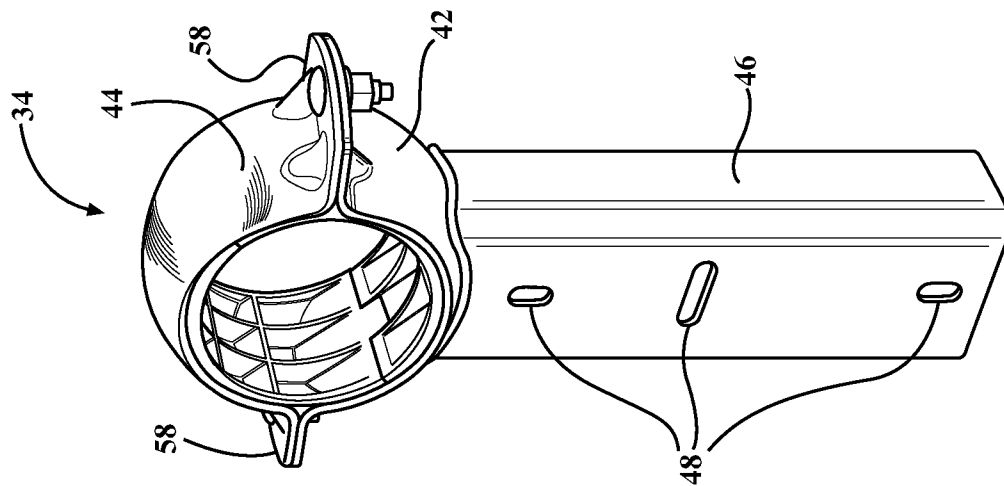


FIG. 4

FIG. 9

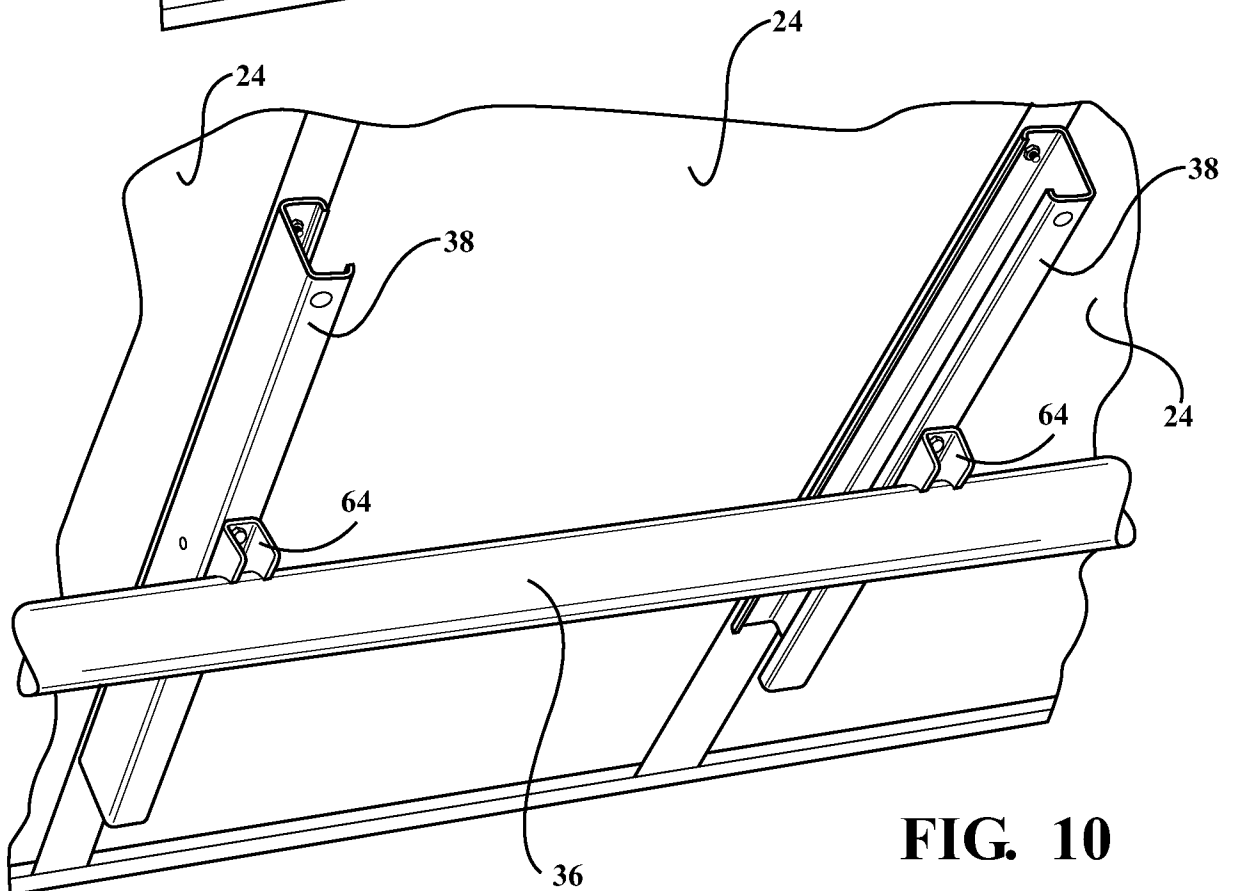
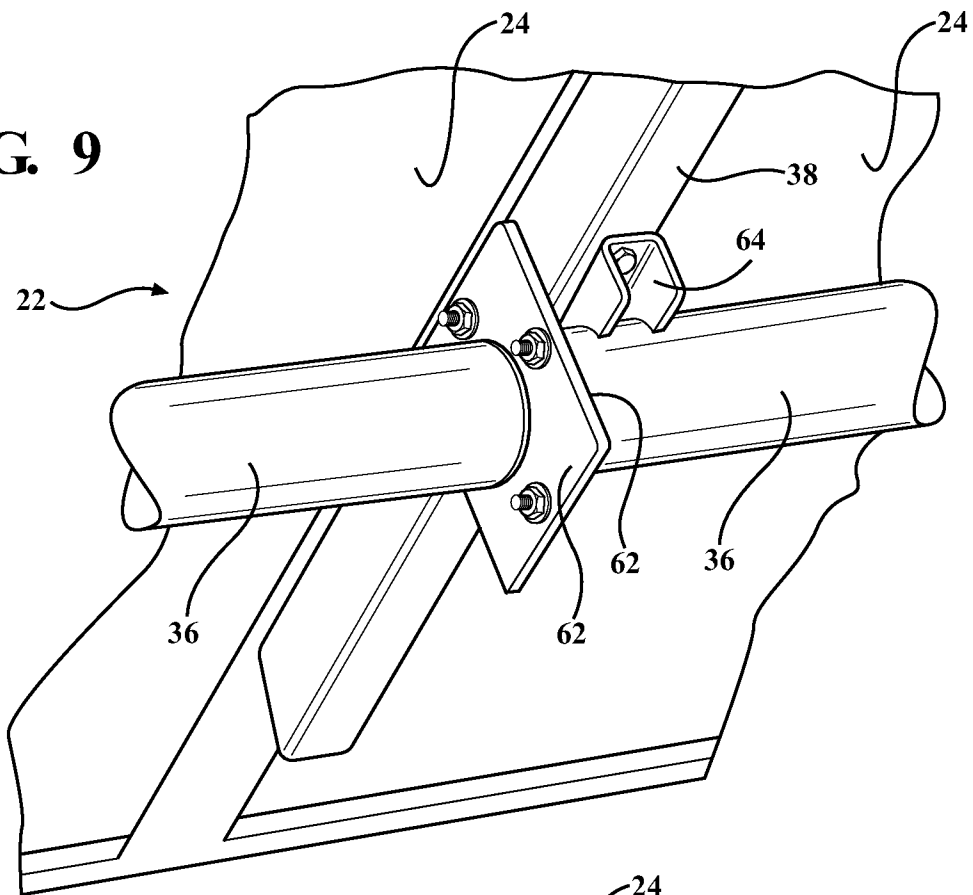
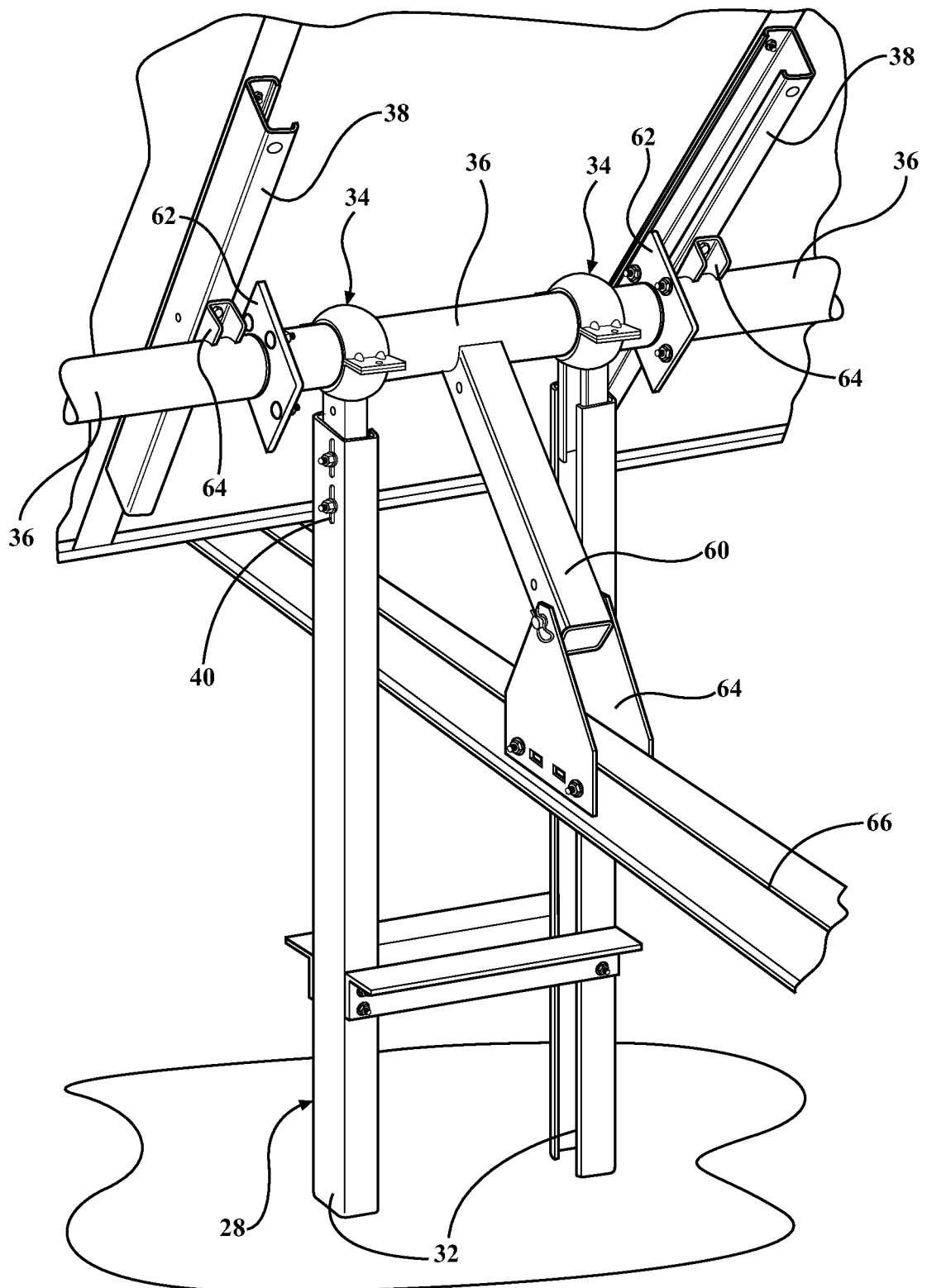


FIG. 10

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2014/059087

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F24J 2/38 (2014.01)

CPC - F24J 2/541(2014.12)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - F24J 2/38, 2/46, 2/52, 2/54 (2014.01)

CPC - F24J 2/523, 2/541, 2002/5451; H02S 20/00 (2014.12)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 126/576, 600, 605 (keyword delimited)

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

PatBase, Google Patents, Google

Search terms used: solar panel, torque, arm, tube, bracket, rotates, driveshaft, torque arm, bearing, races, shell, housing

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008/0308091 A1 (CORIO) 18 December 2008 (18.12.2008) entire document	1-15
Y	US 6,058,930 A (SHINGLETON) 09 May 2000 (09.05.2000) entire document	1-15
Y	US 2010/0101632 A1 (KATS et al) 29 April 2010 (29.04.2010) entire document	2-4
Y	US 2012/0180845 A1 (COLE et al) 19 July 2012 (19.07.2012) entire document	8-11,13

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

17 December 2014

Date of mailing of the international search report

14 JAN 2015

Name and mailing address of the ISA/US

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

Facsimile No. 571-273-3201

Authorized officer:

Blaine R. Copenheaver

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