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Backtracking method for solar tracker installation

Abstract

A method of backtracking for a solar tracker installation utilizing a backtracking algorithm to calculate angles of inclination values for the tables of each of the solar tracker assemblies in the solar tracker installation during a backtracking period including morning backtracking period and evening backtracking period periods wherein the calculated table angles of inclination values mitigate undesirable shading of photovoltaic modules of a solar tracker assembly by adjacent row solar tracker assemblies during morning and evening backtracking periods that would otherwise occur with a normal solar tracking mode. Ends of the torque tube beam of each solar tracker assembly are imaged to provide three dimensional coordinates associated with the torque tube beam ends. Vertical position data is input to the backtracking algorithm, taking into account vertical differences of adjacent solar tracker assemblies in calculating table angles of inclination values for each of the solar tracker assemblies during the backtracking period.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS (1) The following application claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Patent Application Ser. No. 63/417,914, filed Oct. 20, 2022, entitled Backtracking Method for Solar Tracker Installation. The above-identified

U.S. provisional patent application is incorporated by reference herein in its entirety for any and all purposes.

TECHNICAL FIELD

(1) The present disclosure relates to a method of backtracking for a solar tracker installation and, more specifically, to a method of backtracking utilizing a backtracking algorithm to calculate angles of inclination for the tables of each of the solar tracker assemblies in the solar tracker installation during a backtracking period, including post-sunrise, morning backtracking period and a pre-sunset evening backtracking period, wherein the calculated table angles of inclination values calculated by the backtracking algorithm are utilized to set table angles of inclination in place of table angle of inclination positions that would otherwise be used in a normal solar tracking mode to mitigate undesirable shading of photovoltaic modules of a solar tracker assembly by adjacent row solar tracker assemblies during morning and evening backtracking periods that would otherwise occur with the normal tracking mode and an apparatus, such as a solar tracker control system, for implementing the method of backtracking and further wherein a drone is utilized to image ends of a torque tube beam of each solar tracker assembly of the solar tracker installation so that three dimensional coordinates associated with the ends of each of the solar tracker assemblies of the installation are precisely know such that the three dimensional coordinates, including vertical position data, can be input to the backtracking algorithm, which takes into account vertical differences in the height of adjacent solar tracker assemblies in calculating table angles of inclination for each of the solar tracker assemblies during a backtracking period.

BACKGROUND

(2) Various types of solar trackers or solar tracker assemblies are known including horizontal, single axis solar tracker assemblies. A solar tracker installation may include a plurality of horizontal, single axis solar tracker assemblies positioned in spaced apart, parallel rows on an installation site. The installation site is a plot of land that the solar tracker installation is physically situated on. A horizontal, single axis solar tracker assembly typically includes a torque tube beam and a plurality of photovoltaic modules, sometimes referred to as solar modules or panels. The plurality of photovoltaic modules is coupled to the torque tube beam via a frame which typically includes various components including mounting brackets, clamps and fasteners. The torque tube beam of a solar tracker assembly is typically comprised of one or more torque tube beam segments. When multiple torque tube beam segments are utilized, they may be affixed in a linear fashion by couplers or splicing members which couple together end portions of adjacent torque tube beam segments. A typical solar tracker assembly may include ten 40-foot torque tube beam segments for a total length of the torque tube beam (and a total length of the solar tracker assembly) extending 400 feet. The modules of the plurality of photovoltaic modules are typically spaced uniformly along the torque tube beam by the frame mounting brackets. The solar tracker assemblies are typically oriented in a north—south direction on the installation site so that the plurality of photovoltaic modules of each solar tracker assembly of the installation may be pivoted in an east—west direction to follow or track a position of the sun as the sun moves across the sky from east to west.

(3) In a solar tracker installation, a number of parallel solar tracker assemblies extend in a north—south direction so that the table of each of the solar tracker assemblies can pivot to allow the plurality of photovoltaic modules of a solar tracker assembly to follow the path or arc of the sun as it moves across the sky during daylight hours to thereby maximize energy output during daylight hours. Each solar tracker assembly may be considered as a row in a set of aligned, parallel rows of solar tracker assemblies of the installation. For each solar tracker assembly, a table of the solar tracker assembly is driven by the drive mechanism. The table is pivoted or rotated though an angle of inclination range AIR of the table such that the plurality of photovoltaic modules track the sun as it moves across the sky during daylight hours. That is, within the constraints of the table angle of

inclination range AIR, the table pivots such that upper surfaces of the plurality of photovoltaic modules are facing the sun (or are normal to the sun), as the sun moves across the sky from east to west, to maximize energy output by the photovoltaic modules.

(4) In some solar tracker assemblies, the table angle of inclination range AIR is 120 degrees, which means that the table can be rotated or pivoted to a negative angle of inclination of −60 degrees (maximum negative angle of inclination AI−) from horizontal to face in the easterly direction (facing the morning sun) and can be rotated or pivoted to a positive angle of inclination of +60 degrees (maximum positive angle of inclination AI+) from horizontal to face in the westerly direction (facing the evening sun). When the sun is at its apex (solar noon) in the sky, the table would be pivoted such that upper surfaces of the plurality of photovoltaic panels would typically be in a horizontal position for maximum sun exposure. This would correspond to a neutral position or zero angle of inclination AIN of the table.

(5) As noted above, in a solar tracker installation, typically there is an aligned set of solar tracker assemblies comprising parallel rows of spaced apart solar tracker assemblies, each row of the set being a solar tracker assembly and extending in a north-south direction and uniformly spaced apart in the east-west direction. In order to maximize the energy production of the solar tracker installation, it is desirable to have a pitch distance or spacing between the centers of adjacent parallel rows of solar tracker assemblies be relatively small to maximize the number of solar tracker assemblies operating on the site of the solar tracker installation. However, there is a tradeoff in determining pitch distance. Specifically, the smaller the pitch distance, that is, the closer the adjacent rows of solar tracker assemblies are positioned, as measured in the east-west direction, the greater the tendency for photovoltaic modules of adjacent solar tracker assemblies to shade each other during post sunrise, early morning hours and pre-sunset, late evening hours, if the solar tracker assemblies of a set of solar tracker assemblies are in normal or true solar tracking mode. In the normal solar tracking mode, the associated solar tracker controller utilizes a predetermined table of sun positions for each day of each year of the operating life of the solar tracker assembly and operates to pivot the table of its solar tracker assembly in accordance with the sun positions such that the upper surfaces of the plurality of photovoltaic modules point at the sun (that is, the upper surfaces of the modules are normal or orthogonal to the position of the sun) as the sun moves across the sky, within, of course, the angle of inclination range (AIR) of the table.

(6) In the normal tracking mode, at sunrise and sunset, the table of the solar tracker assembly would be pivoted to maximum negative and positive angles of inclination AI−, AI+ in an attempt to point the plurality of photovoltaic modules at the sun's position. That is, during early morning hours, if the normal tracking mode is utilized, the tables of the solar tracker assemblies of the installation would all be pivoted or rotated to a maximum negative angle of inclination AI−, which, for example, may be −60 degrees. However, in such a maximum negative angle of inclination when the sun low in the eastern sky, the steeply angled plurality of photovoltaic modules of the most easterly positioned solar tracker assembly would tend to shade a portion of the plurality of photovoltaic modules of the adjacent (that is, the second most easterly) solar tracker assembly. The plurality of photovoltaic modules of the second most easterly positioned solar tracker assembly would, in turn, tend to shade a portion of the plurality of photovoltaic modules of the adjacent (that is, the third most easterly) solar tracker assembly and so on, along the entire set of aligned, parallel rows of solar tracker assemblies. Since, the photovoltaic modules of a solar tracker assembly are typically connected in series, if even one of the photovoltaic modules of a solar tracker assembly is shaded, this will significantly reduce the energy output of the plurality of photovoltaic modules of the solar tracker assembly. The shading problem similarly occurs prior to sunset. In this situation, the tables of the solar tracker assemblies of the installation would all have their respective tables at the maximum positive angle of inclination AI+, for example, +60 degrees. The steeply angled plurality of photovoltaic modules of the most westerly solar tracker assembly would tend to shade a portion of the plurality of photovoltaic modules of the adjacent (second most westerly) solar tracker

assembly, the steeply angled plurality of photovoltaic modules of the second most westerly solar tracker assembly would tend to shade a portion of the plurality of photovoltaic modules of the adjacent third most westerly solar tracker assembly and so on, along the entire set of aligned, parallel rows of solar tracker assemblies. Hence, shading of adjacent photovoltaic modules of a solar tracker assembly during early morning or late evening periods is a significant problem. The shading problem described above may be further exacerbated if the ground level of the installation site undulates over an extent of the solar tracker installation site. For example, if a portion of the site that includes the most easterly positioned solar tracker assembly is vertically higher over certain portions of the length or longitudinal extent of the torque tube beam as compared to the torque tube beam of the corresponding second most easterly solar tracker assembly, some or all of the photovoltaic modules of the of the most easterly positioned solar tracker assembly may be higher vertically, as compared to the corresponding photovoltaic modules of the second most easterly solar tracker assembly. During early morning hours, this vertical differential between the greater height of the photovoltaic modules of the most easterly positioned solar tracker assembly versus the lower height of the photovoltaic modules of the second most easterly solar tracker assembly would increase a duration of the shading of the photovoltaic modules of the second most easterly solar tracker assembly by the corresponding photovoltaic modules of the most easterly positioned solar tracker assembly. Accordingly, the height differential between adjacent solar tracker assemblies may exacerbate the row-to-row shading problem by: a) increasing a portion of daylight hours during which a shading problem exists thereby decreasing energy output of the second most easterly solar tracker assembly for a longer duration than would otherwise be the case if the ground were level; and/or b) increasing an area of the shaded region of the second most easterly solar tracker assembly at a given post-sunrise time thereby increasing the energy output loss of the second most easterly solar tracker assembly.

SUMMARY

(7) In one aspect, the present disclosure relates to a method of backtracking utilizing a backtracking algorithm to calculate angle of inclination positions for a first table of a first solar tracker assembly and angle of inclination positions for a second table of a second solar tracker assembly, the first and second solar tracker assemblies being adjacent row solar tracker assemblies within a solar tracker installation, to mitigate shading of a first set of photovoltaic modules of the first table of the first solar tracker assembly by a second set of photovoltaic modules of the second table of the second solar tracker assembly, the steps of the method comprising: a) imaging at least one selected element of the first solar tracker assembly and utilizing images of the at least one selected element to determine three dimensional coordinates associated with the first solar tracker assembly; b) imaging at least one selected element of the second solar tracker assembly and utilizing images of the at least one selected element to determine three dimensional coordinates associated with the second solar tracker assembly; c) inputting to the backtracking algorithm: 1) the three dimensional coordinates associated with the first solar tracker assembly; 2) the three dimensional coordinates associated with the second solar tracker assembly; 3) a chord value for the first set of photovoltaic modules of the first table of the first solar tracker assembly and a chord value for the second set of photovoltaic modules of the second table of the second solar tracker assembly; 4) an angle of inclination range for the first table and an angle of inclination range for the second table; and 5) sun position data; d) the backtracking algorithm calculating first angle of inclination values for the first table of the first solar tracker assembly and calculating second angle of inclination values for the second table of the second solar tracker assembly; and e) pivoting first table of the first solar tracker assembly in accordance with the first angle of inclination values and pivoting the second table of the second solar tracker assembly in accordance with the second angle of inclination values.

(8) In another aspect, the present disclosure relates to a method of backtracking utilizing a backtracking algorithm to calculate angle of inclination positions for a first table of a first solar

tracker assembly and angle of inclination positions for a second table of a second solar tracker, the first and second solar tracker assemblies being adjacent row solar tracker assemblies within a solar tracker installation, to mitigate shading of a first set of photovoltaic modules of the first table of the first solar tracker assembly by a second set of photovoltaic modules of the second table of the second solar tracker assembly, the steps of the method comprising: a) determining three dimensional coordinates for at least one element of the first solar tracker assembly, the three dimensional coordinates associated with the first solar tracker assembly; b) determining three dimensional coordinates for at least one element the second solar tracker assembly, the three dimensional coordinates associated with the second solar tracker assembly; c) inputting to the backtracking algorithm: 1) the three dimensional coordinates associated with the first solar tracker assembly; 2) the three dimensional coordinates associated with the second solar tracker assembly; 3) a chord value for the first set of photovoltaic modules of the first table of the first solar tracker assembly and a chord value for the second set of photovoltaic modules of the second table of the second solar tracker assembly; 4) an angle of inclination range for the first table and an angle of inclination range for the second table; and 5) sun position data; d) the backtracking algorithm calculating first angle of inclination values for the first table of the first solar tracker assembly and calculating second angle of inclination values for the second table of the second solar tracker assembly; and e) pivoting first table of the first solar tracker assembly in accordance with the first angle of inclination values and pivoting the second table of the second solar tracker assembly in according with the second angle of inclination values.
(9) In another aspect, the present disclosure relates to a method of method of determining three dimensional coordinates for each solar tracker assembly of a first set of solar tracker assemblies, the first set of solar tracker assemblies being adjacent row solar tracker assemblies within a solar tracker installation, for each of the solar tracker assemblies of the set of solar tracker assemblies includes a table pivoting about an angle of inclination, the table including a torque tube and set of photovoltaic modules coupled to and pivoting with the torque tube, the steps of the method comprising: a) imaging at least one element of a first solar tracker assembly of the first set of solar tracker assemblies; b) analyzing the image data to identify the at least one element of the first solar tracker assembly; c) determining three dimensional coordinates for the at least one element of the solar tracker assembly; d) associating the three dimensional coordinates with the first solar tracker assembly; and e) repeating steps (a) through (d) for each solar tracker assembly of the first set of solar tracker assemblies.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) The foregoing and other features and advantages of the present disclosure will become apparent to one skilled in the art to which the present disclosure relates upon consideration of the following description of the disclosure with reference to the accompanying drawings, wherein like reference numerals, unless otherwise described refer to like parts throughout the drawings and in which:
(2) FIG. **1** is a schematic top perspective view of a solar tracker installation including a plurality of a single row, horizontal, single axis solar tracker assemblies on a solar tracker installation site, the solar installation including two sets of solar tracker assemblies, each set of solar tracker assemblies including adjacent, aligned rows of spaced apart solar tracker assemblies of the plurality of solar tracker assemblies, each solar tracker assembly of the plurality of solar tracker assemblies including a drive mechanism and a pivoting table, the table including a torque tube beam including a plurality of torque tube beam segments, a plurality of photovoltaic modules; a frame for supporting the plurality of photovoltaic modules, and a plurality of bearing apparatus for rotatably supporting the torque tube beam, associated with each solar tracker assembly is a solar tracker

controller that controls the drive mechanism that pivots the table through an angle of inclination range so that the plurality of photovoltaic modules track the sun as the sun moves across the sky, the solar tracker installation including a control and communications systems including an array controller in communication with each of the solar tracker controllers;

(3) FIG. **2** is a schematic bottom perspective view of a portion of a representative solar tracker assembly of the plurality of solar tracker assemblies of the solar tracker installation of FIG. **1**, including a solar tracker controller associated with the solar tracker assembly operatively coupled to a drive mechanism of the solar tracker assembly, the solar tracker controller operating via the drive mechanism to change an angle of inclination of the solar tracker, the solar tracker controller including a dedicated photovoltaic module for providing power to the solar tracker controller;

(4) FIG. **3** is a schematic top perspective view of a portion of the representative solar tracker assembly of FIG. **2**, with all but one of the plurality of photovoltaic modules and the dedicated photovoltaic modules of the solar tracker controller removed to facilitate viewing of components of the table;

(5) FIG. **4** is a schematic top plan view of the representative solar tracker assembly of FIG. **3**;

(6) FIG. **5** is a schematic vertical section view of the representative solar tracker assembly of FIG. **2**, as seen from a plane indicated by the line **5-5** in FIG. **4**, schematically depicting the angle of inclination range of the table;

(7) FIG. **6** is a schematic front elevation view of adjacent first and second east most solar tracker assemblies of a first set of solar tracker assemblies illustrating the row-to-row shading problem of a portion of a plurality of photovoltaic modules of the table of the second solar tracker assembly by a plurality of photovoltaic modules of the table of the first solar tracker assembly at a morning, easterly sun position wherein a backtracking method of the present disclosure is not utilized to modify an angle of inclination of the table of the first solar tracker assembly and instead the angle of inclination of the table is set in accordance with a normal tracking mode;

(8) FIG. **7** is a schematic front elevation view of the adjacent first and second east most solar tracker assemblies of FIG. **6** wherein row-to-row shading of the plurality of photovoltaic modules of the table of the second solar tracker assembly by the plurality of photovoltaic modules of the table of the first solar tracker assembly is mitigated during a morning backtracking period by setting the respective angles of inclination of the tables of the first and second eastern most solar tracker assemblies in accordance with calculated angle of inclination value generated by a backtracking algorithm of the backtracking method of the present disclosure, for sun position SP**1**, the calculated angles of inclination resulting in the early morning sun's rays passing between facing edges of the plurality of photovoltaic modules of the table of the first solar tracker assembly and the plurality of photovoltaic modules of the table of the second solar tracker assembly such that a light stripe having width within a target range light stripe width would be cast upon the ground;

(9) FIG. **8** is a schematic front elevation view of adjacent first and second west most solar tracker assemblies of the first set of solar tracker assemblies wherein row-to-row shading of the plurality of photovoltaic modules of the table of the second solar tracker assembly by the plurality of photovoltaic modules of the table of the first solar tracker assembly is mitigated during an evening backtracking period by setting the respective angles of inclination of the tables of the first and second western most solar tracker assemblies in accordance with calculated angle of inclination values utilizing the backtracking algorithm of the backtracking method of the present disclosure, for sun position SP**2**, the calculated angles of inclination resulting in the late evening sun's rays passing between facing edges of the plurality of photovoltaic modules of the table of the first solar tracker assembly and the plurality of photovoltaic modules of the table of the second solar tracker assembly such that a light stripe having width within a target range light stripe width would be cast upon the ground;

(10) FIG. **9** is a schematic vertical section view of an end of a torque tube beam of the solar tracker assembly of FIG. **2**, the end of the torque tube beam including an end cap;

(11) FIG. **10** is a schematic front elevation view of the end cap of FIG. **9**, the end cap including a machine readable indicia;

(12) FIG. **11** is a simplified time chart plotting the angles of inclination of a table of an exemplary solar tracker assembly of the solar tracker installation over a two day period, the two day period including a normal tracking period, a morning backtracking period, an evening backtracking period, and a night stow period, during the morning and evening backtracking periods, the solar tracker controller operating in backtracking mode and setting the angles of inclination of the table in accordance with calculated table angle of inclination values, as determined by the backtracking algorithm of the backtracking method to mitigate row-to-row shading problems which would otherwise exist if table angles of inclination were set by the solar tracker controller to positions in accordance with the normal solar tracking mode;

(13) FIG. **12** is a simplified flow chart of the backtracking algorithm of the backtracking method of the present disclosure, as applied to two adjacent row solar tracker assemblies of a first set of adjacent, aligned rows of spaced apart solar tracker assemblies;

(14) FIG. **13** is a simplified flow chart illustrating the process used by a solar tracker controller in determining which of the operating modes of a solar tracker assembly would be selected for use based on current time;

(15) FIG. **14** is a simplified flow chart of a specific example embodiment of the imaging method of FIG. **15** wherein end caps of end portions of a torque tube beam of a solar tracker assembly are imaged, identified in one or more image frames, and have three dimensional coordinates determined for each end cap for use in connection with the backtracking method of the present disclosure; and

(16) FIG. **15** is a simplified flow chart of an imaging method of the present disclosure for use in conjunction with or as part of the backtracking method of the present disclosure.

DETAILED DESCRIPTION

(17) The present disclosure relates a method of backtracking **1100** that utilizes a backtracking algorithm **1120** to calculate backtracking angles of inclination CAI for respective tables **110** of a plurality of solar tracker assemblies **100** of a solar tracker installation **1000** during a backtracking period BT. The present disclosure also relates to a method of imaging **1400** that provides three dimensional location data regarding each of the solar tracker assemblies of the plurality of solar tracker assemblies **100** of the installation **1000**. The imaging method **1400** is used in conjunction with or can be considered as part of the backtracking method **1100**. Advantageously, the three dimensional location data or three dimensional coordinate data or values generated by the imaging method **1400** are input to the backtracking algorithm **1120** to enable improved calculated backtracking angle of inclination values CAI by the backtracking algorithm **1120** to mitigate row-to-row shading during morning and evening backtracking periods BTM, BTE for each of the solar tracker assemblies of the plurality of solar tracker assemblies **100** of the solar tracker installation **1000**. The method of imaging **1400** may be implemented on imaging software **1401**, just as the backtracking method **1100** may be implemented on backtracking software **1101** (FIG. **1**). The backtracking software **1121** and the imaging software **1401** may be part of a unified set of control software modules of the solar tracker installation **1000** or they may be stand-alone software modules. The method of imaging **1400** may be viewed as a part of or subsidiary to the method of backtracking **1100**. The plurality of solar tracker assemblies **100** of the solar tracker installation **1000** are located on a solar tracker installation site **1002**.

(18) In one exemplary or example embodiment, each of the plurality of solar tracker assemblies **100** is a horizontal, single axis solar tracker assembly. The installation site **1002** of the solar tracker installation **1000** is schematically depicted as a geographic area within the bounds of a dashed line labeled **1002** in FIG. **1**, however, it should be understood that the site **1002** could include two or more geographic areas or plots of land that are non-contiguous. The solar tracker installation **1000** includes the plurality of solar tracker assemblies **100**. Each solar tracker assembly of the plurality

of solar tracker assemblies **100** operates under the control of an associated different one of a plurality of solar tracker controllers **600**. In one exemplary or example embodiment, each of the plurality of solar tracker controllers **600** is located in proximity to or mounted on its associated solar tracker assembly, the solar tracker controllers **600** are part of a solar tracker control and communications system **500**.

(19) In one exemplary or example embodiment, the solar tracker assemblies **100** of the solar tracker installation **1000** are arranged in one or more sets of parallel, aligned, spaced apart solar tracker assemblies on the installation site **1002**. For example, FIG. **1** schematically illustrates the solar tracker installation **1000** wherein the plurality of solar tracker assemblies **100** includes two geographically separated sets of solar tracker assemblies, namely, a first set of solar tracker assemblies **109***a* and a second set of solar tracker assemblies **109***b*, located on the installation site **1002**. As schematically depicted in FIG. **1**, each of the sets of solar tracker assemblies **109***a*, **109***b* includes a plurality of solar tracker assemblies or adjacent, aligned or parallel rows of solar tracker assemblies. For example, the first set of solar tracker assemblies **109***a* includes parallel, spaced solar tracker assemblies or rows **102**, **103**, **104**, **106**, **107**, **108**, each extending in a north-south direction. Each row **102**, **103**, **104**, **106**, **107**, **108** is substantially parallel to and aligned with its adjacent solar tracker assembly or assemblies of the first set **109***a*. For example, in the first set solar tracker assemblies **109***a*, an eastern most solar tracker assembly **102** is aligned with, that is, parallel to, and adjacent to a second most eastern solar tracker assembly **103**. The second most eastern solar tracker assembly **103** is parallel to and adjacent to the eastern most solar tracker assembly **103** and a third most eastern solar tracker assembly **104**. Similarly, looking at the western most solar tracker assemblies of the first set **109***a*, a western most solar tracker assembly **108** is aligned with, that is, parallel to, and adjacent to a second most western solar tracker assembly **107**. The second most western solar tracker assembly **107** is parallel to and adjacent to the western most solar tracker assembly **108** and a third most western solar tracker assembly **106**. Each set of solar tracker assemblies **109***a*, **109***b* are geographically spaced apart. For brevity, the discussion herein will focus on the first set of solar tracker assemblies **109***a*, it being understood that the same discussion and analysis would equally apply to all other sets of solar tracker assemblies of the solar tracker installation **1000**, which may be greater than two sets, especially in large scale or utility scale solar tracker installations. Additionally, only representative eastern and western solar tracker assemblies **102**, **103**, **104**, **106**, **107**, **108** of the first set of solar tracker assemblies **109***a* are schematically illustrated in FIG. **1**, it should be understood that the first set of solar tracker assemblies **109***a* will include many additional solar tracker assemblies between rows **104**, **106**, the presence of additional solar tracker assemblies is represented schematically by the ellipsis or series of three dots in FIG. **1**.

(20) Each solar tracker assembly of the plurality of solar tracker assemblies **100** includes a table **110** that pivots through an angle of inclination range AIR to track the position of the sun as the sun moves across the sky from east to west. An angle of inclination AI of a table of individual solar tracker assemblies **102**, **103**, **104**, **106**, **107**, **108** is controlled by an associated solar tracker controller **602**, **603**, **604**, **606**, **607**, **608** of the plurality of solar tracker controllers **600**. For example, in the first set of solar tracker assemblies **109***a*, a table angle of inclination AI of the eastern most solar tracker assembly **102** of the first set of solar tracker assemblies **109***a* is controlled by its associated solar tracker controller **602** of a first set of solar tracker controllers **609***a* of the plurality of solar tracker controllers **600**, a table angle of inclination AI of the second most easterly solar tracker assembly **103** of the first set of solar tracker assemblies is controlled by its associated solar tracker controller **603** of the first set of solar tracker controllers **609***a* of the plurality of solar tracker controllers **600**, etc.

(21) The solar tracker controller **602**, via a drive mechanism **150** of the solar tracker assembly **102**, controls an angle of inclination AI of a table **110** of the solar tracker assembly **102**. Each of the plurality of solar tracker assemblies **100**, for example, the solar tracker assembly **102**, includes a plurality of photovoltaic modules **190** mounted to and supported by a torque tube beam **250**. The

plurality of photovoltaic modules **190** are affixed to the torque tube beam **250** by a frame **120**. The torque tube beam **250**, in turn, is supported for rotation or pivoting about an axis of rotation R by a plurality of bearing apparatuses **200** positioned at spaced apart locations along the torque tube beam **250**. Each bearing apparatus of the plurality of bearing apparatuses **200** includes a rotatable or rotating bearing assembly **210** supported by a stationary saddle assembly **220**. The rotatable bearing assembly **210** includes a torque tube beam slot **212** which receives the torque tube beam **250**.

(22) In one example or exemplary embodiment, the method of backtracking **1100** (and associated backtracking software **1101**) of the present disclosure is advantageously implemented or executed by a central controller or array controller **510** of the solar tracker control and communications system **500** of the solar tracker installation **1000**, although it should be recognized that the backtracking method **1100** could be executed by one or more solar tracker installation components having a microprocessor or microcontroller to execute the calculations of the method **1100** and issue appropriate control signals to a plurality of solar tracker controllers **600** associated with the plurality of solar tracker assemblies **100**. In one exemplary or example embodiment, the plurality of solar tracker controllers **600** are part of the solar tracker control and communications system **500** of the solar tracker installation **1000**. Similarly, the method of imaging **1400** (and associated imaging software **1401**) of the present disclosure is advantageously implemented or executed by the central controller or array controller **510** of the solar tracker control and communications system **500**. Alternately, the imaging method **1400** may be executed by a stand-alone or networked computer which is not part of the solar tracker control and communications system **500**.

(23) The control and communications system **500** advantageously employs a long-range, radio frequency, sub GHz, wireless data communications protocol and a star wireless communications network configuration **502** to allow for centralized control of the installation **1000** by the array controller **510** and provide for efficient, wireless transmission of data and control signals between the array controller **510**, the plurality of solar tracker controllers **600**, and a plurality of weather sensors **700**. The plurality of weather sensors **700** of the solar tracker installation **1000** will typically include anemometers (wind speed sensors), snow sensors for detection of snow accumulation on the upper surfaces of a plurality of photovoltaic modules **190** of a solar tracker assembly **102**, and sunlight or irradiance sensors that are used to determine overcast sky conditions. The plurality of wind speed, snow detection weather sensors, and irradiance sensors are schematically depicted as weather sensors WS**1 702**, WS**2 704**, WS**3 706**, WS**4 708**, WS**5 710** in FIG. **1**.

(24) The array controller **510** receives wireless communications from the plurality of weather sensors **700** regarding weather-related data and receives wireless communications from the plurality of solar tracker controllers **600** regarding operating and maintenance data of the associated plurality of solar tracker assemblies **100**. The array controller **510**, in turn, wirelessly communicates control signals to each of the plurality of solar tracker controllers **600**, for example, solar tracker controller **602**, indicating: a) what operating mode the solar tracker controller **602** should operate its associated solar tracker assembly **102** in; and/or b) what the angle of inclination AI of the table **110** of its associated solar tracker assembly **102** should at. Additionally, the control and communications system **500** additionally includes storage of selected data regarding operation and maintenance of the solar track installation **1000**, allowing for remote, real-time access to stored operating and maintenance data by owners/operators of the solar tracker installation **1000** via smart devices. In one exemplary embodiment, the array controller **510** stores operating and maintenance data in a cloud storage database **530** utilizing a cloud storage server **520**, which may be remote from the installation site **1002**. Communications from the array controller **510** to the cloud storage server **520** may be via a router (which is part of electronics of the array controller **510**) or via a cellular network. Additional details of the function and configuration of the solar tracker control system **500** are found in U.S. non-provisional patent application Ser. No. 17/746,322, filed May 17,

2022, and assigned to the assignee of the present application. Application Ser. No. 17/746,322 is incorporated by reference herein in its entirety.

(25) It should be appreciated that the angles of inclination AI for the solar tracker assemblies for example, solar tracker assembly **102** may be calculated either by: a) the array controller **510** and then communicated to the solar tracker controller **602** by the array controller **510** and calculated angles of inclination are implemented by the solar tracker controller **602** to control/change the angle of inclination AI of the associated solar tracker assembly **102**; or b) the solar tracker controller **602**, wherein the solar tracker controller **602** utilizes the calculated angles of inclination to control/change the angle of inclination AI of the associated solar tracker assembly **102**. Where the calculation of the angles of inclination for a solar tracker assembly **102** are performed is a matter of design choice and the present disclosure contemplates multiple options, including the options set forth above.

(26) Solar Tracker Assembly **100** and Solar Tracker Controller **602**

(27) For simplicity, when discussing the plurality of solar tracker assemblies **100** of the solar tracker installation **1000**, a representative solar tracker assembly, namely, solar tracker assembly **102**, will be referenced with the understanding that the description of the solar tracker assembly **102** is applicable to each of the solar tracker assemblies of the plurality of solar tracker assemblies **100**. Similarly, when discussing the plurality of solar tracker controllers **600** associated with respective solar tracker assemblies of the plurality of solar tracker assemblies **100**, a representative solar tracker controller, namely, solar tracker controller **602**, will be referenced with the understanding that the description of the solar tracker controller **602** is applicable to each of the solar tracker controllers of the plurality of solar tracker controllers **600**. The solar tracker assembly **102** includes the pivoting table **110** which is pivoted about the axis of rotation R by the drive mechanism or drive actuator **150** of the solar tracker assembly **102**. The table **110** includes everything that pivots or swings about the axis of rotation R of the table **110**. The table **110** of the solar tracking assembly includes: a) the torque tube beam **250** including a plurality of torque tube beam segments, portions of four torque tube beam segments are schematically depicted in FIG. **4**, namely, torque tube beam segments **265**, **270**, **275**, **280**; b) the plurality of photovoltaic modules **190**; c) a frame **120** which affixes or secures the plurality of photovoltaic modules **190** to the torque tube beam **250**; d) the rotatable bearing assemblies **210** of the plurality of solar tracker bearing apparatuses **200** that support the torque tube beam **250** for pivoting movement such that the table **110** may pivot or rotate about the table axis of rotation R; and e) a pivoting portion of the drive mechanism **150**, which is coupled to the torque tube beam **250** via one or more drive journals and rotates or pivots the table about the table axis of rotation R.

(28) In one exemplary embodiment, the solar tracker assembly **102** is a single row, horizontal, single axis solar tracker assembly wherein the table **110** of the solar tracker assembly **102** is rotated or pivoted by the drive mechanism **150** through the angle of inclination range AIR (schematically depicted in FIG. **5**) to track movement of the sun across the sky/horizon. The drive mechanism **150** of the solar tracker assembly **102** is controlled by the solar tracker controller **602**. As schematically depicted in FIG. **2**, the solar tracker controller **602** includes controller electronics **620** enclosed in a housing **610**. The controller electronics **620** includes an actuator for actuating the drive mechanism **150** of the solar tracker assembly **102**. In one exemplary embodiment, the drive mechanism **150** of the representative solar tracker assembly **102** comprises a single drive motor **180** operatively coupled to a single slew drive or slew gear drive **160**, which pivots the table **110** through the predetermined angle of inclination range AIR. However, one of skill in the art would appreciate that the concepts of the present disclosure are equally applicable to solar tracker systems where multiple slew drives are utilized along an extent of the table to pivot the table **110**. In one exemplary embodiment, the drive motor **180** is a DC drive motor. However, it should be recognized that the drive motor **180** may alternatively be an AC drive motor. Utilizing an AC drive motor, however, will require routing of AC power lines to the AC drive motors of each of the

plurality of solar tracker assemblies **100**. Use of an AC drive motor is within the scope of the present disclosure. If an AC drive motor is utilized, the actuator of the associated solar tracker controller **602** will be an AC motor driver, as opposed to the DC motor driver.

(29) The drive mechanism **150** of the solar tracker assembly **102** operates under the control of the solar tracker controller **602** to pivot or rotate the table **110**, including the plurality of photovoltaic modules **190**, about the table axis of rotation R. Disposed within the stationary housing **162** is a gear train of the slew drive **160** which is operatively coupled to and drives the rotating drive member **170** about a drive mechanism axis of rotation. An output shaft of the DC motor **180** is operatively connected to a gear train of the slew drive **160** such that rotation of the output shaft of the DC motor **180** rotates the slew drive gear train. The slew drive gear train, in turn, is operatively coupled to the rotating drive member **170** of the slew drive **160** such that actuation of the DC motor **180** and rotation of the DC motor output shaft causes a proportional and precise rotation of the rotating drive member **170** of the slew drive **160**. This rotation of the slew drive rotating drive member **170**, in turn, precisely rotates the table **110** of the solar tracker assembly **102** to a desired table angle of inclination AI. That is, rotation of the rotating drive member **170** of the slew drive **160** by the DC motor **180** causes a precise rotation of the table **110** of the solar tracker assembly **102** to a desired table angle of inclination AI (within, of course, the limits of the table angle of inclination range AIR).

(30) As best seen in FIGS. **2-5**, the representative solar tracker assembly **102** includes the drive mechanism **150** to rotate a table **110** of the solar tracker assembly **100** about a table axis of rotation R through the predetermined angle of inclination range AIR, that is, between the maximum negative and positive angles of inclination AI- and AI+. The table **110** of the solar tracker assembly **102** includes the frame **120** supporting a plurality of photovoltaic modules **190**, including, as schematically depicted in FIG. **2**, representative photovoltaic modules **190***a*, **190***b*, **190***c*, **190***d*, **190***e*, **190***f*. The rotatable torque tube beam **250** of the table **110**, in turn, supports the frame **120**. The plurality of bearing apparatuses **200**, including representative bearing apparatuses **202**, **204**, in turn, rotatably support the torque tube beam **250**. The torque tube beam **250** is comprised of a plurality of aligned and couple torque tube beam segments. In FIGS. **3** and **4**, portions of four torque tube beam segments, namely, first, second, third and fourth torque tube beam segments **260**, **265**, **270**, **275** of the torque tube beam **250** are schematically depicted, it being understood that the solar tracker assembly **100** includes additional torque tube beam segments not shown. The plurality of bearing apparatuses **200** are advantageously configured and positioned such that, other than the first and second torque tube beam segments **260**, **265** of the torque tube beam **250** adjacent the drive mechanism **150**, the table axis of rotation R, is vertically aligned with, that is, would pass through or be acceptably close, for design purposes, to passing through a center of gravity or center of mass of the table **110**.

(31) In one example or exemplary embodiment, the torque tube beam **250** comprises a hollow metal tube that is substantially square in cross section, having an open interior that is centered about a central longitudinal axis LA. In one exemplary embodiment, the torque tube beam **250** is approximately 100 mm. by 100 mm. (approximately 4 in. by 4 in.) and includes an upper wall **252** and the lower wall **254** spaced apart by parallel side walls **258**. The torque tube beam **250** extends along the longitudinal axis LA of the torque tube beam **250** and, as noted above, extends generally parallel to the ground G (FIG. **5**). Hence, as the ground is generally horizontal, the solar tracker assembly is referred to as a horizontal, single axis solar tracker assembly **100**. The torque tube beam **250** is comprised of a number of connected torque tube beam segments, each of which is approximately 40 feet in length. In the schematic depiction of FIGS. **2-5**, only a portion of the solar tracker assembly **100** and, thus, only a portion of the extent of the torque tube beam **250** and the frame **120** and a portion of the total number of bearing apparatuses of the plurality of bearing apparatuses **200** are shown. For example, in FIGS. **3** and **4**, the first and second torque tube beam segments **260**, **265** and portions of the third and fourth torque tube beam segments **270**, **275** are

schematically depicted.

(32) Depending on the table configuration, the plurality of photovoltaic modules **190** may be in landscape or portrait orientation with respect to the torque tube beam **250**. For example, in a so-called "one-in-portrait" photovoltaic module mounting configuration for the solar tracker assembly **102**, a single row of photovoltaic modules overlie the torque tube beam **250** and extend outwardly in an east-west direction from the torque tube beam **250**. If each of the photovoltaic modules of the plurality of photovoltaic modules **190** of the solar tracker assembly **102** includes a six foot long by three foot wide photovoltaic module which is mounted to the torque tube beam **250** by the frame **120**, then approximately three feet of each photovoltaic module will extend outwardly on either side of a center of the torque tube beam **250**, as the solar tracker assembly **102** is viewed in top plan view. To achieve a proper balance, the photovoltaic modules of the solar tracker assembly are positioned such that that a total weight of the frame **120**, including the plurality of photovoltaic modules **190** and associated mounting components of the frame **120** (e.g., module rails, clamps, brackets and fasteners), are approximately equally distributed on either side of the torque tube beam **250**, as viewed in top plan view. As viewed in top plan view, an extent of each photovoltaic module, as measured in an east-west direction, when the module **190***a* is horizontal, is referred to as a "chord" or "chord value", while a distance between adjacent solar tracker assemblies, for example, adjacent solar tracker assemblies **102**, **104**, as measured between center lines of the torque tube beam **250**, is referred to as a "pitch" or "pitch distance". The ratio of chord to pitch is typically about 3:1 for a so-called "one-in-portrait" photovoltaic module mounting configuration. For example, if the photovoltaic modules each have a dimension of 6 feet by 3 feet, in a "one-in-portrait" photovoltaic module mounting configuration, each module is mounted to the torque tube beam **250** such that the 6 foot length of the photovoltaic module extends in the east-west direction and the three foot length extends along the torque tube beam in the north-south direction. In such a "one-in-portrait" configuration, the chord value CH is six feet, while the pitch distance P will be on the order of 18-20 feet. Accordingly, a distance D between facing edges **191**, **192** of the photovoltaic modules **190** of solar tracker assemblies **102**, **103** would be 12-14 feet. Of course, it should be appreciated that given that a torque tube beam segment is typically 40 feet in length and a typical photovoltaic module, such as the representative photovoltaic module **190***a* is approximately 3 feet by 6 feet and is mounted to the torque tube beam **250** in portrait orientation, many more photovoltaic modules would be present on any given torque tube beam segment than is schematically depicted in the FIGS. **1-4**.

(33) As noted above, in the solar tracker installation **1000**, the first set of solar tracker assemblies **109***a* includes a number of parallel, spaced apart solar tracker assemblies or rows **102**, **103**, **104**, **106**, **107**, **108**, extend in a north—south direction so that the table **110** of each of the solar tracker assemblies can pivot to allow the plurality of photovoltaic modules of a solar tracker assembly to follow the path or arc of the sun as it moves across the sky during daylight hours to thereby maximize energy output during daylight hours. The torque tube beam **250** of a given solar tracker assembly, for example solar tracker assembly **102**, defines a length or extent of the solar tracker assembly **102**, extending in the north-south direction. Adjacent solar tracker assemblies on one or both sides of the solar tracker assembly **102** similarly extend in parallel, spaced apart configuration in a north-south orientation in the solar tracker installation, e.g., solar tracker assembly **103** is in parallel, spaced apart, aligned relationship with solar tracker assembly **102**, while solar tracker assemblies **102**, **104** are in parallel, spaced apart, aligned relationship with solar tracker assembly **103**. As shown schematically in FIG. **1**, the plurality of solar tracker assemblies **100** are located on a solar tracker installation site **1002** and are constructed or positioned on the site **1002** in one or more sets of parallel solar tracker assemblies **109***a*, **109***b*. Each set of solar tracker assemblies **109***a*, **109***b* includes a group of parallel, spaced apart solar tracker assemblies, for example, the set of solar tracker assemblies **109***a* includes representative rows of parallel, spaced apart solar tracker assemblies **102**, **103**, **104**, **106**, **107**, **108**. It should be understood, of course, that the number of

solar tracker assemblies in the solar tracker assembly first set **109***a* and/or the solar tracker assembly second set **109***b* could include up to hundreds of parallel rows of solar tracker assemblies on the installation site **1002**. The solar tracker assemblies of the set of solar tracker assemblies are oriented in a north-south direction so that a plurality of photovoltaic modules **190** of each of the solar tracker assemblies may be pivoted so as to track the sun as it moves from east to west across the sky. While the parallel solar tracker assemblies of the set of solar tracker assemblies **109** are uniformly spaced apart, the spacing between adjacent solar tracker assemblies (referred to as adjacent rows of solar tracker assemblies, for example, adjacent rows **102**, **103**) it is desired to minimize spacing so that the total number of solar tracker assemblies disposed on the installation site **1002** can be maximized to thereby maximize energy output from the solar tracker installation **1000**

(34) The plurality of bearing apparatuses **200** are positioned at spaced apart positions along the torque tube beam **250**. Each bearing apparatus of the plurality of bearing apparatuses **200** includes the movable or rotatable bearing assembly **210** supporting the torque tube beam **250**, a stationary saddle assembly **220**, and a connecting assembly **230**. The stationary saddle assembly constrains the pivoting or rotation of the rotatable bearing assembly **210** such that the bearing assembly **210** and the torque tube section extending through and supported by the rotatable bearing assembly **210** rotate about a bearing axis of rotation. The bearing axis of rotation defines a portion of the table axis of rotation R. The stationary saddle assembly **220** is mounted by the connecting assembly **230** to a support post **140**, which is driven into the ground/substrate G or otherwise secured in the ground/substrate by, for example, concrete. Thus, the support post **140** and connecting assembly **230** determine the position and the vertical height of the rotatable bearing assembly **210** and, thereby, determine a height of the torque tube beam **250** with respect to the ground G. Each of the support posts **140** extend in the vertical direction V along a vertical center line or central vertical axis PCVA (FIG. **5**) of the support post **140**.

(35) Each bearing apparatus of the plurality of bearing apparatuses **200**, for example first and second bearing apparatuses **202**, **204**, includes the rotatable or rotating bearing assembly **210**, the stationary saddle assembly **220** and the connecting assembly **230** (FIGS. **3** and **5**). The torque tube beam **250** extends through and is supported by the rotatable bearing assembly **210** which rotates the torque tube beam **250** about the table axis of rotation R. The rotatable bearing assembly **210** of the bearing apparatus **200**, in turn, is supported by the stationary saddle assembly **220**. The stationary saddle assembly **220** constrains the pivoting or rotation of the rotatable bearing assembly **210** such that the bearing assembly and the torque tube section extending through and supported by the rotatable bearing assembly **210** rotate about a bearing axis of rotation. The table axis of rotation R (except in the region of the slew drive **160**) is collectively defined by axes of rotation of the plurality of bearing apparatuses **200** positioned at spaced apart internals along the extent of the torque tube beam **250**. Stated another way, each bearing axis of rotation of each bearing apparatus defines a portion of the overall table axis of rotation R. The individual axis of rotation of each of the plurality of solar tracker bearing apparatuses **200** are substantially aligned to or coincident to form a single or combined table axis of rotation R. As best seen in FIGS. **2** and **3**, in the region of the slew drive **160**, the table axis of rotation R is defined by: a) the axes of rotation of the first and second bearing apparatus **202**, **204** of the plurality of bearing apparatuses **200**; and b) the center of rotation of the rotating member **170** of the slew drive **160** and a pair of drive journals **300**, namely, first and second drive journals **310**, **350**, which are affixed to opposite sides **172**, **174** of the rotating member **170** and, in turn, receive end portions of the first and second torque tube beam segments **260**, **265**.

(36) Additional details regarding the structure and function of a horizontal, single axis solar tracker assembly are disclosed in U.S. Pat. No. 10,944,354 to Ballentine et al., issued Mar. 9, 2021 (“the '354 patent”), and U.S. Pat. No. 11,271,518 to Ballentine et al., issued Mar. 8, 2022 (“the '518 patent”), both of which are assigned to the assignee of the present application. Both the '354 patent

and the '518 patent are incorporated by reference herein in their respective entireties.
(37) In one example embodiment, the housing **610** of the solar tracker controller **602**, enclosing electronics **620** of the controller, is mounted to a lower wall **254** of the torque tube beam **250** of the solar tracker assembly **102** and the solar tracker controller **602** is powered by the dedicated photovoltaic module **647**, which is also mounted to the torque tube beam **250**. The dedicated photovoltaic module **647** is mounted to the torque tube beam **250** such that it is aligned with the plurality of photovoltaic modules **190** and pivots with the plurality of photovoltaic modules **190** through the table angle of inclination AI. As best seen in FIGS. **2-5**, the representative solar tracker assembly **102** includes the drive mechanism **150** to rotate the table **110** of the solar tracker assembly **100** about a table axis of rotation R through the predetermined angle of inclination range AIR. The table **110** of the solar tracker assembly **102** includes the frame **120** supporting a plurality of photovoltaic modules **190**, including, as schematically depicted in FIG. **2**, representative photovoltaic modules **190***a*, **190***b*, **190***c*, **190***d*, **190***e*, **190***f*.
(38) The rotatable torque tube beam **250** of the table **110**, in turn, supports the frame **120**. The plurality of bearing apparatuses **200**, including representative bearing apparatuses **202**, **204** (FIGS. **3** and **4**), in turn, rotatably support the torque tube beam **250**. The torque tube beam **250** is comprised of a plurality of aligned and couple torque tube beam segments. In FIGS. **3** and **4**, portions of four torque tube beam segments, namely, first, second, third and fourth torque tube beam segments **260**, **265**, **270**, **275** of the torque tube beam **250** are schematically depicted, it being understood that the solar tracker assembly **100** includes additional torque tube beam segments not shown. The plurality of bearing apparatuses **200** are advantageously configured and positioned such that, other than the first and second torque tube beam segments **260**, **265** of the torque tube beam **250** adjacent the drive mechanism **150**, the table axis of rotation R, is vertically aligned with, that is, would pass through or be acceptably close, for design purposes, to passing through a center of gravity or center of mass of the table **110**.
(39) Each of the solar tracker controllers of the plurality of solar tracker controllers **600** may be considered to be part of its associated solar tracker assembly of the plurality of solar tracker assemblies **100**. For example, the solar tracker assembly **602** may be considered as a component of its associated solar tracker assembly **102**. Additionally, each of the solar tracker controllers of the plurality of solar tracker controllers **600**, for example, representative solar tracker controller **602**, is also part of the solar tracker control and communications system **500**. In FIG. **5**, the angle of inclination range AIR of the table **110** of the solar tracker assembly **102** is schematically depicted, along with maximum positive and negative table angles of inclination AI+, AI−. In FIG. **5**, a representative photovoltaic module **190***a* of the solar tracker assembly **102** is shown in dashed line with a neutral angle of inclination AIN, which means the photovoltaic module **190***a* (and therefore, the table **110** of the solar tracker assembly **102**) is horizontal, facing directly upward, for example, when the sun is at its apex in the sky.
(40) Backtracking Method **1100**
(41) The backtracking method **1100** of the present disclosure advantageously employs the backtracking algorithm or routine **1120**. The backtracking algorithm **1120**, in one exemplary embodiment, is a heuristic methodology which provides calculated backtracking angle of inclination values CAI (calculated angles of inclination or calculated angle of inclination values) for each of the solar tracker assemblies in the first set of solar tracker assemblies **109***a* for each daylight period for each day of the expected useful life of the solar tracker assemblies of the first set **109***a*. It should be understood, of course, the backtracking algorithm **1120** will similarly calculate backtracking angles of inclination CAI for all of the other sets of adjacent row solar tracker assemblies of the solar tracker installation **1000**, for example, calculating backtracking angles of inclination CAI for the second set **109***b* of solar tracker assemblies **100** of the installation **1000**. The calculated backtracking angle of inclination value CAI can be viewed as deviating from or modifying the angles of inclination or angle of inclination positions that would otherwise be

used in a normal solar tracking mode of operation **1200**. The calculated backtracking angle of inclination values CAI mitigate row-to-row shading of one or more of the plurality of photovoltaic modules **190** of a solar tracker assembly by the plurality of photovoltaic modules **190** of an adjacent solar tracker assembly within the first set of solar tracker assemblies **109***a* which would otherwise occur during early morning daylight hours and late evening daylight hours due to the sun's low position with respect to the horizon if table angle of inclination positions were set in accordance with the normal solar tracking mode **1200**. Stated another way, the backtracking method **1100** provides calculated backtracking angles of inclination values CAI that modify or change the angles of inclination that would otherwise be as a result of the first set of solar tracker controllers **609***a* operating in the normal solar tracking mode **1200**.

(42) The backtracking algorithm **1100** calculates the calculated backtracking angle of inclination values CIA to mitigate row-to-row shading by the plurality of photovoltaic modules **190** of adjacent solar tracker modules of the first set of solar tracker assemblies **109***a* that would otherwise occur if the normal solar tracking mode of operation **1200** was used during post-sunrise and pre-sunset period. In one example or exemplary embodiment, the backtracking algorithm **1100** involves an iterative, heuristic procedure or set of calculations because the row-to-row shading problem must be considered along an entirety of the solar tracker assemblies of the first set of aligned solar tracker assemblies **109***a*. That is, if one angle of inclination of one solar tracker assembly in the first set **109***a* is changed from what would otherwise be the angle of inclination position used in the normal solar tracking mode **1200** to mitigate shading of the plurality of photovoltaic modules **190** of its neighboring adjacent solar tracker assembly, such a deviation or change of the table angle of inclination AI will necessarily have a ripple effect. That is, changing one angle of inclination may result in the changing of the angles of inclination of the two adjacent solar tracker assemblies on either side of the one solar tracker assembly and changing the angles of inclinations of the two adjacent solar tracker assemblies may result in changing the angles of inclination of the next two adjacent solar tracker assemblies and so on throughout the entirety of the first set of solar tracker assemblies **109***a*. Hence, the backtracking algorithm **110** may have to cycle through multiple iterations to arrive at a final set of calculated backtracking angle of inclination values CAI for each of the solar tracker assemblies of the first set of solar tracker assemblies **109***a* during morning and evening backtracking periods BTM, BTE over the expected life of the solar tracker assemblies of the first set of solar tracker assemblies **109***a*. The set of calculated backtracking angle of inclination values CAI is generated by the backtracking algorithm **1100** and are used by the first set of solar tracker controllers **609***a* to set table angles of inclination AI for their associate solar tracker assemblies of the first set of solar tracker assemblies **109***a*. A duration of time that the calculated set of values CAI are used by the first set of solar tracker controllers **609***a* to set table angles of inclination AI is what defines the backtracking period BT and, more specifically, the morning and evening backtracking periods BTM, BTE. Thus, the daylight time period for a given day may be viewed as commencing with a backtracking mode of operation **1110** just after sunrise SR wherein calculated backtracking angle of inclination values CIA are utilized by a solar tracker controller to set the table angles of inclination of its associated solar tracker assembly during a morning backtracking period BTM, then entering the normal solar tracking mode **1200** and setting the table angles of inclination utilizing angle of inclination positions utilizing appropriate sun position data for that day, and then, prior to sunset SS, the solar tracker controller reentering the backtracking mode **1110** and utilizing the calculated backtracking angle of inclination values CAI to set the table angles of inclination of its associated solar tracker assembly during an evening backtracking period BTE.

(43) The deviation of the calculated backtracking angle of inclination values CAI utilized in the backtracking mode **1120** from the angle of inclination positions that would otherwise be used in the normal tracking mode **1200** is schematically illustrated in the time chart presented in FIG. **11** which plots time vs. table angle of inclination AI, for a representative solar tracker assembly wherein the

solar tracker assembly includes adjacent solar tracker assembly both to the east and the west of the solar tracker assembly, for example, in FIG. **1**, the representative solar tracker assembly could be solar tracker assembly **103** of the first set of solar tracker assemblies **109***a*. Looking at FIG. **11**, just after midnight (12:00 AM), the table angle of inclination AI of the representative solar tracker assembly **103** is in a night stow mode **1300** wherein the associated solar tracker controller **603** maintains the table **110** in a night stow position NSP of, in one example embodiment, AI=−30 degrees. At sunrise SR, the solar tracker controller **604** pivots the table **110** to the horizontal position AI=0 degrees. If the normal solar tracking mode **1200** were utilized, the solar tracker controller **603** would attempt, just after sunrise SR, to pivot the table **1110** to the maximum table angle of inclination in the easterly direction, namely, AI=−60 degrees to face, within the limits of the angle of inclination range AIR of the table **110**, the rising easterly sun. However, such a maximum easterly angle of inclination of AI=−60 degrees would result in shading a lower portion of the plurality of photovoltaic panels **190** its adjacent western row solar tracker assembly, namely, solar tracker assembly **104** in FIG. **1**. For example, for example, FIG. **6** schematically illustrates such an easterly row-to-row shading problem for the plurality of photovoltaic modules **190** of solar tracker assembly **103** by the plurality of photovoltaic modules **190** of its easterly adjacent solar tracker assemblies **102** of the first set of solar tracker assemblies **109***a* resulting in a shading region labeled SH in FIG. **6**. Similarly, the same type of shading problem would occur for the plurality of photovoltaic modules **190** of solar tracker assembly **104** by the plurality of photovoltaic modules **190** of its easterly adjacent solar tracker assemblies **103**.

(44) The duration of the shading problem during the post-sunrise morning period would continue until the sun's position in the sky were high enough such that there was no longer any row-to-row shading of photovoltaic modules occurring between adjacent rows of the solar tracker assemblies of the first set of solar tracker assemblies **109***a*. At that time, the solar tracker controllers of the first set of solar tracker controllers **609***a* would switch from backtracking mode **1110** to normal solar tracking mode **1200** and the table angle of inclination positions would be set to AI=−60 degrees, as seen in FIG. **11**. The duration of the morning backtracking period BTM, commencing at sunrise SR, is shown in FIG. **11**, as is the evening backtracking period BTE, ending at sunset SS, is also shown in FIG. **11**. The calculated backtracking table angle of inclination values for the morning backtracking period BTM, utilized by the solar tracker controller **603** to set the table angles of inclination for the solar tracker assembly **103** in the backtracking mode **1110** during the morning backtracking period BTM, are labeled as angle of inclination values CAIM in FIG. **11**, while the calculated backtracking table angle of inclination values for the evening backtracking period BTE, utilized by the solar tracker controller **603** to set the table angles of inclination for the solar tracker assembly **103** in the backtracking mode **1110** during the evening backtracking period BTE, are labeled as calculated morning backtracking table angle of inclinations values CAIE in FIG. **11**. The table angle of inclination positions, utilized by the solar tracker controller **603** to set the table angles of inclination for the solar tracker assembly **103** during daylight hours other than the backtracking period BT in the normal solar tracking mode **1200**, are labeled as angle of inclination positions NTP in FIG. **11**.

(45) Stated another way, in the backtracking mode **1110**, to mitigate potential row-to-row shading problem that would otherwise occur if the angle of inclination positions of the normal solar tracking mode **1200** were used, the solar tracker controller **603** uses the calculated backtracking angles of inclination values CAI to pivot the table **110** during the duration of the morning backtracking period BTM to follow or conform to the calculated backtracking angle of inclination values labeled as CAIM (morning backtracking table angle of inclination values) in FIG. **11**. The morning backtracking table positions CAIM utilized during the morning backtracking period BTM may be viewed as a modification of or a deviation from the table positions that would otherwise be used during the normal tracking mode **1200**. That is, as can be discerned from FIG. **11**, during the morning backtracking period BTM, the table angle of inclination would be constant at AI=−60

degrees if the normal solar tracking mode were utilized by the solar tracker controller **603**. The backtracking mode **1110** deviates from or modifies the table angle of inclination positions that would otherwise be used to track the sun's position in the normal solar tracking mode **1200**. An objective of the backtracking mode **1110** is to mitigate row-to-row shading that would occur under the normal solar tracking mode **1200** during daylight hours immediately after sunrise.

(46) As the sun's position moves toward sunset SS at the end of the daylight period, again the row-to-row shading problem arises, this time in a westerly direction. That is, utilizing the normal solar tracking mode **1200**, as is depicted in FIG. **11**, the solar tracker controller **603** has pivoted the table **110** of the solar tracker assembly **103** to the maximum table angle of inclination in the westerly direction, namely, AI=+60 degrees to face, within the angle of inclination range AIR of the table **110**, the westerly setting sun. However, such a maximum westerly angle of inclination of AI=+60 degree would have the tendency to shade a lower portion of the plurality of photovoltaic panels **190** its adjacent eastern row solar tracker assembly, namely, solar tracker assembly **102** (see, for example, FIG. **8** which illustrates the westerly row-to-row shading problem for adjacent solar tracker assemblies **107**, **108** of the first set of solar tracker assemblies **109***a*).

(47) To mitigate this potential row-to-row shading problem that would otherwise occur if the angles of inclination of the normal solar tracking mode **1200** were used, the solar tracker controller **603** instead uses the calculated backtracking angle of inclination values CAI to pivot the table **110** during the evening backtracking period BTE to follow or conform to the calculated backtracking table angle of inclination values labeled as CAIE (evening backtracking table angle of inclination values) in FIG. **11**. At sunset SS, the evening backtracking period BTE terminates and the solar tracker controller **603** modes to the night stow mode **1300** and the table angle of inclination is again set to the night stow position NSP, that is, AI=−30 degrees. The evening backtracking table angle of inclination values CAIE utilized during the evening backtracking period BTE may be viewed as a modification of or a deviation from the table positions that would otherwise be used during the normal tracking mode **1200**. That is, as can be discerned from FIG. **11**, during the evening backtracking period BTE, the table angle of inclination would be AI=+60 degrees if the normal solar tracking mode were utilized by the solar tracker controller **603**. The backtracking mode **1110** deviates from or modifies the table angle of inclination positions that would otherwise be used to track the sun's position in the normal solar tracking mode **1200**. An objective of the backtracking mode **1110** is to mitigate row-to-row shading that would occur under the normal solar tracking mode **1200** during daylight hours just prior to sunset.

(48) During the normal solar tracking period NT, the solar tracker controller **603** utilizes table angle of inclination positions that track the sun's position, within the limits of the table angle of inclination range AIR. As can be seen in FIG. **11**, the normal tracking position NTP moves gradually during daylight hours from AI=−60 degrees in the morning to AI=+60 degrees in the evening. Given certain input data regarding the position and spacing of the solar tracker assemblies of the first set of solar tracker assemblies **109**, a sun position table which provides the position of the sun as measured along an east—west direction at the solar tracker installation site **1002**, and the table angle of inclination range AIR, the backtracking method is applied to calculate backtracking angle of inclination value CAI for each of the solar tracker assemblies in the first set of solar tracker assemblies **109***a* such that the row-to-row shading between adjacent solar tracker assemblies of the first set of solar tracker assemblies **109***a*. In one respect backtracking may be viewed as a backtracking mode of operation **1110** by the solar tracker controllers of the first set of solar tracker controllers **609***a*. That is, during daylight hours, for a given time t, if there is a calculated backtracking angle of inclination values CAI, the solar tracker controllers of first set of solar tracker controllers **609***a* will operate in backtracking mode **1110** and will set the table angles of inclination AI of their associated solar tracker assemblies of the first set of solar tracker assemblies **109***a* in accordance with the backtracking angle of inclination value CAI for that time t, as opposed to using the angle of inclination positions provided by or conforming to the normal

solar tracking mode **1200**. When the first set of solar tracker controllers **609***a* are utilizing the backtracking angle of inclination values CAI, as opposed to using the angles of inclination that would otherwise be used under the normal solar tracking mode **1200** during specific post-sunrise and pre-sunset daylight hours, this is referred to herein as operating in the backtracking mode **1110**. The period of time during which the backtracking mode **1110** is utilized by the first set of solar tracker controllers **609***a* is referred to as a backtracking period BT, as opposed to a normal solar tracking period NT. The backtracking period BT includes an early morning backtracking period BTM, just after sunrise, and also includes a late evening backtracking periods BTE, just before sunset. During the morning backtracking period BTM, potential row-to-row shading occurs because of the sun's low position in the eastern sky, for example, sun position SP**1**, as schematically illustrated in FIG. **6**, while during the evening backtracking period BTE, potential row-to-row shading occurs because of the sun's low position in the western sky, for example, sun position SP**2**, as schematically illustrated in FIG. **8**.

(49) The backtracking period BT, including the morning and evening backtracking periods BTM, BTE can be understood as follows. Ideally, during daylight period, the angle of inclination of the tables **110** of the respective solar tracker assemblies of the first set of solar tracker assemblies **109***a* is set in accordance with the normal sun tracking mode or routine **1200**, that is, in general terms, during daylight hours, the normal sun tracking mode **1200** would calculation the angles of inclination such that the tables **110** point toward the sun's position in the sky, as viewed along an east-west axis. Looking at, for example, FIGS. **6-8**, the sun position is SP**1** in FIGS. **6** and **7**, and is SP**2** in FIG. **8**. The angular position of the sun is labeled SA**1** in FIGS. **6** and **7** and is labeled SA**2** in FIG. **8**. In the normal tracking mode **1200**, a sun position algorithm is used, along with coordinates of longitude and latitude of the solar tracker installation site **1002**. The result of the sun position algorithm is that a sun position table is generated for which corresponds sun position angle values for each date/time period for an extended time period (e.g., 20-30 years or more). In the normal tracking mode **1200**, the solar tracker controllers, for example, solar tracker controller **602** directs the drive mechanism **150** to aim the table **110**, that is, aim the plurality of photovoltaic modules **190** at the sun, within, of course, the angle of inclination range AIR of the table **110**. During the backtracking period BT, if the normal sun tracking mode **1200** were used to set the table angles of inclination, undesirable row-to-row shading between adjacent solar tracker assemblies would occur. Thus, in one sense, the backtracking period BT can be defined as a period during which, if the normal sun tracking mode **1200** were utilized undesirable row-to-row shading would occur. The morning backtracking period BTM is a morning post-sunrise portion of the backtracking period BT, in which, if the normal sun tracking mode **1200** were utilized, undesirable row-to-row shading would occur as a result of the sun's position in the eastern sky (FIGS. **6** and **7**), while the evening backtracking period BTE is an evening pre-sunset portion of the backtracking period BT, in which, if the normal sun tracking mode **1200** were utilized, undesirable row-to-row shading would occur as a result of the sun's position in the western sky (FIG. **8**). Thus, in one sense, the backtracking calculated angle of inclination values CAI resulting from the backtracking method **1100** and utilized in the backtracking mode **1110** can be viewed as a deviation from the angles of inclination positions used in the normal tracking mode **1200**. The backtracking calculated angles of inclination values CAI of the backtracking mode **1110** may be viewed as deviations or deltas from the angle of inclination positions of the normal tracking mode **1200** during a portion of daylight hours referred to as the backtracking period or equally well the calculated angle of inclination values CAI of the backtracking mode **1110** may be viewed as angles of inclination used during a portion of the daylight hours referred to the backtracking period. In either case, the calculated backtracking angle of inclination value CAI, as utilized by the first set of solar tracker controllers **609***a* to set table angles of inclination for the first set of solar tracker assemblies **109***a* mitigate undesirable row-to-row shading that would otherwise occur between adjacent solar tracker assemblies of the set of solar tracker assemblies **109***a* during the morning and evening backtracking

periods BTM, BTE of the daylight hours.

(50) In the normal tracking mode **1200**, a solar tracker controller, for example, solar tracker controller **602** associated with the solar tracker assembly **102**, utilizing a sun position table, directs the drive mechanism **150** of its associated solar tracker assembly **102** to pivot the table of the solar tracker assembly **102** to, within the constraints of the angle of inclination range AIR of the table **110**, point the upper surfaces of the photovoltaic modules **190** of the table **110** at the sun S as the sun moves across the sky from sunrise to sunset. That is, the upper surfaces of the photovoltaic modules are normal or orthogonal to the sun as the sun moves across the sky. Instead, during the backtracking period BT, specifically, in the backtracking mode **1110**, the solar tracker controller **602** deviates from the calculated angle of inclination of the normal tracking mode **1200** and instead utilizes the calculated backtracking table angle of inclination positions or values CAI and commands the drive mechanism **150** to pivot the table angle of inclination AI in accordance with the calculated table angle of inclination values CAI during the backtracking period BT. As noted above, in one example embodiment, the backtracking algorithm **1100** used to calculate the backtracking table angle of inclination values CAI may be executed by the array controller **510** or by the solar tracker controller **602** and the values CAI communicated to each of the controllers of the set of solar tracker controllers **609***a* of the set of solar tracker assemblies **109***a*. Alternately, the calculated backtracking table angle of inclination values CAI, in another example embodiment, may be executed by each of the set of solar tracker controllers **609***a* of the set of solar tracker assemblies **109***a* and the values CAI used directly by each controller to control its respective table angle of inclination AI. As explained above, in one sense, the calculated angle of inclination values CAI utilized by the solar tracker controller in the backtracking mode **1110** during the backtracking period BT can be viewed as a deviation or modification of the table angle of inclination values AI that would otherwise be utilizing by the solar tracker controller **602** during normal tracking mode **1200** to mitigate shading problems between adjacent solar tracker assemblies.

(51) Again, for brevity, discussion will be with respect calculating angles of inclination AI during a backtracking period BT for tables **110** of selected solar tracker assemblies of the first set of solar tracker assemblies **109***a*, with the understanding that the discussion similarly applies to calculation of angles of inclination AI during the backtracking period BT for the tables **110** of the remaining solar tracker assemblies of the first set of solar tracker assemblies **109***a*, as well as the solar tracker assemblies of other sets of solar tracker assemblies of the solar tracker installation **1000**, including the second set of solar tracker assemblies **109***b* of the solar tracker installation **1000**. In one exemplary embodiment, the backtracker period BT includes the morning backtracker period BTM, subsequent to sunrise, and the evening backtracking period BTE, subsequent to sunset. Advantageously, in accord with the backtracking method **1100**, in one exemplary embodiment, the array controller **510** executes the backtracking algorithm **1120** and calculates table angles of inclination CAI for each solar tracker assembly of the set of solar tracker assemblies **109***a* for the morning and evening backtracking periods BTM, BTE based on data including: a) sun position data provided by a sun position table accessible to the array controller **510**; b) pitch data P for each of the solar tracker assemblies of the set of solar tracker assemblies **109***a*, the pitch being the distance between torque tube beams **250** of adjacent solar tracker assemblies or rows of the first set of solar tracker assemblies **109***a*; c) chord data CH corresponding to a width of each table **110** of the set of solar tracker assemblies **109***a*; and d) vertical height data HT corresponding to a vertical height of a torque tube beam **250** above the ground G for each table **110** of the set of solar tracker assemblies **109***a*. Utilizing the backtracking method **1120**, in one example embodiment, the array controller **520** generates calculated table angles of inclination CAI for each of the set of solar tracker assemblies **109***a* during the morning and evening backtracking periods BTM, BTE. The calculated table angle of inclination values CAI, for example, the calculated table angles of inclination CAI for the solar tracker assembly **102** are transmitted by the array controller **510** to the associated solar tracker controller **602**. The solar tracker controller **602** then utilizes the calculated

table angles of inclination values CAI to control angles of inclination AI of respective tables **110** of the set of solar tracker assemblies **109***a*. The calculated table angle of inclination values CAI generated by the array controller **510** utilizing the backtracking algorithm **1120** are utilized by the plurality of solar tracker controllers **609***a* to control the table angles of inclination AI of the set of solar tracker assemblies **109***a* to advantageously mitigate row-to-row shading of photovoltaic modules of one row or solar tracker assembly by the photovoltaic modules of an adjacent row or adjacent solar tracker assembly that otherwise would occur during morning and evening backtracking periods BTM, BTE if the normal sun tracking mode **1200** were employed by the plurality of solar tracker controllers **609***a* to control angles of inclination AI of the respective tables **110** of the set of solar tracker assemblies **109***a*.
(52) The backtracking method **1100** of the present disclosure also includes the method of imaging **1400** each of the plurality of solar tracker assemblies **100** of the installation to image and accurately determine three dimensional coordinates or three dimensional coordinate values **410** of one or more selected elements or features **400** of a solar tracker assembly, for example, solar tracker assembly **102**. The terms three dimension coordinates, three dimension coordinate values, three dimensional coordinates, three dimensional coordinate values, coordinates, and coordinate values as used herein will be understood to be interchangeable and will be associated with reference number **400**. A flow chart depicting selected steps of the method of imaging **1400** is set forth in FIG. **15**, while a flow chart depicting selected steps of the method of imaging **1400**, as applied to an example embodiment wherein two selected elements **400** (namely, endcaps **290**, **292**) of the solar tracker assembly **102** is shown as method of imaging **1420** in FIG. **14**. The coordinate values **410** in the method of imaging **1420** are three dimensional coordinate values **280***a*, **282***a*. The accurate three dimension coordinate values **400** resulting from the method of imaging **1400** are input to the backtracking algorithm **1120** and permit the algorithm to account for vertical or height differences between the tables of adjacent solar tracker assemblies (for example, solar tracker assemblies **102**, **103** depicted in FIGS. **6** & **7**) which may occur due to undulations of the ground level G over an extent of an installation site **1002** of the solar tracker installation **1000**. The imaging of the solar tracker assemblies **100** of the installation **1000** facilitates the determination of accurate three dimensional coordinate values **410** associated with one or more elements or features **400** of each solar tracker assembly of the plurality of solar tracker assemblies **100** such that when the three dimensional coordinate values **410** corresponding to the selected elements are input to the backtracking algorithm **1120**, the calculated angles of inclination CAI are more accurate and valid than would otherwise be the case if: a) estimated coordinate values were input to the backtracking algorithm **1120**; or b) if the backtracking algorithm calculations were made with the simplifying assumption that all tables of the plurality of solar tracker assemblies **100** were at the same vertical height.
(53) In one exemplary or example embodiment, the method of imaging **1400** utilizes a drone DR (schematically depicted in FIGS. **1** and **9**) having an imaging system **1450** to image one or more elements or features of interest or selected elements **400** of each solar tracker assembly of the plurality of solar tracker assemblies **100**. The purpose of imaging the one or more selected elements **400** for a given solar tracker assembly, for example, solar tracker assembly **102** of the set of solar tracker assemblies **109***a* of the plurality of solar tracker assemblies **100**, is to accurately obtain three dimensional coordinates **410** for each of the one or more selected elements **400** of the solar tracker assembly **102**. The calculated three dimensional coordinates **410** associated with the solar tracker assembly **102** are input to the backtracking algorithm **1120** and utilized by the backtracking algorithm **1120** to determine table angles of inclination AI of the set of solar tracker assemblies **109***a* to advantageously mitigate row-to-row shading of photovoltaic modules of one row or solar tracker assembly by the photovoltaic modules of an adjacent row or adjacent solar tracker assembly that otherwise would occur during morning and evening backtracking periods BTM, BTE for the backtracking periods. A simplified flow chart generally illustrating selected steps of the method of

imaging **1400** is depicted in FIG. **15**, while a more specific flow chart illustrated one example embodiment of the method of imaging **1400** is depicted in FIG. **14** wherein the one or more selected elements **400** are first and second end caps **282***a*, **282***b* overlying the first and second ends **280**, **282** of torque tube beams **250** of the tables **150** of each of the solar tracker assemblies of the plurality of solar tracker assemblies **100**. The method of imaging **1400** also utilizes imaging software **1401** (schematically depicted in FIG. **1**) to analyze the imaged data or image data (images or image frames), identify within the images the selected elements **400**, e.g., the end caps **290**, **292** of the first and second ends **280**, **282** of the torque tube beam **250**, and determine three dimensional coordinate values **410** for each element **400**, for example, a three dimensional coordinate value **280***a* associated with and corresponding to the first end cap **290** and a three dimensional coordinate value **282***a* associated with and corresponding to the second end cap **292** of the torque tube beam **250** of the table **200** of the solar tracker assembly **102**.

(54) The imaging system **1450** of the drone DR is characterized by the field of view **1450***a*, schematically depicted in FIGS. **1** and **9**. As the drone DR flies or hovers over the solar tracker installation site **1002**, the imaging system **1450** takes many images or image frames of the plurality of solar tracker assemblies **100** of the solar tracker installation **1000**. The imaging software associated with the imaging system **1450** performs the following functions: a) analyzing the images or image frames generated by the imaging system **1450**; b) identifying the one or more selected elements or features **400** of each solar tracker assembly, for example, identifying first and second ends or end portions **280**, **282** of the torque tube **250** of each solar tracker assembly of the installation **1000**, for example, solar tracker assembly **102**, of the plurality of solar tracker assemblies **100**; and c) determining the three dimensional coordinates or three dimensional coordinate values **410** corresponding to the location of the selected elements or features of each of the plurality of solar tracker assemblies **100** of the installation **1000**, for example, the three dimensional coordinate values **280***a*, **282***a* of the first and second ends **280**, **282** of the torque tube beam **250** of the solar tracker assembly **102**. In the foregoing example embodiment, obtaining coordinates of the torque tube beam ends **280**, **282** for the table **120** of a solar tracker assembly allows an accurate estimate of the coordinates of a middle portion of the torque tube beam because, generally, the respective torque tube beams of each of the solar tracker assemblies are constructed such that the torque tube beams are linear or straight from one end **280** of the torque tube beam **250** to the other end **282** of the beam **250**. Thus, the coordinates of the ends **280**, **282** of the torque tube beam **250** allow the backtracking algorithm **1120** to optimize backtracking, that is, calculating table angle of inclination values CAI such that row-to-row shading of photovoltaic modules of a solar tracker assembly by adjacent row solar tracker assemblies, in the east and west directions, of the solar tracker assembly, is minimized during morning and evening backtracking periods BTM, BTE.

(55) As previously discussed, it is assumed that the plurality of solar tracker assemblies **100** of the solar tracker installation **1000** are arranged in one or more sets of parallel, aligned, spaced apart solar tracker assemblies on an installation site **1102**. For example, FIG. **1** schematically illustrates two such sets of solar tracker assemblies, namely, sets of solar tracker assemblies **109***a*, **109***b* located on the installation site **1002**. As schematically depicted in FIG. **1**, the first set of solar tracker assemblies **109***a* includes from east to west, rows of solar tracker assemblies **102**, **103**, **104**, **106**, **107**, **108** (recognizing, of course, that in an actual solar tracker installation, the number of rows, that is, the number of parallel, spaced apart solar tracker assemblies comprising the first set **109***a* would typically include more than six rows of solar tracker assemblies and, defending on the size of the installation site **1002**, could include up to hundreds of rows of spaced apart, parallel, aligned rows of solar tracker assemblies). The presence of additional rows of solar tracker assemblies between solar tracker assembly row **104** and solar tracker assembly row **106** is represented schematically by the ellipsis or three dots in FIG. **1**. Each solar tracker assembly row **102**, **103**, **104**, **106**, **107**, **108** of the solar tracker assembly set **109***a* is oriented such that a pivoting table **150** of the solar tracker assembly, including the longitudinally extending torque tube beam

250 of the table **150**, is oriented in a north-south direction such that a plurality of photovoltaic modules **190** supported by the torque tube beam **250** may be pivoted through an angle of inclination range AIR of the table **150** thereby allowing the upper surfaces of the plurality of photovoltaic modules **190** to track the sun S as it moves across the sky from east to west. In the schematic depiction of FIG. **1**, solar tracker assemblies **102**, **103** are adjacent and represent the two most easterly rows of solar tracker assemblies of the set **109***a*, while solar tracker assemblies **108**, **107** are adjacent and represent the two most westerly rows of solar tracker assemblies of the set **109***a*. The rows of the solar tracker assembly set **109***a* are generally adjacent, aligned, parallel, and uniformly spaced apart, within the installation tolerances and variations to be expected, of course, when installing solar tracker assemblies, which may be 400 feet long, at a remote installation site **1002**. Additionally, because of undulations of the ground G over an extent of the installation site **1002**, there may be vertical differences in height of the torque tube beams **250** of the set **109***a*. For each adjacent pair of solar tracker assembly rows, for example, eastern-most adjacent rows **102**, **103**, of the solar tracker assembly set **109***a*, the solar tracker assembly rows **102**, **104** are generally parallel, aligned, and uniformly spaced apart, as viewed in the top plan view of FIG. **1**.

(56) When the tables **150** of the solar tracker assembly rows **102**, **104** are in a neutral angle of inclination AIN, i.e., the plurality of photovoltaic modules **190** of each of the rows **102**, **104** are horizontal, the adjacent pair of solar tracker assemblies **102**, **103** are characterized by the following values schematically depicted in FIG. **1**: a) a chord or width of table value CH (as measured in the east-west or Y direction and in top plan view of FIG. **1**), which is the same for both assemblies **102**, **103**; b) a pitch distance P between center lines or longitudinal axes LA of the solar tracker assembly rows **102**, **103** (as measured in the east-west or Y direction and in top plan view); and c) horizontal edge distance D between facing edges **191**, **192** of a set of photovoltaic modules **190** of the solar tracker assembly **102** and a set of photovoltaic modules **190** of the solar tracker assembly **103** (as measured in the east-west or Y direction and in top plan view).

(57) During the backtracking period BT, the calculated angle of inclination values CAI for the respective tables **150** of each of the solar tracker assemblies of the set of solar tracker assemblies **109***a* are utilized by associated solar tracker controllers of the set of solar tracker controllers **609***a*, via the associated drive mechanism **150** of the associated solar tracker assembly, to control the angles of inclination AI of the respective tables of the plurality of solar tracker assemblies **100** of the installation **1000**. The backtracking method **1100** advantageously seeks to mitigate undesirable shading of photovoltaic modules of a solar tracker assembly by adjacent row solar tracker assemblies during morning and evening backtracking periods that would otherwise occur if the table angles of inclination were determined in accordance with the normal tracking mode **1200**. In the normal tracking mode **1200**, the table angles of inclination AI of each of the plurality of solar tracker assemblies **100** are periodically pivoted or moved, within a range AIR of the table angles of inclination AI, so that the upper surfaces of the plurality of photovoltaic modules **190** track the position of the sun S as the sun S moves across the sky from east to west during daylight hours. For example, in the normal tracking mode **1200**, the table **110** of the first solar tracker assembly **102**, is periodically pivoted by its associated controller **602**, utilizing the tracker's drive assembly **150**, during daylight hours such that the upper surfaces of the plurality of photovoltaic modules **190** of the first solar tracker assembly **102** is perpendicular or orthogonal to the position of the sun S, as the sun moves across the sky (as viewed in a two dimensional front elevation view, as shown, for example, in FIGS. **6-8**), and within, of course, the angle of inclination range AIR of the table **110**. Similarly, in the normal tracking mode **1200**, the adjacent row solar tracker assembly, namely, solar tracker assembly **103** is pivoted by its associated controller **604**, utilizing the tracker's drive assembly **150**, during daylight hours such that the upper surfaces of the plurality of photovoltaic modules **190** of the second solar tracker assembly **102** is perpendicular or orthogonal to the position of the sun S, as the sun moves across the sky (again, as viewed in a two dimensional front elevation view, as shown, for example, in FIGS. **6-8**), and within, of course, the angle of inclination

range AIR of the table **110**.

(58) By way of example, FIG. **6** diagrammatically depicts an example of a potential shading problem between solar tracker assemblies **102**, **103**, in normal tracking mode **1200** at an early morning time when the sun's position SP**1** is relatively low above the horizon in the east, that is, the sun's angle with respect to the horizon is SAL In the normal tracking mode **1200**, a sun position table is used by the respective solar tracker controllers **602**, **603** to determine table angles of inclination. In the normal tracking mode **1200**, the table **110** of the most eastern most solar tracker assembly **102** is pivoted by the associated solar tracker controller **602**, utilizing the drive mechanism of the solar tracker assembly **102**, to a table angle of inclination AI=AI**11** in accord with the calculations of the controller **602** utilizing the sun position table. The table **110** of the adjacent second eastern most solar tracking assembly **103** is pivoted by the associated solar tracker controller **603**, utilizing the drive mechanism **150** of the solar tracker assembly **103**, to a table angle of inclination AI=AI**21**, in accord with the calculations of the controller **603** utilizing the sun position table. However, as is diagrammatically depicted in FIG. **6**, with the sun position at SP**1** above the horizon or ground G, if the tables **110** of the first and second row solar tracker assemblies **102**, **104** are at angles of inclination AI**11**, AI**21** wherein the plurality of photovoltaic modules **190** of the table **110** of the first solar tracker assembly **102** cast a shadow or shade on a portion of one or more of the plurality of photovoltaic modules **190** of the adjacent row solar tracker assembly **103** (schematically depicted as shaded portion SH in FIG. **6**). This will be referred to herein as “row-to-row shading”, that is, the photovoltaic modules of the table of one solar tracker assembly shade at least some portion of the photovoltaic modules of the table of an adjacent solar tracker assembly in a set of adjacent, aligned, spaced apart solar tracker assemblies. Since the photovoltaic modules of the plurality of photovoltaic modules **190** of the second solar tracker assembly **103** are electrically connected in series, shading even a portion of one of the photovoltaic modules of the plurality of photovoltaic modules **190** will result in a significant decrease in energy output by the solar tracker assembly **103**.

(59) By comparison, FIG. **7** diagrammatically illustrates a situation wherein the backtracking method **1100** is utilized during the morning backtracking period BTM to mitigate the row-to-row shading problem illustrated in FIG. **6**. In the backtracking mode **1120**, the solar tracker controllers **602**, **603** utilize the calculated table angle of inclination values CAI for the respective eastern most solar tracker assemblies **102**, **103**, which, in one exemplary or example embodiment, have been previously calculated by the array controller **510** and stored in the controller electronics **620** of the solar tracker controllers **602**, **603**. In the example of FIG. **7**, during the morning backtracking period, BTM, when the sun's position is at SP**1** and the sun angle is SA**1**, the calculated angle of inclination value CAI of the table **110** of the solar tracker assembly **102** is determined by the array controller **510** via the backtracking algorithm **1120** to be a table angle of inclination AI=AI**12**. The solar tracker controller **602** accordingly sets the table angle of inclination AI=AI**12** for the solar tracker assembly **102**. As can be seen in FIG. **7**, the table angle of inclination AI**12** is smaller or less steep than the angle of inclination AI=AI**11** which would have used in the normal tracking mode **1200** at sun position SP**1**. Similarly, the calculated angle of inclination CAI of the table **110** of the solar tracker assembly **103** is determined via the backtracking algorithm **1120** to be table angle of inclination AI=AI**22**. The solar tracker controller **603** accordingly sets the table angle of inclination at the calculated angle of inclination for sun position SP**1**, i.e., AI=AI**22**. Again, the table angle of inclination AI=AI**22** is smaller or less steep than the angle of inclination AI=AI**21** which would have used in the normal tracking mode **1200** at sun position SP**1**. The reason that the calculated angle of inclination value CAI of AI**22** changes to a smaller value as compared to AI**21** for the solar tracker assembly **103** is that the backtracking algorithm **1120** is simultaneously taking into account the potential of the photovoltaic modules **190** of the solar tracker assembly **103** shading the photovoltaic modules **190** of the next row in the western direction, namely, the photovoltaic modules **190** of the solar tracker assembly **104**. Although only two solar tracker

assemblies **102**, **103** are illustrated in FIG. **7**, it should be understood that the backtracking algorithm **1120** seeks to mitigated row-to-row shading along the entirety of the first set of solar tracker assemblies **109***a*. Accordingly, in the morning backtracking period BTM wherein the backtracking mode **1110** is employed, the calculated table angle of inclination values CAI of potentially all of the solar tracker assemblies of the first set of solar tracker assemblies **109***a* may be changed or modified as compared to the normal tracking mode **1200** to mitigate row-to-row shading in a westerly direction by an early morning sun position. Similarly, in the evening backtracking period BTE wherein the backtracking mode **1110** is employed, the calculated table angle of inclination values CAI of potentially all of the solar tracker assemblies of the first set of solar tracker assemblies **109***a* may be changed or modified as compared to the normal tracking mode **1200** to mitigate row-to-row shading in an easterly direction by a late evening sun position. Thus, as noted above, in one example embodiment, the backtracking algorithm **1120** is an iterative, heuristic algorithm that utilizes algebra, geometry and/or trigonometry on the input value to iteratively determine the calculated table angle of inclination values CAI.

(60) As schematically illustrated in FIG. **7**, the calculated table angle of inclination values CAI, namely, the table angle of inclination AI**12** of the table **110** of the first solar tracker assembly **102** and the table angle of inclination AI**22** of the table **110** of the second solar tracker assembly **103** are calculated by the array controller **510** utilizing the backtracking algorithm **1120** and communicated to the solar tracker controllers **602**, **603** such that, at sun position SP**1** and sun angle SA**1**, sunlight passes between a facing edge **191** of the plurality of photovoltaic modules **192** of the table **110** of the first solar tracker assembly **102** and a facing edge **193** of the plurality of photovoltaic modules **190** of the table of the second solar tracker assembly **103** such that a light stripe having a light stripe width LSW within a target range light stripe width TR which would be cast on the ground G. The reason that the phrase “which would be cast on the ground G” is used above is that the backtracking algorithm **1120** uses input values input to the algorithm **1120** and calculates table angle of inclination values CAI for the tables **110** of each of the solar tracker assemblies of the first set of solar tracker assemblies **109***a* at various sun positions during the morning and evening backtracking periods BTM, BTE, such that, for each pair of adjacent solar tracker assemblies, e.g., solar tracker assemblies **102**, **103**, in a set of solar tracker assemblies, e.g., the set of parallel, aligned, spaced apart solar tracker assemblies **109***a*, a light stripe width LSW that is less than or equal to a target range light stripe width TR (schematically depicted in FIGS. **7** and **8**), would be cast on the ground G. Thus, no measurements of actual light stripe width LSW are made, other than for the purpose of periodically check the validity/accuracy of the backtracking algorithm **1100** by measuring the light stripe width LSW of two random rows of solar tracker assemblies of the first set of solar tracker assemblies **109***a*. In one example embodiment, a width of the light stripe target range TR is between 40 mm. and 80 mm. The input values to the backtracking algorithm **1120** include: a) three dimensional coordinates of opposite ends **280**, **282** of the torque tube beams **250** of each of the plurality of solar tracker assemblies **100** of the solar tracker installation **1000**; b) edge distance values (distance between facing edges **191**, **192** of photovoltaic modules of adjacent solar tracker assemblies in Y direction when the angle of inclination AI=0 degrees—neutral or horizontal position); c) sun position data; and d) table angle of inclination range AIR.

(61) The backtracking method **1100**, as implemented in the backtracking mode **1110** during the evening backtracking period BTE, is diagrammatically depicted in FIG. **8**. Specifically, the backtracking method **1100** is utilized during the evening backtracking period BTE to mitigate the row-to-row shading problem in an easterly direction when the sun is positioned in the west, near sunset. In the backtracking mode **1110**, the solar tracker controllers **608**, **607** utilize the calculated table angle of inclination values CAI for the respective western most solar tracker assemblies **108**, **107**, which, in one exemplary or example embodiment, have been previously calculated by the array controller **510** and stored in the controller electronics **620** of the solar tracker controllers **602**, **603**. In the example of FIG. **8**, during the evening backtracking period, BTE, when the sun's

position is at SP**2** and the sun angle is SA**2**, the calculated angle of inclination value CAI of the table **110** of the solar tracker assembly **108** is determined by the array controller **510** via the backtracking algorithm **1120** to be a table angle of inclination AI=AI**32**. The solar tracker controller **608** accordingly sets the table angle of inclination AI=AI**32** for the solar tracker assembly **102**. As can be seen in FIG. **7**, the table angle of inclination AI**32** is smaller or less steep than the angle of inclination AI=AI**31** which would have used in the normal tracking mode **1200** at sun position SP**2** (AI**31** is shown in dashed line in FIG. **8**). Similarly, the calculated angle of inclination value CAI of the table **110** of the solar tracker assembly **107** is determined via the backtracking algorithm **1120** to be table angle of inclination AI=AI**42**. The solar tracker controller **607** accordingly sets the table angle of inclination at the calculated angle of inclination for sun position SP**2**, i.e., AI=AI**42**. Again, the table angle of inclination AI=AI**42** is smaller or less steep than the angle of inclination AI=AI**41** which would have used in the normal tracking mode **1200** at sun position SP**2** (AI**41** is shown in dashed line in FIG. **8**). The reason that the calculated angle of inclination value CAI of AI**42** changes to a smaller value as compared to AI**41** for the solar tracker assembly **107** is that the backtracking algorithm **1120** is simultaneously taking into account the potential of the photovoltaic modules **190** of the solar tracker assembly **107** shading the photovoltaic modules **190** of the next row in the eastern direction, namely, the photovoltaic modules **190** of the solar tracker assembly **106**. Although only two solar tracker assemblies **108**, **107** are illustrated in FIG. **8**, it should be understood that the backtracking algorithm **1120** seeks to mitigated row-to-row shading along the entirety of the first set of solar tracker assemblies **109***a*. Accordingly, when the backtracking mode **1110** is employed in the evening backtracking period BTE, the calculated table angle of inclination values CAI of potentially all of the solar tracker assemblies of the first set of solar tracker assemblies **109***a* may be changed or modified as compared to the normal tracking mode **1200** to mitigate row-to-row shading in an easterly direction by a late evening sun position. Similarly, in the backtracking mode **1110**, during the evening backtracking period BTE, the calculated table angle of inclination values CAI of potentially all of the solar tracker assemblies of the first set of solar tracker assemblies **109***a* may be changed or modified as compared to the normal tracking mode **1200** to mitigate row-to-row shading in an easterly direction by a late evening sun position.

(62) FIG. **11** schematically illustrates the table angle of inclination AI over an approximate 48 hour time period for a given solar tracker assembly, for example, solar tracker assembly **103** of the set of aligned, parallel, spaced apart solar tracker assemblies **109***a*. During night hours, the associated solar tracker controller **603**, utilizing the drive mechanism **150**, operates in the night stow mode **1300** and positions the angle of inclination AI of the table **110** of the solar tracker assembly **103** at a night stow position NSP during a night stow period NS that commences at sunset time SS and ends at sunrise time SR. In one exemplary embodiment, the night stow position NSP corresponds to a table angle of inclination AI=−10 degrees (facing east at an angle of inclination of −10 degrees below horizontal or the neutral angle of inclination). At sunrise, the solar tracker controller **603**, pivots the table **110** to the neutral or horizontal angle of inclination, AI=0 degrees. Subsequent to sunrise SR, the controller **603** switches to the backtracking mode or routine **1110**. In the backtracking mode **1110**, the controller **603** utilizes the calculated angle of inclination values CAI for the solar tracker assembly **102** and associated times or solar positions, as determined by the array controller **510** utilizing the backtracking algorithm **1120** and communicated by the array controller **510** to the solar tracker controller **603**. The solar tracker controller **603**, in turn, utilizes the calculated table angle of inclination values CAI to control the angle of inclination AI of the table **110** of the solar tracker assembly **103** during the morning backtracking period BTM such that the plurality of photovoltaic panels **190** of the solar tracker assembly **102** do not shade parts or all of the plurality of photovoltaic panels **190** of the next westerly adjacent solar tracker assembly **104**. As can be seen in FIG. **11**, as the sun rises during the morning backtracking period BTM, the controller **603** pivots the angle of inclination AI of the table **1100** from the neutral angle of inclination AI=0 degrees ultimately reaching the maximum negative angle of inclination AI− of the

table (in this exemplary case, AI−=−60 degrees). Utilization of the backtracking mode **1110** by the controller **603** during the morning backtracking period BTM advantageously mitigates row-to-row shading of the plurality of photovoltaic modules of the next westerly adjacent solar tracker assembly **104** by the plurality of photovoltaic modules **190** of the solar tracker assembly **103** (row-to-row shading in the easterly direction). As can be seen in FIG. **2**, an approximate length of the morning backtracking period BTM is two hours.

(63) At such time as the morning backtracking mode **1110** ends with the table **110** at AI−, the solar tracker controller **603** switches to the normal tracking mode **1200** for the normal tracking period NT during daylight hours, wherein the table **110** is positioned such that the plurality of photovoltaic modules **190** of the solar tracker assembly **103** track the position of the sun S. The normal tracking mode **1200** continues and the table **110** reaches the maximum positive angle of inclination AI+(in this exemplary case, AI+=+60 degrees). At such time that row-to-row shading in the westerly direction would commence (i.e., row-to-row shading of the plurality of photovoltaic modules **190** of the next easterly adjacent solar tracker assembly **102** by the plurality of photovoltaic modules **190** of the solar tracker assembly **103**, the solar tracker controller **603** changes from the normal tracking mode **1200** to the backtracking mode **1110** to commence the evening backtracking period BTE. Utilization of the calculated backtracking angle of inclination values CAI by the controller **603** during the evening backtracking period BTE advantageously mitigates row-to-row shading of the plurality of photovoltaic modules **190** of the next easterly adjacent solar tracker assembly **102** by the plurality of photovoltaic modules **190** of the solar tracker assembly **103** (row-to-row shading in the westerly direction).

(64) For the set of solar tracker assemblies **109***a*, the morning backtracking period BTM commences at sunrise time SR and continues to such a time after sunrise where the sun's position in the eastern sky is sufficiently high above the eastern horizon wherein the normal tracking mode **1200** may be used without row to row shading occurring within the set of solar tracker assemblies **109***a*. Similarly, for a set of aligned, parallel, spaced apart solar tracker assemblies, for example, the set of solar tracker assemblies **109***a*, the evening backtracking period BTE commences when the sun's position in the western sky is sufficiently low above the western wherein the normal tracking mode **1200** would result in one or more instances of row to row shading within the set of solar tracker assemblies **109***a* occurring and the evening backtracking period BTE terminates as sunset. Thus, as is schematically depicted in FIG. **11**, the normal tracking mode **1200** is in effect during daylight hours other than the morning and evening backtracking periods BTM, BTE. Those daylight hours where the normal tracking mode **1200** is in effect is referred to as a normal tracking period NT. During the nighttime hours, between the evening and morning backtracking periods BTM, BTE, the tables of the plurality of solar tracker assemblies **100** of the set of solar tracker assemblies **109***a* are stored in a night stow position **1300**. This nighttime period wherein the solar tracker assemblies **100** of the set of solar tracker assemblies **109***a* are in the night stow position is referred to as the night stow period NSP.

(65) As set forth in the simplified flow chart of FIG. **12**, execution of the backtracking algorithm **1120** by the array controller **510** in connection with calculating table angles of inclination CAI for use during the backtracking period BT for two of the solar tracker assemblies of the first set of solar tracker assemblies **109***a*, namely, the first and second solar tracker assemblies **102**, **103** of the first set of solar tracker assemblies **109***a* is depicted. It being understood, of course, that the backtracking algorithm would be executed by the array controller **510** to calculate table angles of inclination CAI during the backtracking periods BT of all of the solar tracker assemblies of both the first and second sets of solar tracker assemblies **109***a*, **109***b* of the solar tracker installation **1000**. However, for ease of explanation, the discussion herein will focus on calculating table angles of inclination CAI for the first and second solar tracker assemblies **102**, **103** of the first set of solar tracker assemblies **109***a* utilizing the backtracking algorithm **1120**. In one example embodiment, the backtracking algorithm **1120**, as executed or implemented by the array controller **510**, may be

viewed as including the following steps: a) at step **1130**, data value inputs are provided to backtracking algorithm **1120**; b) at step **1140**, the array controller **510** executes the backtracking algorithm **1120** on the data value inputs, the backtracking algorithm **1120** performs calculations on the data value inputs; c) at step **1150**, the outputs of the backtracking algorithm **1120** are generated and provided to the array controller **510**; d) at step **1160**, the array controller **520** communicates the backtracking algorithm outputs to the solar tracker controllers **602**, **603** associated with the solar tracker controllers **102**, **103**; and e) at step **1170**, the solar tracker controllers **602**, **603** actuate the respective drive mechanisms **150** of the first and second solar tracker assemblies **102**, **103** to set and periodically change the table angles of inclination AI in conformity with the calculated table angle of inclination positions CAI for the first and second solar tracker assemblies **102**, **103** during morning and evening backtracking periods BTM, BTE.

(66) At step **1130**, the inputs to the backtracking algorithm **1120** include: a) three dimensional coordinates for ends of the torque tube beam of the first solar tracker assembly **102**; b) three dimensional coordinates for ends of the torque tube beam of the second solar tracker assembly **103**; c) horizontal distance between facing edges **191**, **192** of the respective photovoltaic modules **190** of the first and second solar tracker assemblies **102**, **103**; d) sun position data from a sun position table appropriate for the geographical location of the solar tracker installation **1000**; e) light strip width target range TR (e.g., a target range TR of 40-80 mm.); and e) an angle of inclination range AIR for each of the tables **110** of the first and second solar tracker assemblies **102**, **103**. At step **1140**, the calculations performed by the backtracking algorithm **1120** include: a) calculate average horizontal distance between torque tube beams of the tables of the first and second solar tracker assemblies **102**, **103**; b) calculate average vertical differential between the torque tube beams of the tables of the first and second solar tracker assemblies **102**, **103**; and c) calculate table angle of inclination positions CAI for first and second solar tracker assemblies **102**, **103** such that a width of a hypothetical light stripe LSW (schematically depicted in FIGS. **7** and **8**) from sunlight passing between facing edge surfaces **191**, **192** of the first set of photovoltaic modules **190** of the table **110** of the first solar tracker assembly **102** and the second set of photovoltaic modules **190** of the table **110** of the second solar tracker assembly **103** which would be projected onto the ground G is within the light stripe width target range TR (schematically depicted in FIGS. **7** and **8**). At step **1150**, the calculated values output to the array controller **510** from the calculations performed by the backtracking algorithm **1120** include: a) calculated angle of inclination values CAI of the table **110** of the first solar tracker assembly **102** and the associated times or sun position for each backtracking value CAI for each day of the expected life of the solar tracker controller **102**; and b) calculated angle of inclination values CAI of table **110** of the second solar tracker assembly **103** and the associated times or sun position for each backtracking value CAI for each day of the expected life of the solar tracker controller **103**.

(67) During the backtracking period BT, that is, during the morning backtracking period BTM and the evening backtracking period BTE, the solar tracker controller **602** utilizes the stored, calculated table angle of inclination values CAI, along with the associated times or sun positions, and actuates the drive mechanism **150** of the solar tracker assembly **102** to set and periodically change the table angle of inclination AI of the solar tracker assembly **102** to comport with the calculated table angle of inclination values CAI for the corresponding times or sun positions of the backtracking period BT. Similarly, during the backtracking period BT, the solar tracker controller **603** utilizes the stored, calculated table angle of inclination values CAI, along with the associated times or sun positions, and actuates the drive mechanism **150** of the solar tracker assembly **103** to set and periodically change the table angle of inclination AI of the solar tracker assembly **103** to comport with the calculated table angle of inclination values CAI for the corresponding times or sun positions of the backtracking period BT.

(68) Select steps of the various operating modes of the solar tracker controller **102** are set forth in the simplified flow chart of FIG. **13**. Turning to the simplified flow chart of FIG. **13**, shown

generally at **1162** is a simplified flow chart for the various operating modes, namely: a) the normal tracking mode **1200**; b) the night stow mode **1300**; c) the backtracking mode **1110**, wherein calculated table angles of inclination CAI, as calculated by the backtracking algorithm **1120** are utilized by the solar tracker controllers of the first set of solar tracker controllers **609***a* to mitigate row-to-row shading during early morning and evening backtracking periods BTM, BTE which otherwise would occur if the normal sun tracking mode **1200** were utilized to set the table angles of inclination for the solar tracker assemblies of the first set of solar tracker assemblies **109***a*; and d) an abnormal weather condition mode **2000**. The abnormal weather condition mode **2000** would be entered upon receiving an abnormal weather condition interrupt from the array controller **510** indicative of an unusual weather condition that requires corrective action to be taken by the solar tracker controller **602** to mitigate the effects of the unusual weather condition on the solar tracker assembly **102**. Example of unusual weather conditions would include high wind conditions, overcast sky conditions, snow accumulation on the upper surfaces of the photovoltaic modules **190**, etc.

(69) At step **1052**, the current time is examined. At step **1054**, the solar tracker controller **602** determines if the current time is a night period by consulting sun position table. If at step **1054**, the answer is yes, then the solar tracker controller **102** enters the night stow mode **1300** and sets the table **110** of the solar tracker assembly **102** is set to the night stow position NSP. At step **1054**, the current time is not a night period, then it must be a daylight period. At step **1056**, the current time is a daylight period, then at step **1058**, the solar tracker controller **602** commences operation in the normal tracking mode **1200**. At step **1058**, if it is determined if there is a calculated backtracking table angle of inclination value CAI for the current time. If there is no calculated backtracking table angle of inclination value CAI for the current time, at step **1060**, normal solar tracking mode **1200** is utilized by the solar tracker controller **602**. At step **1062**, the solar tracker controller **602** utilizes normal solar tracking table angles of inclination to set the angle of inclination position of the table **110** of the solar tracker assembly **102**. If at step **1058**, there is a calculated backtracking table angle of inclination value CAI for the current time, then at step **1066**, the backtracking mode **1110** is utilized by the solar tracker controller **602**. At step **1068**, the solar tracker controller **602** utilizes the calculated backtracking table angle of inclination value to set the angle of inclination position of the table **110** of the solar tracker assembly **102**. In all cases, the current time is periodically updated at step **1069** and the process **1050** is repeated. If, at any time, an abnormal weather condition interrupt is received by the solar tracker controller **102** from the array controller **510**, for example, at step **1070**, then at step **1072**, the solar tracker controller **602**, at step **1072**, enters the abnormal weather condition mode **2000** and moves the angle of inclination AI of the table **110** of the solar tracker assembly **102** in accordance with one or more predetermined routines. When the array controller **510** communicates to the solar tracker controller **102** that the abnormal weather condition has terminated, the current time is updated at step **1069** and the process **1050** is repeated.

(70) Method of Imaging **1400**

(71) Advantageously, the method of backtracking **1100** of the present disclosure also accounts for vertical differences in the heights of the respective plurality of photovoltaic modules of the first and second solar tracker assemblies **102**, **104** when determining the angles of inclination AI of the respective tables **110** of the first and second solar tracker assemblies **102**, **104** during the morning and evening backtracking periods BTM, BTE. The vertical height difference between the respective photovoltaic modules of the first and second solar tracker assemblies **102**, **104** may be due to undulations of the land of an installation site **1002** on which the solar tracker installation **1000** is located. In one exemplary or example embodiment, as schematically depicted in FIGS. **1**, **9** and **10**, the opposite ends **280**, **282** of the torque tube beam **250** include end caps **290**, **292** (FIG. **1**) which are imaged to provide accurate three dimensional coordinate values **280***a*, **282***a* for the beam ends **280**, **282**. The respective vertical dimensions of the torque tube beam ends **280**, **282** permit an average vertical height of the solar tracker assembly **102** to be estimated. In one exemplary

embodiment, the three dimensional coordinate values **280***a*, **282***a* for the beam ends **280**, **282** of the respective torque tube beams **250** of the plurality of solar tracker assemblies **100** of the solar tracker installation **1000** are obtained via an imaging system **1450** of a drone DR. In FIGS. **1** and **9**, a field of vision **1450***a* of the imaging system **1450** of the drone DR is schematically depicted in dashed line. One or more drones DR may be utilized, each drone having an imaging system **1450**. Turning to FIGS. **9** and **10**, the drone images the end caps **290**, **292** overlying the beam ends **280**, **282** of the torque tube beam **250** of the solar tracker assembly **102**. In FIGS. **9** and **10**, only the first end **280** of the torque tube beam **250** and its associate endcap **290** is shown. The first end **280** of the torque tube beam **250** is part of the torque tube beam segment **270** and is overlied by the end cap **290**. The end cap **290** includes four corner points CR**1**, CR**2**, CR**3**, CR**4** which are imaged, and the corresponding coordinate values are averaged to determine a center point CP of the end cap **290** and, specifically, three dimensional coordinates CPV of the center point CP of the end cap **290**. The longitudinal axis LA of the torque tube beam **250** will pass through the calculated center point value CPV. The three dimensional coordinates CPV of the center point CP of the end cap **290** substantially correspond to the three dimensional coordinates of the end **280** of the torque tube beam **250** and is aligned with the longitudinal axis LA though the torque tube beam **250**. The three dimensional coordinates of the opposite ends **280**, **282** of the torque tube beam are then used to find the average three dimensional coordinates of the torque tube beam **250**, including the average height or vertical coordinate of the torque tube beam **250**. The average height or vertical coordinate of the torque tube beams **250** of each of the solar tracker assemblies of the first set of solar tracker assemblies **109***a* are input to the backtracking algorithm **1120** to advantageously allow for accounting for vertical or height differences in the solar tracker assemblies when calculating the table angle of inclination values CAI for the morning and evening backtracking periods BTM, BTE. In one exemplary embodiment, the end cap **290** includes a machine readable indicia **294**, such as a matrix code, bar code, or QR code, which is imaged by the imaging system **1450** of the drone DR to allow for identification information concerning the solar tracker assembly identification number, the specific end of the torque tube being imaged, etc.

(72) Two simplified flow charts illustrating selected steps of a method of imaging **1400** are set forth in FIG. **15** and FIG. **14**. For simplicity, both flow charts reference the representative solar tracker assembly **102**, it being understood that all of the other solar tracker assemblies of the solar tracker installation **1000** would be similarly imaged. Turning to FIG. **15**, at step **1402**, one or more selected elements **400** of the solar tracker assembly **102** are identified for which three dimensional coordinate values **410** are desired. At step **1404**, imaging of the plurality of solar tracker assemblies **100** is undertaken. At step **1406**, analysis of the images or image frames of the plurality of the solar tracker assemblies **100** is undertaken by the imaging software **1401**. At step, **1408**, for each solar tracker assembly, for example, solar tracker assembly **102**, the imaging software **1401**, utilizing the analyzed images, the one or more selected elements **400** of the solar tracker assembly **102** are identified. At step **1410**, for each solar tracker assembly, for example, the solar tracker assembly **102**, the imaging software **1401**, determines three dimensional coordinate values **410** for each of the one or more selected elements **400** of the solar tracker assembly **102**. At step **1412**, the three dimensional coordinate values **410** for each of the one or more selected elements **400**, or transformations thereof, are associated with the solar tracker assembly **102** and input to the backtracking algorithm software **1101**. What is input to the backtracking algorithm **1120** may be the three dimensional coordinate values **410** associated with the corresponding solar tracker assembly **102** or it may be a transformation of the three dimensional coordinate values **410**. For example, it could be an average of the two coordinate values **410** or if multiple coordinate values **410** are obtained, the transformation may be a linear regression or other function of the multiple coordinate values **410**. Thus, the backtracking algorithm **1120** will either be receiving the “raw” three dimensional coordinate values **410** of some numerical transformation of the coordinate values **410**.

(73) The method of imaging **1400** set forth in the flow chart of FIG. **15** is more general, while the method of imaging **1420** set forth in the flow chart of FIG. **14** is a specific example embodiment of the method of imaging **1400** depicted by the flow chart of FIG. **15**. The flow chart of the method of imaging **1420** depicted in FIG. **14**, as stated above, is a more specific embodiment wherein it is assumed that the selected elements **400** are the two opposite end portions **280**, **282** of the torque tube beam **250** of the table **110** and the ends of the torque tube beam **250** are overlied by first and second end caps **290**, **292**. At step **1422**, utilizing one or more drones DR, the first and second end caps **290**, **292** of the first and second ends **280**, **282** of the torque tube beams **250** of each of the solar tracker assemblies of the plurality of solar tracker assemblies **100** of the solar tracker installation **1000** are imaged by the imaging system **1450** of the one or more drones DR. At step **1424**, the image data is transferred or downloaded from the imaging system **1450** of the drone DR and the imaging program, routine, or algorithm **1401** is utilized to analyze the image data. Three dimensional coordinate values are determined for each of the four corner points CR**1**, CR**2**, CR**3**, CR**4** of each end cap **290**, **292**. At step **1426**, the imaging program **1401** determines for each end cap, an end cap center point coordinate value CPV by averaging the three dimensional coordinate values of the center caps **290**, **292**. At step **1428**, the imaged data is analyzed for the presence of machine readable indicia **294**. If such machine readable indicia **294** is found, then at step **1430**, the machine readable indicia **294** is appropriately decoded, the decoded data providing identification data regarding the solar tracker assembly **102** and/or the corresponding solar tracker controller **602**. At step **1432**, the decoded solar tracker assembly/controller identification data is associated with the three dimensional coordinate values **280***a*, **282***a* for each of the end caps **290**, **292**. At step **1434**, the decoded solar tracker assembly/controller identification data and the associated three dimensional coordinate values **280***a*, **282***a* for each of the end caps **290**, **292** of each of the solar tracker assemblies of the first set **109***a* are input to the backtracking algorithm **1120**. The backtracking algorithm **1120** utilizes the three dimensional coordinate value for the end caps as surrogates for the corresponding coordinate values of the torque tube beam ends **280**, **292** and, in one exemplary embodiment, the coordinate values are used by the backtracking algorithm **1120** to find an average three dimensional value that characterizes a location of the associated solar tracker assembly, for example, a location of solar tracker assembly **102** on the installation site **1002**, as to x, y and z (height) location values of the solar tracker controllers. The z (height) location values allow the backtracking algorithm **1120** to account for height differences among the solar tracker controllers of the set of solar tracker controllers **109***a* due to undulations in ground level over an extent of the set of solar tracker controllers **109***a* on the installation site thereby advantageously allowing the backtracking algorithm **1120** to account for height differential between solar tracker controllers when calculating table angles of inclination for the backtracking period BT for each of the solar tracker assemblies of the first set of solar tracker assemblies **109***a.*

(74) It should be understood, of course, that there are a number of variations/alternatives possible regarding the method of imaging **1400**, as would be appreciated by one of skill in the art. Each of these variations/alternative should be understood to be part of the present disclosure and within the scope of the present disclosure, including its claims. Generally, the method of imaging **1400** images one or more features of each solar tracker assembly, say solar tracker assembly **102** of the first set of solar tracker assemblies **109***a* of the plurality of solar tracker assemblies **100** of the solar tracker installation **1000**, to obtain one or more three dimensional coordinate values that characterize a location of the solar tracker assembly **102** for purposes of providing the backtracking algorithm **1120** with accurate three dimension or three dimensional coordinate values or three dimension or three dimensional location values, including height location values, of the solar tracker assemblies. One variation of the method of imaging **1400** is described above, that is, for each solar tracker assembly, say solar tracker assembly **102**, of the plurality of solar tracker assemblies **100** of the solar tracker installation **1002**, the imaging method **1400** includes imaging two selected elements or features of the solar tracker assembly **102**, the two elements/features being the first and second end

caps **290**, **292** of the first and second ends **280**, **282** of the torque tube beam **250** of the solar tracker assembly **102**. The three dimensional coordinate values **280***a*, **282***a* of the endcaps **290**, **292** are representative of the location of the two ends **280**, **282** of the torque tube beam **250** of the solar tracker assembly **102**. These three dimensional coordinates **280***a*, **282***a* may be used directly by the backtracking algorithm **1120** or they may be transformed by either the imaging software **1401** or the backtracking software **1101**. For example, the imaging software **1401** or the backtracking software **1101** may take an average of the two coordinates to find an average three dimensional coordinate value for the solar tracker assembly **102**. This average three dimensional location value for the solar tracker assembly **102** would be utilized by the backtracking algorithm **1120** when computing appropriate table angles of inclination for the backtracking period BT for each solar tracker assembly in the set of adjacent solar tracker assemblies **109***a*.

(75) Another variation/alternative of the method of imaging **1400** would involve imaging/identifying a single element or feature of each solar tracker assembly (as opposed to opposite ends **280**, **282** of the torque tube beam **250**), for example, imaging/identifying the drive mechanism **150** driving the torque tube beam **250** of the solar tracker assembly **102** or imaging/identifying an easternmost (or westernmost) photovoltaic module of the plurality of photovoltaic modules **190** of the solar tracker assembly **102**. The drive mechanism **150** of the solar tracker assembly **102** includes the DC motor **180** and associated slew drive housing **162** which houses the gear train of the slew drive **160**. The rationale here would be that the drive mechanism **150** is typically positioned near a midpoint of the torque tube beam **250** of the solar tracker assembly **102**, thus, the associated three dimensional coordinate value of the drive mechanism **150** would be a reasonable approximation of the location (including height) of the solar tracker assembly **102**. Another variation/alternative of the method of imaging **1400** would involve imaging/identifying a single element, for example, an easternmost (or a westernmost) photovoltaic module of the plurality of photovoltaic modules **190** of the solar tracker assembly **102**. Another alternative would be to image and identify both an easternmost and a westernmost photovoltaic module of the plurality of photovoltaic modules **190** of the solar tracker assembly **102**.

(76) Yet another variation/alternative of the method of imaging **1400** would be to image three or more elements/features of each solar tracker assembly **102** to thereby increase the number of three dimensional coordinate data points or values associated with the solar tracker assembly **102**. Thus, the number of data points input available to the backtracking algorithm **1120** thereby allowing the backtracking algorithm to more accurately account for height difference between various portions or segments of the solar tracker assembly **102**. This multi data point approach would be helpful where there are ground level undulations over a north-south extent of the solar tracker assembly **102**. By way of example, the elements to be imaged may include the two end caps **290**, **292** and the drive mechanism **150**, thereby imaged features and associated three dimensional coordinate values would be obtained for both end portions **280**, **282** of the torque tube beam **250**, as well as at or near the midpoint of the torque tube beam **250**. Another multi data point method of imaging **1400** would be to image the solar tracker assembly **102** in predetermined increments, for example, imaging one end portion **280** by imaging end cap **290** of the torque tube beam **250**, and also imaging the torque tube beam in 50 foot intervals from the respective end portion **280** (or, more specifically, imaging a corresponding photovoltaic module overlying the torque tube beam **250** in 50 foot intervals). As can be seen in FIGS. **1-4**, the plurality of photovoltaic modules **190** overlie the torque tube beam **250** over a large portion of a total extent of the torque tube beam **250**). Thus, for a 400 foot torque tube beam, there would be nine elements **400** of the solar tracker assembly **102** imaged and nine corresponding three dimensional coordinate values determined by the imaging software **1140**, as follows: end portion **280**, +50 feet from end portion **280**, +100 feet, +150 feet, +200 feet, +250 feet, +300 feet, +350 feet, and +400 feet.

(77) It is also within the contemplation of the present disclosure that the method of imaging **1400**, that is, the imaging of elements **400** of the solar tracker assemblies **100**, may be accomplished by a

variety or combination of systems and technologies, as would be understood by those of skill in the art. That is, it should be understood that including and/or in addition to an imaging system including the one or more drones DR and associated drone imaging systems **1450** as discussed above, the present disclosure also contemplates and includes, for example and without limitation, satellite imaging systems, ground based imaging systems, such as imaging with cameras, smart phones, etc., hand-held or mounted on vehicles, autonomous or human-controlled, etc., as well as anal imaging systems utilizing planes, balloons, etc. Additionally, it should be understood that the imaging technology utilizing by the imaging system(s) could any one or a combination of imaging technologies, including LiDAR and optical imaging.
(78) As used herein, terms of orientation and/or direction such as upward, downward, forward, rearward, upper, lower, inward, outward, inwardly, outwardly, horizontal, horizontally, vertical, vertically, distal, proximal, axially, radially, etc., are provided for convenience purposes and relate generally to the orientation shown in the Figures and/or discussed in the Detailed Description. Such orientation/direction terms are not intended to limit the scope of the present disclosure, this application and the invention or inventions described therein, or the claims appended hereto.
(79) What have been described above are examples of the present disclosure/invention. It is, of course, not possible to describe every conceivable combination of components, assemblies, or methodologies for purposes of describing the present disclosure/invention, but one of ordinary skill in the art will recognize that many further combinations and permutations of the present disclosure/invention are possible. Accordingly, the present disclosure/invention is intended to embrace all such alterations, modifications, and variations that fall within the spirit and scope of the appended claims.

Claims

1. A method of backtracking utilizing a backtracking algorithm to calculate angle of inclination positions for a first table of a first solar tracker assembly and angle of inclination positions for a second table of a second solar tracker assembly, the first and second solar tracker assemblies being adjacent row solar tracker assemblies within a solar tracker installation, to mitigate shading of a first set of photovoltaic modules of the first table of the first solar tracker assembly by a second set of photovoltaic modules of the second table of the second solar tracker assembly, the steps of the method comprising: a) imaging at least one selected element of the first solar tracker assembly and utilizing images of the at least one selected element to determine three dimensional coordinates associated with the first solar tracker assembly; b) imaging at least one selected element of the second solar tracker assembly and utilizing images of the at least one selected element to determine three dimensional coordinates associated with the second solar tracker assembly; c) inputting to the backtracking algorithm: 1) the three dimensional coordinates associated with the first solar tracker assembly; 2) the three dimensional coordinates associated with the second solar tracker assembly; 3) a chord value for the first set of photovoltaic modules of the first table of the first solar tracker assembly and a chord value for the second set of photovoltaic modules of the second table of the second solar tracker assembly; 4) an angle of inclination range for the first table and an angle of inclination range for the second table; and 5) sun position data; d) the backtracking algorithm calculating first angle of inclination values for the first table of the first solar tracker assembly and calculating second angle of inclination values for the second table of the second solar tracker assembly; and e) pivoting first table of the first solar tracker assembly in accordance with the first angle of inclination values and pivoting the second table of the second solar tracker assembly in accordance with the second angle of inclination values.
2. The method of claim 1 wherein the step of part (a) of determining the three dimensional coordinates associated with the first solar tracker assembly includes the substep of determining three dimensional coordinates of first and second ends of the torque tube beam of the first table of

the first solar tracker assembly and wherein the step of part (b) of determining the three dimensional coordinates associated with the second solar tracker assembly includes the substep of determining three dimensional coordinates of first and second ends of the torque tube beam of the second table of the second solar tracker assembly.

3. The method of claim 2 wherein a numerical average of the three dimensional coordinates of the first and second ends of the torque tube beam of the first table of the first solar tracker assembly is the three dimensional coordinates associated with the first solar tracker assembly and a numerical average of the three dimensional coordinates of the first and second ends of the torque tube beam of the second table of the second solar tracker assembly is the three dimensional coordinates associated with the second solar tracker assembly.

4. The method of claim 1 wherein a drone images the at least one selected element of the first solar tracker assembly and images the at least one selected element of the second solar second solar tracker assembly.

5. The method of claim 1 wherein the step of part (d) includes the substep of the backtracking algorithm determining a horizontal distance between facing edge surfaces of the first set of photovoltaic modules of the first table of the first solar tracker assembly and the second set of photovoltaic modules of the second table of the second solar tracker assembly when the first and second set of photovoltaic modules are in a horizontal position.

6. The method of claim 1 wherein the step of part (d) includes of the substep of the backtracking algorithm calculating first angle of inclination values for the first table of the first solar tracker assembly and calculating second angle of inclination values for the second table of the second solar tracker assembly such that a width of a light stripe from sunlight passing between facing edge surfaces of the first set of photovoltaic modules of the first table of the first solar tracker assembly and the second set of photovoltaic modules of the second table of the second solar tracker assembly and projected onto ground would be within a light stripe width target range.

7. The method of claim 1 wherein a duration of time during which the first table of the first solar tracker assembly is pivoted in accordance with the first angle of inclination values and the second table of the second solar tracker assembly is pivoted in accordance with the second angle of inclination values is referred to as a backtracking period and the backtracking period includes a morning backtracking period and an evening backtracking period.

8. The method of claim 2 wherein the step of part (e) of claim 1 includes of the substep of the backtracking algorithm calculating an average vertical distance between the respective torque tube beams of the first and second tables of the first and second tracker assemblies utilizing the coordinates of the first and second ends of the torque tube beam of the first table of the first solar tracker assembly and the coordinates of the first and second ends of the torque tube beam of the second table of the second solar tracker assembly.

9. The method of claim 2 wherein the step of part (a) of determining the three dimensional coordinates of the first and second ends of the torque tube beam of the first table of the first solar tracker assembly includes the substep of determining three dimensional coordinates of first and second end caps affixed to the first and second ends of the torque tube beam of the first table of the first solar tracker assembly and wherein the step of part (b) of determining the three dimensional coordinates of the first and second ends of the torque tube beam of the second table of the second solar tracker assembly includes the substep of determining three dimensional coordinates of first and second end caps affixed to the first and second ends of the torque tube beam of the second table of the second solar tracker assembly.

10. The method of claim 9 wherein the first and second end caps attached to the torque tube beam of the first table of the first solar tracker assembly include machine readable indicia identifying the first solar tracker assembly and the first and second end caps attached to the torque tube beam of the second table of the second solar tracker assembly include machine readable indicia identifying the second solar tracker assembly.

11. A method of backtracking utilizing a backtracking algorithm to calculate angle of inclination positions for a first table of a first solar tracker assembly and angle of inclination positions for a second table of a second solar tracker, the first and second solar tracker assemblies being adjacent row solar tracker assemblies within a solar tracker installation, the first table of the first solar tracker assembly including a first set of photovoltaic modules and the second table of the second solar tracker assembly including a second set of photovoltaic modules, the steps of the method comprising: a) imaging at least one selected element of the first solar tracker assembly and utilizing images of the at least one selected element to determine three dimensional coordinates associated with the first solar tracker assembly; b) imaging at least one selected element of the second solar tracker assembly and utilizing images of the at least one selected element to determine three dimensional coordinates associated with the second solar tracker assembly; c) inputting to the backtracking algorithm: 1) the three dimensional coordinates associated with the first solar tracker assembly; 2) the three dimensional coordinates associated with the second solar tracker assembly; 3) a chord value for the first set of photovoltaic modules of the first table of the first solar tracker assembly and a chord value for the second set of photovoltaic modules of the second table of the second solar tracker assembly; and 4) sun position data; d) the backtracking algorithm calculating first angle of inclination values for the first table of the first solar tracker assembly and calculating second angle of inclination values for the second table of the second solar tracker assembly; and e) pivoting first table of the first solar tracker assembly in accordance with the first angle of inclination values and pivoting the second table of the second solar tracker assembly in accordance with the second angle of inclination values.
12. The method of claim 11 wherein, in part (c), an angle of inclination range for the first table and an angle of inclination range for the second table are input to the backtracking algorithm.
13. The method of claim 11 wherein the step of part (a) of determining the three dimensional coordinates associated with the first solar tracker assembly includes the substep of determining three dimensional coordinates of first and second ends of the torque tube beam of the first table of the first solar tracker assembly and wherein the step of part (b) of determining the three dimensional coordinates associated with the second solar tracker assembly includes the substep of determining three dimensional coordinates of first and second ends of the torque tube beam of the second table of the second solar tracker assembly and further wherein a numerical average of the three dimensional coordinates of the first and second ends of the torque tube beam of the first table of the first solar tracker assembly is the three dimensional coordinates associated with the first solar tracker assembly and a numerical average of the three dimensional coordinates of the first and second ends of the torque tube beam of the second table of the second solar tracker assembly is the three dimensional coordinates associated with the second solar tracker assembly.
14. The method of claim 11 wherein a drone images the at least one selected element of the first solar tracker assembly and images the at least one selected element of the second solar second solar tracker assembly.
15. The method of claim 11 wherein the step of part (d) includes the substep of the backtracking algorithm determining a horizontal distance between facing edge surfaces of the first set of photovoltaic modules of the first table of the first solar tracker assembly and the second set of photovoltaic modules of the second table of the second solar tracker assembly when the first and second set of photovoltaic modules are in a horizontal position.
16. The method of claim 13 wherein the step of part (e) includes of the substep of the backtracking algorithm calculating an average vertical distance between the respective torque tube beams of the first and second tables of the first and second tracker assemblies utilizing the coordinates of the first and second ends of the torque tube beam of the first table of the first solar tracker assembly and the coordinates of the first and second ends of the torque tube beam of the second table of the second solar tracker assembly.
17. The method of claim 13 wherein the step of part (a) of determining the three dimensional

coordinates of the first and second ends of the torque tube beam of the first table of the first solar tracker assembly includes the substep of determining three dimensional coordinates of first and second end caps affixed to the first and second ends of the torque tube beam of the first table of the first solar tracker assembly and wherein the step of part (b) of determining the three dimensional coordinates of the first and second ends of the torque tube beam of the second table of the second solar tracker assembly includes the substep of determining three dimensional coordinates of first and second end caps affixed to the first and second ends of the torque tube beam of the second table of the second solar tracker assembly and further wherein the first and second end caps attached to the torque tube beam of the first table of the first solar tracker assembly include machine readable indicia identifying the first solar tracker assembly and the first and second end caps attached to the torque tube beam of the second table of the second solar tracker assembly include machine readable indicia identifying the second solar tracker assembly.

18. A method of backtracking utilizing a backtracking algorithm to calculate angle of inclination positions for a first table of a first solar tracker assembly and angle of inclination positions for a second table of a second solar tracker, the first and second solar tracker assemblies being adjacent row solar tracker assemblies within a solar tracker installation, the first table of the first solar tracker assembly including a first set of photovoltaic modules and the second table of the second solar tracker assembly including a second set of photovoltaic modules, the steps of the method comprising: a) imaging at least one element of the first solar tracker assembly and utilizing the imaging to determine coordinates associated with the first solar tracker assembly; b) imaging at least one element of the second solar tracker assembly and utilizing the imaging to determine coordinates associated with the second solar tracker assembly; c) inputting to the backtracking algorithm: 1) the coordinates associated with the first solar tracker assembly; 2) the coordinates associated with the second solar tracker assembly; 3) a chord value for the first set of photovoltaic modules of the first table of the first solar tracker assembly and a chord value for the second set of photovoltaic modules of the second table of the second solar tracker assembly; and 4) sun position data; d) the backtracking algorithm calculating first angle of inclination values for the first table of the first solar tracker assembly and calculating second angle of inclination values for the second table of the second solar tracker assembly; and c) pivoting first table of the first solar tracker assembly in accordance with the first angle of inclination values and pivoting the second table of the second solar tracker assembly in accordance with the second angle of inclination values.

19. The method of claim 18 wherein, in part (a), the coordinates associated with the first solar tracker assembly are three dimensional coordinates and, in part (b), the coordinates associated with the second solar tracker assembly are three dimensional coordinates.

20. The method of claim 18 wherein, in part (c), an angle of inclination range for the first table and an angle of inclination range for the second table are input to the backtracking algorithm.

21. The method of claim 19 wherein the step of part (a) of determining the three dimensional coordinates associated with the first solar tracker assembly includes the substep of determining three dimensional coordinates of first and second ends of the torque tube beam of the first table of the first solar tracker assembly and wherein the step of part (b) of determining the three dimensional coordinates associated with the second solar tracker assembly includes the substep of determining three dimensional coordinates of first and second ends of the torque tube beam of the second table of the second solar tracker assembly.

22. The method of claim 21 wherein a numerical average of the three dimensional coordinates of the first and second ends of the torque tube beam of the first table of the first solar tracker assembly is the three dimensional coordinates associated with the first solar tracker assembly and a numerical average of the three dimensional coordinates of the first and second ends of the torque tube beam of the second table of the second solar tracker assembly is the three dimensional coordinates associated with the second solar tracker assembly.

23. The method of claim 18 wherein a drone images the at least one element of the first solar

tracker assembly and images the at least one element of the second solar second solar tracker assembly.

24. The method of claim 18 wherein the step of part (d) includes the substep of the backtracking algorithm determining a horizontal distance between facing edge surfaces of the first set of photovoltaic modules of the first table of the first solar tracker assembly and the second set of photovoltaic modules of the second table of the second solar tracker assembly when the first and second set of photovoltaic modules are in a horizontal position.

25. The method of claim 21 wherein the step of part (e) includes of the substep of the backtracking algorithm calculating an average vertical distance between the respective torque tube beams of the first and second tables of the first and second tracker assemblies utilizing the coordinates of the first and second ends of the torque tube beam of the first table of the first solar tracker assembly and the coordinates of the first and second ends of the torque tube beam of the second table of the second solar tracker assembly.

26. The method of claim 21 wherein the step of part (a) of determining the three dimensional coordinates of the first and second ends of the torque tube beam of the first table of the first solar tracker assembly includes the substep of determining three dimensional coordinates of first and second end caps affixed to the first and second ends of the torque tube beam of the first table of the first solar tracker assembly and wherein the step of part (b) of determining the three dimensional coordinates of the first and second ends of the torque tube beam of the second table of the second solar tracker assembly includes the substep of determining three dimensional coordinates of first and second end caps affixed to the first and second ends of the torque tube beam of the second table of the second solar tracker assembly.

27. The method of claim 26 wherein the first and second end caps attached to the torque tube beam of the first table of the first solar tracker assembly include machine readable indicia identifying the first solar tracker assembly and the first and second end caps attached to the torque tube beam of the second table of the second solar tracker assembly include machine readable indicia identifying the second solar tracker assembly.