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Inventor(s)	Delgado-Nanez; Ricardo

FASTENING ASSEMBLY FOR SOLAR POWER SYSTEMS AND TOOLS THEREOF

Abstract

The present disclosure relates to fastening assemblies for solar power systems including at least a strap, a buckle member, and a locking member. It also relates to a hand-held strap tensioning tool that includes a handle, a strap tensioning tool assembly operatively coupled to the handle and configured to perform one or more strap tensioning operations, and a power assembly operatively coupled to both the handle and the strap tensioning tool assembly.

Inventors: **Delgado-Nanez; Ricardo (San Jose, CA)**

Applicant: **Nextracker LLC** (Fremont, CA)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION [0001] This application is a divisional application of U.S. patent application Ser. No. 17/975,523 filed on Oct. 27, 2022, which claims the benefit of, and priority to, U.S. Provisional Patent Application Ser. No. 63/272,664, filed on Oct. 27, 2021, the entire content of which is hereby incorporated by reference herein.

BACKGROUND

Technical Field

[0002] The present technology is generally related to fastening assemblies for solar power systems, and more particularly, fastening assemblies designed for securing a first support structure of a solar power system to a supplemental support structure and/or a solar module of a solar power system, the assemblies including at least a strap, a buckling member, and a locking member.

Description of Related Art

[0003] Solar power has long been viewed as an important alternative energy source. To this end, substantial efforts and investments have been made to develop and improve upon solar energy collection technology. Of particular interest are residential-, industrial- and commercial-type applications in which relatively significant amounts of solar energy can be collected and utilized in supplementing or satisfying power needs. One way of implementing solar energy collection technology is by assembling an array of multiple solar modules.

[0004] Solar modules can employ solar panels made of silicon or other materials (e.g., III-V cells such as GaAs) to convert sunlight into electricity. Solar panels typically include a plurality of photovoltaic (PV) cells interconnected with wiring to one or more appropriate electrical components (e.g., switches, inverters, junction boxes, etc.).

[0005] Most solar power systems place an array of solar modules at a location where sunlight is readily present. This is especially true for residential, commercial, or industrial applications in which multiple solar modules are desirable for generating substantial amounts of energy.

[0006] In some arrangements, solar modules are placed side-by-side in an array. Each solar module and/or array can be mounted to a fixed or rotatable support system. The support system may include one or more of a ground-based structure (e.g., a pole or generally vertical post), a support structure (e.g., a torque tube or generally horizontal beam), and/or a mounting rail (e.g., a saddle or transverse rail) configured to mount the solar module or array on the support structure.

[0007] The assembly process of the solar power system can be physically challenging and inefficiently time-consuming because space can be limited between each of the modules, arrays, structures and/or rails. Particularly, space above the support structure may be limited by the mounting rails, saddles, and/or solar modules, potentially making assembly work performed above the support structure more difficult, less desirable, and/or time consuming as compared to performing similar work from below the support structure where there may be more room to operate. Thus, there remains a continuing need for improved methods for fastening and/or mounting solar modules and/or supplemental support structures (e.g., mounting rails, saddles, etc.) to a primary support structure (such as a torque tube, ground base support structure, etc.) of a solar power system, such as a solar tracker.

SUMMARY

[0008] The present disclosure describes a fastening assembly for a solar power system including at least a locking member, a strap including an elongate body extending between a first end portion and an opposite second end portion, and a buckle member configured to receive both the locking member and the strap therein and/or therethrough.

[0009] The buckle member includes a locking cavity defined therein and a strap channel defined therethrough. In some embodiments, the locking cavity overlaps and/or is in communication with

the strap channel. The strap channel being configured to receive a portion of the strap through the buckle member. The locking cavity includes a tapered end portion configured to receive the locking member therein to lock the strap in a fixed position relative to the buckle member. In some embodiments, the tapered end portion configured to wedge the locking member against the strap if the strap tries to back out of the buckle member once locked. In some embodiments, the fastening assembly is self-locking.

[0010] In some embodiments, the buckle member defines a top face, a bottom face opposite the top face, a front face, a rear face opposite the front face, a first side face, and a second side face opposite the first side face, wherein the strap channel extends from a portion of the first side face to a portion of the second side face through the buckle member.

[0011] In some embodiments, the buckle member may further include an opening in communication with the locking cavity, the opening defined through the bottom face of the buckle member and configured to pass the locking member therethrough into or out of the locking cavity and/or the buckle member.

[0012] In some embodiments, the buckle member may further include a slot in communication with the locking cavity and the strap channel, the slot defined through the first side face of the buckle member and configured to allow a device therethrough to advance the locking member towards the tapering portion of the locking cavity. In some embodiments, the device may be part of a tensioning tool used to tension the strap around a support structure as described herein. In some embodiments, the slot is narrower than the strap channel to prevent the strap from entering the slot.

[0013] In some embodiments, the tapered end portion of the locking cavity further includes a recess positioned below the strap channel to receive a portion of the locking member therein.

[0014] Hand-held strap tensioning tools configured to be used with the fastening assemblies described herein are also provided. The hand-held tools are portable and include at least a handle, a strap tensioning tool assembly operatively coupled to a handle, the strap tensioning tool assembly configured to perform one or more strap tensioning operations, and a power assembly operatively coupled to both the handle and the strap tensioning tool assembly.

[0015] In some embodiments, the hand-held strap tensioning tools may be driven by a gear and/or rotary motor.

[0016] In some embodiments, the hand-held strap tensioning tool may be hydraulically driven.

[0017] Kits for a solar power system are also provided. Each kit includes one or more of the fastening assemblies described herein. Each fastening assembly including a locking member, a strap, and a buckle member having a locking cavity defined therein and a strap channel defined therethrough, the locking cavity in communication with the strap channel, the strap channel configured to receive a portion of the strap through the buckle member and the locking cavity including a tapered end portion configured to receive the locking member therein to lock the strap in a fixed position relative to the buckle member. The kits may further optionally include a hand-held tensioning tool, a solar module, or one or more support structures for the solar power system.

[0018] Methods of use of the fastening assemblies and tools are also provided herein.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Various aspects and features of the present disclosure are described herein below with reference to the drawings, wherein:

[0020] FIG. **1** depicts a perspective view of a solar power system including one or more fastening assemblies as described in at least one embodiment herein;

[0021] FIG. **2**A is a perspective view of a fastening assembly as described in at least one embodiment herein;

[0022] FIGS. **2**B and **2**C are cross-sectional views of the fastening assembly of FIG. **2**A as described in at least one embodiment herein;
[0023] FIG. **3**A is a perspective view of a fastening assembly as described in at least one embodiment herein;
[0024] FIG. **3**B is a cross-sectional view of the fastening assembly of FIG. **3**A as described in at least one embodiment herein;
[0025] FIGS. **4**A and **4**B are cross-sectional views of a fastening assembly as described in at least one embodiment herein;
[0026] FIGS. **5-7** depict perspective views of various locking members as described in at least one embodiment herein.
[0027] FIG. **8** depicts a side view of a first support structure fastened to a second support structure of a solar power system via a fastening assembly as described in at least one embodiment herein;
[0028] FIGS. **9**A and **9**B depict a perspective and side view, respectively, of a hand-held strap tensioning tool as described in at least one embodiment herein;
[0029] FIG. **9**C is a perspective end view of a strap tensioning tool assembly of the hand-held strap tensioning tool of FIGS. **9**A-**9**B as described in at least one embodiment herein;
[0030] FIGS. **9**D and **9**E are cross-sectional views the strap tensioning tool assembly of FIG. **9**C as described in at least one embodiment herein;
[0031] FIG. **10**A is a perspective view of hand-held strap tensioning tool as described in at least one embodiment herein;
[0032] FIG. **10**B is an expanded view of the strap tensioning tool of FIG. **10**A as described in at least one embodiment herein; and
[0033] FIGS. **11**A and **11**B are a perspective and side view, respectively, of a hand-held strap tensioning tool in combination with fastening assembly as described in at least one embodiment herein.

DETAILED DESCRIPTION

[0034] The present disclosure describes a fastening assembly for use with a solar power system. The solar power system may be any type of solar power system, such as a fixed solar power system or a solar tracker power system. In particular embodiments, the solar power system is a solar tracker system.
[0035] As shown in FIG. **1**, a solar power system **5** as described herein, and particularly a solar tracking power system **5**, may include at least one or more base support structures **16** (e.g., a pile), one or more supplemental support structures **12**, **13** (e.g., a torque tube, mounting rail, and/or saddle), an array of solar modules **14** mounted thereon, and one or more fastening assemblies **10***a*, **10***b* as described herein.
[0036] In some embodiments, a plurality of fastening assemblies **10***a* are shown securing and/or locking one supplemental support structure **13** (e.g., a mounting rail or saddle) to another supplemental support structure **12** (e.g. a torque tube or generally horizontal beam). In some embodiments, a plurality of second fastening assemblies **10***b* are shown securing and/or locking one or more of the solar modules **14** to a supplemental support structure **13** (e.g., a mounting rail or saddle).
[0037] FIGS. **2**A-**2**C depict a fastening assembly **10** as described herein configured to be used with a solar power system. The assembly **10** includes a locking member **20**, a strap **30**, and a buckle member **40**. The strap **30** includes an elongate body extending between a first end portion **31** and an opposite second end portion **32**. The strap **30** has a length greater than its width. The strap **30** may be made of any suitable material including but not limited to leather, metal, plastics, rubber, and the like. The strap may be selected from the group consisting of a weave, a knit, a braid, or combinations thereof.
[0038] The fastening assembly **10**, as shown particularly in FIG. **2**B, is configured to be wrapped around a support structure **12**, such as a torque tube, mounting rail, saddle, etc., of a solar power

system to secure another support structure and/or solar module thereto. The solar module and/or additional support structure are not shown in FIGS. **2**A-**2**C to better visualize the fastening assembly. Although the support structure **12** is depicted in FIGS. **2**A-**2**B to define a generally circular cross-section, the fastening assembly **10** described herein may be utilized with a support structure **12** of any particular cross-sectional dimension, such as a cross-section which is elliptical or polygonal (e.g., triangular, square, rectangular, octagonal, etc.).

[0039] FIGS. **2**B-**2**C depict a cross-sectional view of the buckle member **40** in an unlocked configuration. In the unlocked configuration a first end portion **31** of the strap **30** is secured to the a portion of the buckle member **40** and the second end portion **32** of the strap **30** is configured to freely pass into or out of the buckle member **40**.

[0040] The buckle member **40** may define any polygonal or circular shape. In some embodiments, as particularly shown in FIGS. **2**A-**2**C, the buckle member **40** may define a generally rectangular shape including a front face **41***a* and an opposite rear face **41***b*, a top face **42***a* and opposite bottom face **42***b*, and a first side face **43***a* and an opposite second side face **43***b*. The buckle member **40** includes a locking cavity **44** defined therein and a strap channel **45** defined therethrough. The locking cavity **44** may be in communication with the strap channel **45**. The locking cavity **44** is positioned on top of the strap channel **45**. The strap channel **45** is configured to receive the strap **30** through the buckle member **40**. The strap channel **45** has a width generally equal to or slightly greater than the width of the strap **30**. As depicted, the strap channel **45** extends from a portion of the first side face **43***a* to a portion of the second side face **43***b* completely through the buckle member **40**.

[0041] In some embodiments, the first end portion **31** of the strap **30** forms a loop **30***a* secured to the buckle member **40** by extending from the second side face **43***b* through the strap channel **45** and exiting out the first side face **43***a* to wrap back around the bottom face **42***b* beyond the second side face **43***b* to close the loop. The second end portion of the strap **32** is free of the buckle member **40** and configured to be passed through the buckle member **40** after being wrapped around the support structure **5**.

[0042] As further depicted in FIGS. **2**B-**2**C, the locking cavity **44** is configured to receive a locking member **20** therein. Unlike the strap channel **45**, the locking cavity **44** does not extend to both the first and second side faces **43***a*, **43***b*. In some embodiments, the locking cavity **44** further includes an opening **46** extending from the bottom face **42***b*. The opening **46** being in communication with both the locking cavity **44** and the strap channel **45**. The opening **46** is designed to introduce and/or remove the locking member **20** from the locking cavity **44** when the buckle member **40** and/or the strap channel **45** is free of any strap.

[0043] As depicted in FIGS. **2**B-**2**C, the locking cavity **44** narrows from one end to another and/or includes a tapered end portion **48**. The tapered end portion **48** is configured to receive the locking member **20** therein to lock the strap **30** in a fixed position relative to the buckle member **40**, and particularly, within the strap channel **45** of the buckle member **40** (FIGS. **3**B and **4**B).

[0044] As further depicted in FIGS. **2**A-**2**C, the buckle member **40** may also include a slot **47** in communication with both the locking cavity **44** and the strap channel **45**. The slot **47** is defined through the second side face **43***b* of the buckle member **40** and on top of strap channel **45**. The slot **47** is configured to advance a strapping tool and/or pusher device (not shown in FIGS. **3**A-**3**D) therein to advance the locking member **20** towards the tapered end portion **48** of the locking cavity **44**.

[0045] The slot **47** defines a width which is smaller and/or narrower than the width of the strap **30**, the width of the strap channel **45**, and/or the width of the locking cavity **44**. The narrower slot **47** prevents the locking member **20** from falling out and/or being removed from the locking cavity **44** through the second sidewall **43***b*. The narrower slot **47** may also prevent the strap **30** from entering the slot **47** and/or locking cavity **44**.

[0046] In FIGS. **2**A-**2**C, the fastening assembly **10** is shown in an unlocked configuration wherein

the locking member **20** fails to pinch or lock the strap **30** to the buckle member **40**. In FIGS. **3**A-**3**B, the fastening assembly **10** is shown in a locked configuration wherein the locking member **20** is positioned within the tapered end portion **48** of the locking cavity **44** to pinch or lock the overlapping parts of the strap **30** to the buckle member **40**.

[0047] FIG. **3**B a cross-sectional view of the buckle member **40** in a locked configuration. In the locked configuration, the second end portion **32** of the strap **30** is locked into position inside the locking cavity **44** by the locking member **20**. As the locking member **20** advances into the tapered end portion **48** of the locking cavity **44**, the narrowing of tapered end portion **48** causes the locking member **20** into a part **32***a* of the second end portion **32** of the strap **30** positioned within the buckle **40** (and/or strap channel **45**) pinching the part **32***a* of the second end portion **32** of the strap **30** between the locking member **20** and a part **31***a* of the first end portion **31** of the strap **30** also positioned within the buckle **40** (and/or strap channel **45**) and the bottom surface **45***a* of the strap channel **45**.

[0048] As depicted in FIGS. **4**A and **4**B, in some embodiments, the strap channel **45** (and/or locking cavity **44**) may further include a recess **55** defined with the bottom surface **45***a* of the strap channel in the tapered end portion **48** of the cavity **44**. The recess **55** enhance the locking member's **20** ability to secure the strap **30** to the buckle member **40** thereby increasing the overall locking strength of the fastening assembly.

[0049] In FIG. **4**A, the fastening assembly **10** is shown in an unlocked configuration wherein the locking member **20** fails to pinch or lock the strap **30** to the buckle member **40**. In FIG. **4**B, the fastening assembly **10** is shown in a locked configuration wherein the locking member **20** is positioned within the tapered end portion **48** of the locking cavity **44** to pinch or lock the overlapping parts of the strap **30** to the buckle member **40** with the locking member **20** positioned within the recess **55**.

[0050] As shown in FIGS. **5**-**7**, the locking member **20** may be useful in various different shapes. For example, as shown in FIG. **5**, in some embodiments, the locking member **20** may be a rod including a plurality of grip-enhancing features **52**, such as barbs, extending therefrom to enhance the gripping ability of the locking member **50**. In some embodiments, at least a majority, if not all, of the outer surface of the locking member **20** may include grip-enhancing features. In another example, as shown in FIG. **6**, in some embodiments, the locking member **20** may be a rod including grip-enhancing features **52**, such as longitudinal ridges, extending on an outer surface thereof along a longitudinal axis of the locking member **20**. The features **52** extending between smooth and/or non-gripping ends **53**. In yet another example, as shown in FIG. **7**, in some embodiments, the locking member **20** may include a generally circular (or elliptical) ball **26** centered between two rod-like opposite ends **27**. In some embodiments, the locking member **20** may be free of any texture and/or gripping enhancing barbs, ridges, etc. The locking members **20** described herein may be made of any suitable material including, but not limited to, metal, plastic, and/or ceramic materials.

[0051] FIG. **8** illustrates a fastening assembly **10** as described herein securing a first support structure, such as a torque tube **5**, to a second support structure, such as saddle **6** configured to support solar panels (not shown). The saddle **6** includes a first and second slit **7***a*, **7***b* on opposite sides of the saddle **6** configured to pass the strap **30** therethrough as the strap **30** is wrapped around the outer perimeter or circumference of the torque tube **5** and then passed through the buckle member **40** and locked into place by the advancing the locking member towards the tapered end portion of the buckle member **40**.

[0052] As depicted in FIG. **8**, the fastening assembly **10** is configured to be fastened from underneath the support structure or torque tube **5**. Fastening from underneath the support structures can be easier and less time-consuming because beneath the primary support structure may often be where the most open space to operate is in a solar power system because the solar modules are commonly positioned on top of the support structures and not below. In addition, the first support

structure **5** may bear the weight of any additional support structures and/or solar modules positioned thereon while the fastening assembly is tightened and ultimately locked thereto.
[0053] FIGS. **9**A-**9**B depict at least one embodiment of a hand-held tensioning tool **60** designed to apply tension and/or pull on a strap as described herein. The tensioning tool **60** includes a strap tensioning tool assembly **70** operatively coupled to a power assembly **80**. The strap tensioning tool assembly **70** is configured to perform one or more strap tensioning operations, including pulling on the free end of the strap, maintaining tension on the free end of the strap, advancing of the locking member inside the buckle member, cutting of the free end portion of the strap after locking of the strap to the buckle member, and/or crimping of the buckle member after locking of the strap to the buckle member.
[0054] In some embodiments, the power assembly **80** includes a power drill **81** configured to drive the strap tensioning tool assembly **70** and a power source **86** configured to power the power drill **81**. The power drill **81** may be of any commonly known drills.
[0055] In some embodiments, the power drill **81** may include at least a handle **82**, a trigger **83**, a gear-driven rotary motor **84**, and a drive screw **85**. The motor **84** configured to rotate the drive screw **85** in a clockwise and/or counterclockwise direction.
[0056] In some embodiments, the power source **86** may be stored in and/or extend from the handle **82**. The power source **86** may include one or more of a battery, electricity from a power grid, a fuel cell-based system, or compressed air.
[0057] As further illustrated in FIGS. **9**A-**9**C, the strap tensioning tool assembly **70** may include an elongate housing **71** configured to attach to the power assembly **80**, and particularly the power drill **81**, via the drive screw **85**. The housing **71** defines a chamber **72** configured to receive the drive screw **85** therein. The housing **71** attached to the drill **81** on a first end portion of the housing.
[0058] In some embodiments, the housing **71** defines a generally rectangular housing defining a generally rectangular chamber **72**. The housing **71** including a front face **91***a* and an opposite rear face **91***b*, a top face **92***a* and opposite bottom face **92***b*, and a first side face **93***a* and an opposite second side face **93***b*. The second side face **93***b* includes a protrusion **95** extending longitudinally therefrom and an insert aperture **94** sized and dimensioned to receive a strap, and particularly a free end portion of the strap, therethrough. The insert aperture **94** being of similar shape as strap channel **45**. The protrusion **95** may be located above the insert aperture **94**. The protrusion **95** is configured to enter the slot **47** of the buckle member **40** to advance the locking member **20** towards the tapered end portion **48** of the locking cavity **44**. In some embodiments, the protrusion **94** may be used to positively engage the locking member **20** after the strap **30** is at or near a sufficient tension to secure the buckle member **40** to the support structure **5**.
[0059] As shown in FIGS. **9**C and **9**D, the housing **71** further includes a carriage **73** positioned therein. The carriage **73** includes a cover portion **73***a* and a base portion **73***b*. The base **73***b* includes a threaded lumen **74** defined therein, the threaded lumen **74** configured to receive the drive screw **85** therein. The carriage **73** includes a strap chamber **75** positioned between a top **76** of the base **73***b* and the cover portion **73***a*. The strap chamber **75** is configured to receive and maintain the free second end portion **32** of a strap **30** therein. The strap chamber **75** includes one or more springs **77** positioned at an angle on top of the base **73***b*. The springs **77** may be anchored to the top of the base on a first end **77***a* by a mount **78** and secured to a wedging member **79** on a second opposite end **77***b*. The springs **77** may be configured to force the wedge member **79** against the top surface **76** of the base **73***b* of the carriage **73**. The springs **77** and wedge member **79** are operatively connected to pinch and/or secure a free second end portion **32** of the strap **30** between the wedge member **70** and the top surface **76** of the base **73***b*. The cover portion **73***a* sits on top of the base **73***b*, and particularly covering the one or more springs **77** and the wedge member **79**. The spring/wedge assembly may be configured to secure the strap to the movable carriage. The carriage **73** further includes at least one carriage openings **88** positioned on a side of the carriage **73** to allow passage of the free second end portion **32** of the strap **30** into the carriage **73**.

[0060] As further shown in FIGS. **9**C-**9**D, the carriage **73** sits on the drive screw **85** via the threaded lumen **84**. Rotation of the drive screw **85**, via the power drill **80**, in a first direction, e.g., clockwise, or counterclockwise, causes the carriage **73** to move linearly in a first direction (e.g., forward or towards the power drill **80**) along the screw drive **85** while the housing **71** remains stationary. When a strap **30** is anchored to the carriage **73**, forward movement of the carriage **73** will draw the strap **30** further into the housing **70**. This may also cause the strap **30** to be pulled through the buckle member **40** and tighten the strap **30** around the support structure.
[0061] Rotation of the drive screw **85**, via the power drill **80**, in a second direction, e.g., counterclockwise, or clockwise, causes the carriage **73** to move linearly in a second direction (e.g., reverse or away from the power drill **80**) along the screw drive **85** opposite the first direction. When a strap **30** is anchored to the carriage **73**, reverse movement of the carriage **73** may loosen the strap **30** around the support structure and/or may be used to remove the strap **30** from the housing **70** once locked in place in the buckle member **40**.
[0062] Conversion of the drive screw rotation into linear motion of the carriage also creates tension to the strap when secured within the spring/wedge assembly of the carriage. Exact motion and/or tension can be adjusted by a clutch or gear on the power drill and/or also by the pitch of the threads on the screw drive and/or threaded lumen o the carriage. A load cell may also be included to measure the force on the strap.
[0063] The housing may further include one or more cutting devices, such as a knife, pincher, laser-cutting device, ultrasonic cutting device, etc. The cutting device may be positioned on any portion of the housing suitable for cutting the strap contained therein. In some embodiments, the cutting device may be on an inner or outer surface of the second side face of the housing. In some embodiments, the cutter may be positioned somewhere along a length of the strap chamber.
[0064] FIGS. **10**A-**10**B depict at least one embodiment of a hand-held hydraulic tensioning tool **160** designed to apply tension and/or pull on a strap as described herein. The tool **160** includes a strap tensioning tool assembly **170** operatively coupled to a hydraulic power assembly **180**. The strap tensioning tool assembly **170** is configured to perform one or more strap tensioning operations, including pulling on the free end of the strap, maintaining tension on the free end of the strap, advancing of the locking member inside the buckle member, cutting of the free end portion of the strap after locking of the strap to the buckle member, and/or crimping of the buckle member after locking of the strap to the buckle member
[0065] In some embodiments, the hydraulic power assembly **180** includes a base frame **179** upon which a hydraulic ratchet **181**, hydraulic hose fittings **182**, a solenoid **183**, a handle **184**, and a power source **185** may be individually or collectively secured thereto. The hydraulic power assembly **180** is configured to drive the strap tensioning tool assembly **170**. The use of hydraulics may not only provide additional tension to the strap **30** but also may provide the additional power needed to properly crimp the buckle member **40**. In some embodiments, to achieve a high level of tension, the tensioning tool **160** may use hydraulics to provide both a high level of tension and also to actuate the crimping mechanism when the proper tension level is achieved. The ratchet **181** helps release and/or apply more torque when needed. The hydraulic power assembly **180** may be of any commonly known assemblies.
[0066] As further illustrated in FIGS. **10**A-**10**B, the strap tensioning tool assembly **170** may include a plurality of interconnected parts operatively coupled to each other and/or the hydraulic power assembly **180**. The tool assembly **170** may include at least a wheeled-type tensioning mechanism **171** configured to apply tension to a free end portion **32** of a strap **30**, a strap cutting device **172**, one or more pairs of crimper jaws **173**, **174** configured to crimp the buckle member, and a hydraulic cylinder **175** operatively coupled to the crimper, cutter, and/or tensioning mechanism. The tool assembly **170** is also attached to the tool frame **179**.
[0067] FIGS. **11**A-**11**B depict a saddle rail **6** secured to a torque tube **5** using a fastening assembly **10** as described herein, and/or particularly a strap **30**, a buckle member **40**, and a locking member

(not shown). A hydraulic tensioning tool **160** may be deigned to come in from beneath the torque tube and/or rail to apply tension to the strap and/or fasten the fastening assembly **10** to the torque tube **5**. The handle **184** includes one or more triggers **195** designed to, individually or collectively, activate the wheel-type tensioning mechanism **171**, the crimping jaws **173**, **174**, and/or the strap cutting device **172**, when pressed upon.

[0068] As further depicted in FIG. **11**A, the hydraulic tensioning tool **160** may include a wheel-type tensioning mechanism **171**, such as knurled tensioning wheel, to apply tension to the strap **30**. In some embodiments, tension is applied to the strap **30** using the wheel-type mechanism **171** while the buckle member **40** is positioned within one or more of the crimping jaw members **173**. In some embodiments, the buckle member **40** is free of a locking member. In some embodiments, the buckle member **40** includes a locking member **20**.

[0069] As further depicted in FIG. **11**B, the one or more pairs of crimping jaw members **173** are configured to act on the buckle member **40** perpendicular to the wheel-type tensioning mechanism **171** to crimp the buckle member **40** onto the strap **30** under tension. The crimping jaw members **173** are designed to pivot between an open position (as shown in FIGS. **11**A/**11**B) and a crimping position (as shown in FIGS. **10**A/**10**B). In the open position, the jaw members are spaced sufficiently apart to receive the buckle member therebetween. In the crimping position, the jaws **173** are pressed towards each other with sufficient force to deform at least a portion of the buckle member **40** about the strap **30**. After crimping the excess strap **30** may remain or be removed from the assembly **10**.

[0070] Methods of forming a solar tracker system are also provided. The methods include positioning one or more of the fastening assemblies described herein around a first support structure, such as a torque tube, and at least a part of a solar related device, such as a solar module, and/or a supplemental support structure (e.g., a saddle or mounting rail), to connect the device to the first support structure, and tightening and/or locking the assembly to affix the device to the support structure in a generally stationary manner.

[0071] In some embodiments, positioning of one or more assemblies may include wrapping a free second end of a strap around an outer perimeter of a support structure and passing the free end of the strap through at least a portion of a solar related device, before passing the second free end of the strap back through and out of a buckle member. Because the opposite first end of the strap is secured the buckle member via the loop on the first end of the strap, once the second free end of the strap is passed through the buckle member, the strap forms a closed shape mirroring the shape of the outer perimeter of the support structure. For example, the strap may generally form a circular closed shape when wrapped around a support structure having a generally circular cross-section. Any closed shape, e.g., rectangular, triangular, etc., may be envisioned.

[0072] Initially, in some embodiments, the fastening assembly, and particularly the strap, may be loosely wrapped about the support structure and/or through at least a portion of the related solar device and/or through the buckle member to loosely connect the solar related device to the support structure in an unlocked configuration and/or prior to tightening. After the second free end of the strap is passed through the buckle member, the second free end of the strap may be pulled upon to further extend away from the buckle member until the strap is tightly wrapped about the support structure and/or through the solar related device to secure the device to the support structure. At the same time and/or thereafter, the locking member positioned within the buckle member may be advanced towards a locked position nearest the tapered portion of the locking cavity to lock the strap within the buckle member while tightened to lock and/or fix the position of the solar related device to the torque tube. Pulling of the second free end of the strap may be performed by hand, e.g., manually, or by any of the tightening tools described in.

[0073] In some embodiments, a power strap tensioning tool assembly may be used to tighten the strap. For example, in some embodiments, the power tool assembly of FIGS. **9**A-**9**E may be used to tighten the strap. In another example, in some embodiments, the power tool assembly of FIGS.

10A-**11**B may be used to tighten the strap. In addition to tightening of the strap, the methods described herein may further include the steps of maintaining tension on the free end of the strap, advancing of the locking member inside the buckle member, cutting of the free end portion of the strap after locking of the strap to the buckle member, and/or crimping of the buckle member.
[0074] In some embodiments, the fastening assemblies described herein may be part of kit for a solar power system. Such kits may include one or more fastening assemblies as described herein and at least one of a support structure, a solar related device, or both. The fastening assembly including at least a strap, a buckle member, and a locking member.
[0075] In some embodiments, the kits described herein may include one or more fastening assemblies as described herein and one or more saddles or mounting rails for connecting a solar panel to a support structure, and optionally one or more solar panels and/or one or more support structures such as a torque tube.
[0076] It will be understood that various modifications may be made to the embodiments disclosed herein. Therefore, the above description should not be construed as limiting, but merely as an exemplification of preferred embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the present disclosure. Such modifications and variations are intended to come within the scope of the following claims.

Claims

1. A hand-held strap tensioning tool comprising: a handle, a strap tensioning tool assembly operatively coupled to the handle, the strap tensioning tool assembly configured to perform one or more strap tensioning operations, and a power assembly operatively coupled to both the handle and the strap tensioning tool assembly.
2. The hand-held tensioning tool of claim 1, wherein the power assembly includes a power drill configured to drive the strap tensioning tool assembly and a power source configured to power the power drill, the power source including one or more of a battery, electricity from a power grid, a fuel cell-based system, compressed air, or an internal combustion engine.
3. The hand-held tensioning tool of claim 2, wherein the power drill includes the handle, a trigger, and a gear driven rotary motor configured to rotate a drive screw, and the strap tensioning tool assembly includes an elongate housing extending from the power drill.
4. The hand-held tensioning tool of claim 3, wherein the elongate housing defines a chamber of sufficient size to accommodate the screw drive therein, and a carriage including a threaded lumen in which the screw drive is positioned, the carriage including a strap chamber configured to receive and maintain a free end portion of the strap therein, the strap chamber including one or more springs positioned on a first portion of an inner surface of the strap chamber, the one or more springs configured to force a wedge member against a second portion of the inner surface of the strap chamber with the free end portion of the strap therebetween.
5. The hand-held tensioning tool of claim 1, where the strap tensioning tool assembly is operatively coupled to a hydraulic power assembly tool including a base frame upon which a hydraulic ratchet, hydraulic hose fittings, a solenoid, a handle, and a power source are secured thereto.
6. The hand-held tensioning tool of claim 5, wherein the tool assembly includes at least a wheeled-type tensioning mechanism configured to apply tension to a free end portion of the strap, a strap cutting device, one or more pairs of crimper jaws configured to crimp the buckle member, and a hydraulic cylinder operatively coupled to the crimper, cutter, and/or tensioning mechanism, wherein the tool assembly is secured to the base frame.