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(57) Abstract: An octahedral space frame includes a first plurality of double octahedral structures disposed in a first row in a longitudinal direction, adjacent ones of the first plurality of double octahedral structures sharing two common members. Each of the first plurality of double octahedral structures includes respective first and second single octahedron structures joined in a transverse direction and sharing three common members, the transverse direction being orthogonal to the longitudinal direction.



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OCTAHEDRAL SPACE FRAMES AND ASSOCIATED SYSTEMS AND METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority from United States Patent Application No. 15/587,586, filed May 5, 2017 and Chinese Patent Application No. 201710675157.8, filed August 9, 2017, which are incorporated herein by reference in its entirety.

BACKGROUND

[0002] Solar thermal power plants, also called concentrating solar power plants, concentrate sunlight to heat a fluid and transport the thermal energy of the heated fluid to drive a process such as electricity-generating turbines or engines. The fluid flows through concentrating solar collector assemblies, which include parabolic troughs and receiver tube(s). The parabolic troughs include a reflective surface that reflects the incident sunlight onto the receiver, through which the fluid flows. The parabolic trough, together with the receiver, may be rotated to track the sun. A space frame provides structural support for the parabolic trough. The space frame experiences significant torsional loads caused, for example, by wind. The space frame must hold the weight of the parabolic trough, particularly as it is rotated, and not fail under the torsional loads. The space frame must further provide sufficient stiffness, such that the parabolic troughs do not deflect from the desired position for optimal collection of light. With all these requirements, the space frame may account for approximately 25% of the total installation cost of a concentrating solar collector assembly.

BRIEF SUMMARY OF THE INVENTION

[0003] Applicant has developed octahedral space frames that are capable of efficiently carrying torsional loads while maintaining torsional stiffness. In certain embodiments, the octahedral space frames support a parabolic trough of a concentrating solar collector assembly. In particular embodiments, the octahedral space frames include a plurality of double octahedral structures, disposed in a row, each double octahedral structure including two single octahedron structures. Certain

embodiments of the featured octahedral space frames include a V-shaped opening formed when viewing the octahedral space frame in a longitudinal direction. Certain embodiments include a parabolic trough supported in the V-shaped opening of the octahedral space frame.

[0004] In an aspect, an octahedral space frame includes a first plurality of double octahedral structures disposed in a first row in a longitudinal direction, adjacent ones of the first plurality of double octahedral structures sharing two common members. In an embodiment of this aspect, each of the first plurality of double octahedral structures includes respective first and second single octahedron structures joined in a transverse direction and sharing three common members, the transverse direction being orthogonal to the longitudinal direction.

[0005] In an embodiment, for example, the first plurality of double octahedral structures collectively forms a V-shaped opening, as seen when the octahedral space frame is viewed in the longitudinal direction.

[0006] In an embodiment, for example, the V-shaped opening has an internal angle greater than 0 degrees and less than or equal to 180 degrees.

[0007] In an embodiment, for example, each of the first plurality of double octahedral structures includes twenty one members.

[0008] In an embodiment, for example, each of the twenty one members of each of the first plurality of double octahedral structures has equal length.

[0009] In an embodiment, for example, the octahedral space frame has a rectangular outline as seen when viewed in the longitudinal direction.

[0010] In an embodiment, for example, each of the first plurality of double octahedral structures includes twenty one members, wherein seven members of the twenty one members have a common first length and fourteen members of the twenty one members have a common second length, the second length being different from the first length.

[0011] In an embodiment, for example, the octahedral space frame further includes: a first axial chord joining each first single octahedron structure of the first plurality of double octahedral structures in the longitudinal direction; and a second axial chord joining each second single octahedron structure of the first plurality of double octahedral structures in the longitudinal direction.

[0012] In an embodiment, for example, the octahedral space frame further includes: a first plurality of axial chords joining each first single octahedron structure of the first plurality of double octahedral structures in the longitudinal direction; and a second plurality of axial chords joining each second single octahedron structure of the first plurality of double octahedral structures in the longitudinal direction.

[0013] In an embodiment, for example, the octahedral space frame further includes an end member assembly disposed at an end of the first plurality of double octahedral structures. In this embodiment, the end member assembly includes: one or more first end members connected to the first single octahedron structure of an end one of the first plurality of double octahedral structures; and one or more second end members connected to the second single octahedron structure of the end one of the first plurality of double octahedral structures.

[0014] In an embodiment, for example, the octahedral space frame further includes a torque transfer assembly disposed at the end one of the first plurality of double octahedral structures.

[0015] In an embodiment, for example, the torque transfer assembly includes at least one torque transfer plate and a central torsion element.

[0016] In an embodiment, for example, the octahedral space frame further includes a second plurality of double octahedral structures disposed in a second row in the longitudinal direction, adjacent ones, in the longitudinal direction, of the second plurality of double octahedral structures sharing two common members, the first and second rows being joined in the transverse direction.

[0017] In an embodiment, for example, each of the second plurality of double octahedral structures includes twenty one members.

[0018] In an embodiment, for example, the first and second rows share at least one common axial chord.

[0019] In an embodiment, for example, the octahedral space frame further includes a third plurality of double octahedral structures disposed in a third row in the longitudinal direction, adjacent ones, in the longitudinal direction, of the third plurality of double of octahedral structures sharing two common members, the third row being joined to each of the first and second rows in a vertical direction orthogonal to each of the longitudinal and transverse directions.

[0020] In another aspect, a concentrating solar collector assembly includes an octahedral space frame. In an embodiment of this aspect, the octahedral space frame includes a plurality of double octahedral structures disposed in a first row in a longitudinal direction, adjacent ones of the plurality of double octahedral structures sharing two common members, the plurality of double octahedral structures collectively forming a V-shaped opening in the octahedral space frame, as seen when the octahedral space frame is viewed in the longitudinal direction. In an embodiment of this aspect, each of the plurality of double octahedral structures includes respective first and second single octahedron structures joined in a transverse direction and sharing three common members, the transverse direction being orthogonal to the longitudinal direction. In an embodiment of this aspect, the octahedral space frame further includes a parabolic trough disposed in the V-shaped opening in the octahedral space frame.

[0021] In an embodiment, for example, the V-shaped opening has an internal angle greater than 0 degrees and less than or equal to 180 degrees.

[0022] In an embodiment, for example, the concentrating solar collector assembly further includes a receiver configured to carry a heat transfer fluid, the parabolic trough being configured to reflect light incident on the parabolic trough onto the receiver.

[0023] In an embodiment, for example, the concentrating solar collector assembly further includes receiver support elements configured to structurally support the receiver.

[0024] In an embodiment, for example, the receiver has an elongated axis extending in the longitudinal direction.

[0025] In an embodiment, for example, the concentrating solar collector assembly further includes a fluid distribution subsystem configured to circulate the heat transfer fluid through the receiver.

[0026] In an embodiment, for example, each of the plurality of double octahedral structures of the octahedral space frame includes twenty one members.

[0027] In an embodiment, for example, each of the twenty one members of each of the plurality of double octahedral structures has an equivalent length.

[0028] In an embodiment, for example, the octahedral space frame, of the concentrating solar collector assembly, further includes: a first axial chord joining each first single octahedron structure of the plurality of double octahedral structures in the longitudinal direction; and a second axial chord joining each second single octahedron structure of the plurality of double octahedral structures in the longitudinal direction.

[0029] In an embodiment, for example, the octahedral space frame, of the concentrating solar collector assembly, further includes: a first plurality of axial chords joining each first single octahedron structure of the first plurality of double octahedral structures in the longitudinal direction; and a second plurality of axial chords joining each second single octahedron structure of the first plurality of double octahedral structures in the longitudinal direction.

[0030] In an embodiment, for example, the octahedral space frame, of the concentrating solar collector assembly, further includes an end member assembly disposed at an end of the plurality of double octahedral structures. In this embodiment, the end member assembly includes: one or more first end members connected to the first single octahedral structure of an end one of the plurality of double octahedral structures; and one or more second end members connected to the second single octahedral structure of the end one of the plurality of double octahedral structures.

[0031] In an embodiment, for example, the octahedral space frame, of the concentrating solar collector assembly, further includes a torque transfer assembly disposed at the end one of the plurality of double octahedral structures.

[0032] In an embodiment, for example, the torque transfer assembly, of the concentrating solar collector assembly, further includes at least one torque transfer plate and a central torsion element.

[0033] In an embodiment, for example, the concentrating solar collector assembly further includes: a plurality of pylons configured to support the octahedral space frame and the parabolic trough; and a tracking subsystem configured to rotate the octahedral space frame and the parabolic trough with respect to the plurality of pylons, to track an incident light source.

[0034] In another aspect, a method for supporting a parabolic trough in a concentrating solar collector assembly includes: transferring weight of the parabolic trough to an octahedral space frame including a plurality of double octahedral structures disposed in a first row in a longitudinal direction, wherein (a) adjacent ones of the plurality of double octahedral structures share two common members and (b) each of the plurality of double octahedral structures includes respective first and second single octahedron structures joined in a transverse direction and sharing three common members, the transverse direction being orthogonal to the longitudinal direction; and transferring weight of the parabolic trough and the octahedral space frame to a base surface via a plurality of pylons.

[0035] In an embodiment, for example, the method for supporting a parabolic trough further includes carrying torsional load while maintaining torsional stiffness.

[0036] In an embodiment, for example, the base surface is a ground surface.

[0037] In an embodiment, a method for capturing solar energy includes: the method for supporting a parabolic trough in a concentrating solar collector assembly; reflecting light incident on the parabolic trough onto a receiver; and circulating a heat transfer fluid through the receiver.

[0038] In an embodiment, for example, the method for capturing solar energy further includes rotating the parabolic trough and the octahedral space frame with respect to the plurality of pylons to track an incident light source.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] **FIG. 1** shows a portion of a parabolic trough system, according to an embodiment.

[0040] **FIG. 2A** illustrates an embodiment of a single octahedron structure. **FIG. 2B** illustrates two instances of the **FIG. 2A** single octahedron structure. **FIG. 2C** illustrates a double octahedral structure formed by joining the two single octahedron structure instances of **FIG. 2B**, according to an embodiment.

[0041] **FIG. 3A** illustrates a first double octahedral structure and a second double octahedral structure. **FIG. 3B** shows a plurality of double octahedral structures formed when first and second double octahedral structures are joined, in an embodiment.

[0042] **FIG. 4** illustrates an octahedral space frame, according to an embodiment.

[0043] **FIG. 5** illustrates an octahedral space frame, according to another embodiment.

[0044] **FIGs. 6A** and **6B** illustrate side views of an octahedral space frame, in an embodiment, viewed in the longitudinal and the transverse directions, respectively.

[0045] **FIG. 7** illustrates a parabolic trough supported by an octahedral space frame, according to an embodiment.

[0046] **FIG. 8** shows a side view of the parabolic trough system of **FIG. 7**, viewed in the longitudinal direction.

[0047] **FIGs. 9A, 9B, and 9C** show a top view, a longitudinal side view, and a transverse side view of an octahedral space frame, according to an embodiment.

[0048] **FIGs. 10A-10C** illustrate alternate embodiments of the single octahedron structure of **FIG. 2A** which are irregular octahedrons in their shape, wherein members have two or more lengths.

[0049] **FIGs. 11A-11C** illustrate side views, in the longitudinal direction, of several examples of a double octahedron structure, the examples differing in shape of the single octahedron structures, according to an embodiment. **FIG. 11A** shows an embodiment of a double octahedral structure that includes single octahedron structures that resemble a regular octahedron. **FIGs. 11B** and **11C** show additional examples of double octahedral structure that include single octahedron structures that resemble irregular octahedrons.

[0050] **FIGs. 12A, 12B, and 12C** illustrate a top view, a longitudinal side view, and a transverse side view of an octahedral space frame, according to an embodiment, including irregular single octahedron structures such as that shown in **FIG. 10C**, wherein the internal angle of the V-shaped opening is 180 degrees, such as shown in **FIG. 11B**.

[0051] **FIGs. 13A-13B** illustrate side views in a transverse direction and a longitudinal direction, respectively, of an embodiment of an octahedral space frame including double octahedral structures joined in a vertical direction, according to an embodiment.

[0052] **FIG. 14** depicts an operational method, in an embodiment, for supporting a parabolic trough using an octahedral space frame in a concentrating solar collector assembly and for capturing solar energy.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0053] In general the terms and phrases used herein have their art-recognized meaning, which can be found by reference to standard texts, journal references and contexts known to those skilled in the art.

[0054] Referring to the drawings, like numerals indicate like elements and the same number appearing in more than one drawing refers to the same element.

[0055] Without wishing to be bound by any particular theory, there may be discussion herein of beliefs or understandings of underlying principles relating to the devices and methods disclosed herein. It is recognized that regardless of the ultimate correctness of any mechanistic explanation or hypothesis, an embodiment of the invention can nonetheless be operative and useful.

[0056] Applicant discloses space frames and associated systems and methods where face- and/or edge-sharing octahedral structures are configured to produce a multi-layer grid space frame. Certain embodiments of the space frames form a planar surface, complex surface, or a combination of planer and complex surfaces. The space frames are used, for example, as a support structure for a parabolic trough used in a concentrated solar power application. Each space frame, henceforward referred to as an octahedral space frame, includes multiple pairs of face sharing double octahedral structures repeated along an axis and sharing edges to produce a long structure for supporting a parabolic trough, in certain embodiments.

[0057] Certain embodiments of the octahedral space frames provide structural support when used with parabolic troughs, as part of a concentrating solar collector assembly. The octahedral space frames efficiently carry a torsional load, while maintaining torsional stiffness, with low overall weight.

[0058] A further advantage of certain embodiments of the octahedral space frames is reduced complexity. In certain embodiments, members (e.g., struts and/or chords) are of the same length, thereby allowing the majority of struts used in the manufacture of an octahedral space frame to be of the same length. In this embodiment, the octahedral space frame takes a form desirable for a parabolic trough application in which the parabolic trough is cradled in the V-shape defined by the structure. As a result, additional space frame elements may be unnecessary or minimal to support the parabolic trough. The octahedral space frames featured herein provide reduced installation cost compared to conventional space frames.

[0059] Certain configurations of the octahedral space frames could also have utility in the architectural, civil, structural and other engineering fields where a configurable, multi-layer grid space frame structure is desirable.

[0060] **FIG. 1** shows a portion of an exemplary parabolic trough system **100**, including an octahedral space frame **102**. Parabolic trough system **100** is, for example, part of a concentrating solar collector assembly of a solar concentrating solar power system. Octahedral space frame **102** supports one or more parabolic troughs **104**. Parabolic troughs **104** reflect incident ambient light onto a receiver **106**, which is structurally supported by a receiver support elements **108**. Pylons **110** provide structural support to the parabolic trough system. Parabolic trough system **100** may include one or more parabolic troughs **104** supported by one or more octahedral space frames **102**.

[0061] An octahedral space frame includes one or more double octahedral structures, each of which includes two single octahedron structures. **FIG. 2A** illustrates a single octahedron structure **200**, which is formed of 12 members (e.g., struts and/or chords) **202**. For illustration purposes, only two of the twelve (12) members **202** are explicitly called out in **FIG. 2A**. In an embodiment, single octahedron structure **200** is a regular octahedron in its shape, where each of members **202** share one common length. In certain other embodiments, single octahedron structure **200** is an irregular octahedron in its shape, such as that depicted in any of **FIGs. 10A-10C**, for example, where members **202** have two, three, four, or five different lengths within single octahedron **200**. **FIG. 2B** illustrates a first single octahedron structure **210** and a second octahedron structure **212**, each of which is an embodiment of single octahedron structure **200**. First and second octahedron structures **210** and **212** are preferably equivalent to each other. First and second octahedron structures **210** and **212** are effectively joined, in a transverse direction **206**, as illustrated in **FIG. 2C**, such that three members (e.g., struts and/or chords) **204** are shared in the resulting embodiment of a double octahedral structure **250**. Shared members **204** are embodiments of members **202**. Double octahedral structure **250** includes twenty one (21) members (e.g., struts and/or chords) **202**, including shared members **204**. In an embodiment, each of the twenty one members

202, including shared members **204**, of double octahedral structure **250** are of equal length. In certain other embodiments, the twenty one members **202**, including shared members **204**, of double octahedral structure **250** have two, three, four, or five different lengths.

[0062] **FIG. 3A** illustrates a first double octahedral structure **310** and a second double octahedral structure **312**, each of which are embodiments of double octahedral structure **250**. First and second double octahedral structures **310** and **312** are preferably equivalent to each other. First and second double octahedral structures **310** and **312** are formed of members **202**, only two of which are explicitly called out for illustration purposes. **FIG. 3B** shows a plurality (i.e., two) of double octahedral structures **300** formed when first and second double octahedral structures **310** and **312** are effectively joined, in a longitudinal direction **208**, which is orthogonal to transverse direction **206**, such that two members **302** of first and second octahedral structures **310** and **312** are shared in resulting plurality of double octahedral structures **300**. Shared members **302** are embodiments of members **202**. In an embodiment, each of members **202**, including shared members **302**, in plurality of octahedral structures **300** is of equal length. In certain other embodiments, the members **202**, including shared members **302**, of plurality of double octahedral structures **300** have two, three, four, or five different lengths. In certain embodiments, plurality of double octahedral structures **300** includes three or more effectively joined double octahedral structures, such as **250**, **310**, and **312**.

[0063] **FIG. 4** illustrates an octahedral space frame **400**, which is one possible embodiment of the octahedral space frames featured herein. Octahedral space frame **400** includes a plurality of double octahedral structures **420**, which are an embodiment of plurality of double octahedral structures **300**, disposed in a row in longitudinal direction **208**. Plurality of double octahedral structures **420** includes six double octahedral structures **250**, one of which is labeled in **FIG. 4**, effectively joined in longitudinal direction **208**, any two adjacent double octahedral structures **250** share two common members. Other embodiments of the octahedral space frames featured herein include a different number of double octahedral structures **250** in plurality of double octahedral structures **420**, without departing from the scope

hereof. Octahedral space frame **400** includes first longitudinal end **410** and second longitudinal end **412**, which are opposite of each other along longitudinal direction **208**. Octahedral space frame **400** also includes first transverse side **414** and second transverse side **416**, which are opposite each other along transverse direction **206**. For illustration and clarity purposes, only one single octahedron structure **200** is labeled in **FIG. 4**. Octahedral space frame **400** includes axial chords **404**, which are embodiments of members **202**. Three series of six linearly connected axial chords **404** run in longitudinal direction **208** between first longitudinal end **410** and second longitudinal end **412** ultimately connecting ends of torque transfer plates **452** at first longitudinal end **410** to the corresponding ends of torque transfer plates **452** at second longitudinal end **412** of octahedral space frame **400**, as illustrated in **FIG. 4**. In other embodiments, the number of axial chords **404** connected in series between first and second longitudinal ends **410** and **412** is n , where n is the number of double octahedral structures **250** effectively joined in longitudinal direction **208** within plurality of double octahedral structures **420**. In certain embodiments, any number of members **404** may be struts, for example. Octahedral space frame **400** further includes axial chords **402**. Two series of five linearly connected axial chords **402** run in longitudinal direction **208** between first longitudinal end **410** and second longitudinal end **412**, axial chords **402** of each series connecting upper vertices **252** of each longitudinally adjacent double octahedral structure **250**, within plurality of double octahedral structures **420**, on respective first or second transverse side **414** or **416**. In other words, axial chords **402** in a first series join each adjacent first single octahedron structure **210** and axial chords **402** in a second series join each adjacent second octahedron structure **212**, in longitudinal direction **208**. In other embodiments, the number of axial chords **402** connected in each series, or in other words, the number of axial chords **402** connecting each first single octahedron structure **210** and the number of axial chords **402** connecting each second octahedron structure **212**, is $(n-1)$. Other embodiments of the octahedral space frames featured herein include a different number of axial chords **402**, without departing from the scope hereof. For example, one axial chord **402** may span two single octahedron structures **200**, or any other number of single octahedron structures within octahedral space frame **400**. In an embodiment, the length of each axial chord **404** is approximately the length of each strut member within the single

octahedron structures. In an embodiment, the length of axial chord **402** is equal to the distance between any two upper vertices **252** that axial chord **402** connects.

[0064] Octahedral space frame **400** further includes an end member assembly **440** proximate each of first and second longitudinal ends **410** and **412**. In this embodiment, each end member assembly **440** includes end axial chords **406** and end members **442**. Each end axial chord **406** is connected to nearest upper vertex **252** proximate the respective longitudinal end, **410** or **412**, and respective transverse side, **414** or **416**, to proximate end members **442** at respective longitudinal end and respective transverse side of octahedral space frame **400**, as illustrated in **FIG. 4**. In other words, proximate each longitudinal end, **410** and **412**, an end axial chord **406** connects proximate first single octahedron structure to proximate end members **442**, and another end axial chord **406** connects proximate second single octahedron structure to proximate end members **442**. End members **442** connect proximate end axial chords **406** and proximate ends of torque transfer plates **452**, as depicted in **FIG. 4**, in an embodiment. In other embodiments, end member assembly **440** may include other quantities of end axial chords **406** and of end members **442**. In certain embodiments, each end axial chord **406** may be cantilevered, such that an end portion of end chord **406** is cantilevered, optionally supported by other structural members such as brackets other than struts. End members **442** are embodiments of members **202**, and may be struts. Octahedral space frame **400** includes a torque transfer assembly **450** at each of first and second longitudinal ends **410** and **412**. At each of first and second longitudinal ends **410** and **412**, a central torsion element **454** is located proximate where inner ends of torque transfer plates **452** and an axial chord **404** connect. The center of central torsion element **454** is coincident with the rotational axis of parabolic trough **104**.

[0065] **FIG. 5** illustrates an octahedral space frame **500**, which is another possible embodiment of the octahedral space frame featured herein. Octahedral space frame **500** includes axial chords **502**. One axial chord **502** spans the length of octahedral space frame **500**, from first longitudinal end **510** to second longitudinal end **512**, connecting upper vertex **252** of each first single octahedron structure of each double octahedral structure **250** within plurality of double octahedral structures **420**. Another

axial chord **502** spans the length of octahedral space frame **500**, from first longitudinal end **510** to second longitudinal end **512**, connecting upper vertex **252** of each second single octahedron structure of each double octahedral structure **250** within plurality of double octahedral structures **420**. In other embodiments, octahedral space frame **500** may include more than three axial chords **502**. Octahedral space frame **500** further includes axial chords **504**. Each axial chord **504** runs from an end of torque transfer plates **452** to a corresponding end of torque transfer plates **452** between first longitudinal end **510** and second longitudinal end **512**, as illustrated in **FIG. 5**. For example, one of axial chords **504** spans the length of octahedral space frame **500** between central torsion element **454** at first longitudinal end **510** and central torsion element **454** at second longitudinal end **512**. In certain embodiments, axial chords **502** and axial chords **504** are equivalent. Other features of octahedral space frame **500** are common with octahedral space frame **400**.

[0066] In certain embodiments, the octahedral spaces frame featured herein may have any combination of features of octahedral space frame **400** and octahedral space frame **500**.

[0067] **FIG. 6A** illustrates a side view of an octahedral space frame, in an embodiment octahedral space frame **400**, viewed in longitudinal direction **208**. A V-shaped opening is formed at the upper portion of the side view of an octahedral space frame **400**. Angle **602** describes the internal angle of the V-shaped opening. **FIG. 6B** illustrates a side view of an octahedral space frame, for example **400**, viewed in transverse direction **206**.

[0068] **FIG. 7** illustrates parabolic trough **104** supported by an octahedral space frame, in an embodiment octahedral space frame **400**. The elements shown in **FIG. 7** may be part of parabolic trough system **100**, in an embodiment, and further part of a concentrating solar collector assembly. Receiver **106** is structurally supported by receiver support elements **108**. Parabolic trough **104** is configured to reflect incident light, such as sunlight, onto receiver **106**, which carries a heat transfer fluid. Receiver **106** has an elongated axis extending in longitudinal direction **208**. **FIG. 8** shows a side view of the parabolic trough system of **FIG. 7**, in an embodiment, viewed in

longitudinal direction **208**. In an embodiment, parabolic trough support elements **802** provide structural support to parabolic trough **104** disposed in the V-shaped opening of octahedral space frame **400**. In an embodiment, parabolic trough support elements **802** are brackets or struts.

[0069] Certain embodiments of the octahedral space frame featured herein include more than one plurality of double octahedral structures **300**, effectively joined in transverse direction **206**, and one or more double octahedral structures **250** included in each plurality of double octahedral structures **300**. For example, **FIGs. 9A-9C** show a top view, longitudinal side view, and a transverse side view, respectively, of an embodiment of the octahedral space frames featured herein. In this embodiment, an octahedral space frame **900** includes three pluralities of double octahedral structures **920**, **922**, and **924**, effectively sequentially joined in transverse direction **206**, each of plurality of double octahedral structures **920**, **922**, and **924** including six double octahedral structures **910** effectively sequentially joined in longitudinal direction **208**. For illustration purposes, only members **202** of octahedral space frame **900** are shown. In other embodiments, octahedral space frame **900** includes features of octahedral space frame **400** and/or **500**, for example.

[0070] **FIGs. 10A-10C** illustrate alternate embodiments of single octahedron structure **200** which are irregular octahedrons in their shape, wherein members have two or more lengths.

[0071] **FIGs. 11A-11C** illustrate side views, in longitudinal direction **208**, of certain example embodiments of double octahedron structure **250**, the examples differing in shape of comprising single octahedron structures. **FIG. 11A** shows an embodiment of double octahedral structure **300** that includes single octahedron structures that resemble a regular octahedron. In this embodiment, angle **602** is approximately 141 degrees. **FIGs. 11B** and **11C** show embodiments of double octahedral structure **300** that include single octahedron structures that resemble irregular octahedrons, such that angle **602** is 180 degrees and 90 degrees, respectively. In other embodiments, angle **602** may be greater than 0 degrees and less than or equal to 180 degrees.

[0072] Certain embodiments of the octahedral space frame featured herein include single octahedron structures **200** that are irregular octahedrons in their shape, such as those illustrated in **FIGs. 10A-10C**. **FIGs. 12A-12C** illustrate a top view, a longitudinal side view, and, and a transverse side view, of an embodiment of the octahedral space frames featured herein. In this embodiment, an octahedral space frame **1200** includes irregular single octahedron structures **1210** such as that shown in **FIG. 10C**, wherein angle **602** is 180 degrees, as depicted in **FIG. 11B**, for example. Octahedral space frame **1200** includes three pluralities of double octahedral structures **1220**, **1222**, and **1224**, effectively sequentially joined in transverse direction **206**, each of plurality of double octahedral structures **1220**, **1222**, and **1224** including six double octahedral structures **1210** effectively sequentially joined in longitudinal direction **208**. For illustration purposes, only members **202** of octahedral space frame **1200** are shown. In other embodiments, octahedral space frame **1200** includes features of octahedral space frame **400** and/or **500**, for example.

[0073] In other embodiments, an octahedral space frame includes double octahedral structures effectively joined in a vertical direction **1302**, which is orthogonal to longitudinal and transverse directions **208** and **206**. **FIGs. 13A** and **13B** illustrate side views in transverse direction **206** and longitudinal direction **208**, respectively, of an example embodiment of octahedral space frames featured herein. In this embodiment, an octahedral space frame **1300** includes pluralities of double octahedral structures **1320**, which include double octahedral structures **1310**, effectively joined in vertical direction **1302**. For illustration purposes, only members **202** of octahedral space frame **1300** are shown. In other embodiments, octahedral space frame **1300** includes features of octahedral space frame **400** and/or **500**, for example.

[0074] **FIG. 14** depicts an operational method **1400**, in an aspect, for supporting a parabolic trough using an octahedral space frame in a concentrating solar collector assembly and for capturing solar energy. In an embodiment of method **1400**, the parabolic trough is parabolic trough **104** and the octahedral space frame is octahedral space frame **400**. In step **1402**, the weight of parabolic trough **104** is

transferred onto octahedral space frame **400**, for example. In step **1404**, the weight of parabolic trough **104** and octahedral space frame **400**, for example, is transferred to a base surface, such as a ground surface, via pylons **110**. In step **1406**, torsional load is carried by octahedral space frame **400**, for example, while maintaining torsional stiffness. In step **1408**, light incident on parabolic trough **104** is reflected onto a receiver, such as receiver **106**. In step **1410**, a heat transfer fluid, such as an oil, steam, or molten salt, is circulated through the receiver. In step **1412**, parabolic trough **104** and octahedral space frame **400**, for example, are rotated to track an incident light source, such as the sun. Although **FIG. 14** illustrates steps **1402-1412** being serially performed for illustrative convenience, it is anticipated that some or all of steps **1402-1412** will frequently be performed in parallel.

STATEMENTS REGARDING VARIATIONS

[0075] Having now fully described the present invention in some detail by way of illustration and examples for purposes of clarity of understanding, it will be clear to one of ordinary skill in the art that the same can be performed by modifying or changing the invention within a wide and equivalent range of conditions, formulations and other parameters without affecting the scope of the invention or any specific embodiment thereof, and that such modifications or changes are intended to be encompassed within the scope of the appended claims.

[0076] The terms and expressions which have been employed herein are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed. Thus, it should be understood that although the present invention has been specifically disclosed by preferred embodiments, exemplary embodiments and optional features, modification and variation of the concepts herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are considered to be within the scope of this invention as defined by the appended claims. The specific embodiments provided herein are examples of useful embodiments of the present invention and it will be apparent to one skilled in the art that the present invention may be carried out

using a large number of variations of the devices, device components, methods steps set forth in the present description. Methods and devices useful for the present methods can include a large number of optional composition and processing elements and steps.

[0077] When a group of substituents is disclosed herein, it is understood that all individual members of that group and all subgroups are disclosed separately. When a Markush group or other grouping is used herein, all individual members of the group and all combinations and subcombinations possible of the group are intended to be individually included in the disclosure.

[0078] It must be noted that as used herein and in the appended claims, the singular forms "a", "an", and "the" include plural reference unless the context clearly dictates otherwise. Thus, for example, reference to "a heating pipe" includes a plurality of such heating pipes and equivalents thereof known to those skilled in the art, and so forth. As well, the terms "a" (or "an"), "one or more" and "at least one" can be used interchangeably herein. It is also to be noted that the terms "comprising", "including", and "having" can be used interchangeably. The expression "of any of claims XX-YY" (wherein XX and YY refer to claim numbers) is intended to provide a multiple dependent claim in the alternative form, and in some embodiments is interchangeable with the expression "as in any one of claims XX-YY."

[0079] Although any methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, the preferred methods and materials are now described. Nothing herein is to be construed as an admission that the invention is not entitled to antedate such disclosure by virtue of prior invention.

[0080] Whenever a range is given in the specification, for example, a temperature range, a time range, or a composition or concentration range, all intermediate ranges and subranges, as well as all individual values included in the ranges given are intended to be included in the disclosure. As used herein, ranges specifically include the values provided as endpoint values of the range. For example, a range of 1 to

100 specifically includes the end point values of 1 and 100. It will be understood that any subranges or individual values in a range or subrange that are included in the description herein can be excluded from the claims herein.

[0081] As used herein, "comprising" is synonymous with "including," "containing," or "characterized by," and is inclusive or open-ended and does not exclude additional, unrecited elements or method steps. As used herein, "consisting of" excludes any element, step, or ingredient not specified in the claim element. As used herein, "consisting essentially of" does not exclude materials or steps that do not materially affect the basic and novel characteristics of the claim. In each instance herein any of the terms "comprising", "consisting essentially of" and "consisting of" may be replaced with either of the other two terms.

[0082] Herein, and unless otherwise indicated, the term "exemplary" means serving as an example, instance, or illustration.

[0083] One of ordinary skill in the art will appreciate that device elements and combinations of components other than those specifically exemplified can be employed in the practice of the invention without resort to undue experimentation. All art-known functional equivalents, of any such materials and methods are intended to be included in this invention. The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention that in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed. Thus, it should be understood that although the present invention has been specifically disclosed by preferred embodiments and optional features, modification and variation of the concepts herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are considered to be within the scope of this invention as defined by the appended claims.

CLAIMS

What is claimed is:

1. An octahedral space frame, comprising:
a first plurality of double octahedral structures disposed in a first row in a longitudinal direction, adjacent ones of the first plurality of double octahedral structures sharing two common members;
each of the first plurality of double octahedral structures including respective first and second single octahedron structures joined in a transverse direction and sharing three common members, the transverse direction being orthogonal to the longitudinal direction.
2. The octahedral space frame of claim 1, the first plurality of double octahedral structures collectively forming a V-shaped opening, as seen when the octahedral space frame is viewed in the longitudinal direction.
3. The octahedral space frame of claim 2, the V-shaped opening having an internal angle greater than 0 degrees and less than or equal to 180 degrees.
4. The octahedral space frame of any one of claims 1-3, each of the first plurality of double octahedral structures comprising twenty one members.
5. The octahedral space frame of claim 4, each of the twenty one members of each of the first plurality of double octahedral structures having equal length.
6. The octahedral space frame of claim 1, the octahedral space frame having a rectangular outline as seen when viewed in the longitudinal direction.
7. The octahedral space frame of claim 6, each of the first plurality of double octahedral structures comprising twenty one members, wherein seven members of the twenty one members have a common first length and fourteen members of the twenty one members have a common second length, the second length being different from the first length.
8. The octahedral space frame of any one of claims 1-7, further comprising:
a first axial chord joining each first single octahedron structure of the first

- plurality of double octahedral structures in the longitudinal direction;
and
a second axial chord joining each second single octahedron structure of the first plurality of double octahedral structures in the longitudinal direction.
9. The octahedral space frame of any one of claims 1-7, further comprising:
a first plurality of axial chords joining each first single octahedron structure of the first plurality of double octahedral structures in the longitudinal direction; and
a second plurality of axial chords joining each second single octahedron structure of the first plurality of double octahedral structures in the longitudinal direction.
10. The octahedral space frame of any of claims 1-9, further comprising:
an end member assembly disposed at an end of the first plurality of double octahedral structures; the end member assembly including:
one or more first end members connected to the first single octahedral structure of an end one of the first plurality of double octahedral structures; and
one or more second end members connected to the second single octahedral structure of the end one of the first plurality of double octahedral structures.
11. The octahedral space frame of claim 10, further comprising a torque transfer assembly disposed at the end one of the first plurality of double octahedral structures.
12. The octahedral space frame of claim 11, the torque transfer assembly including at least one torque transfer plate and a central torsion element.
13. The octahedral space frame of any one of claims 1-12, further comprising a second plurality of double octahedral structures disposed in a second row in the longitudinal direction, adjacent ones, in the longitudinal direction, of the second plurality of double octahedral structures sharing two common members, the first and

second rows being joined in the transverse direction.

14. The octahedral space frame of claim 13, each of the second plurality of double octahedral structures comprising twenty one members.

15. The octahedral space frame of claim 13, the first and second rows sharing at least one common axial chord.

16. The octahedral space frame of any one of claims 13-15, further comprising a third plurality of double octahedral structures disposed in a third row in the longitudinal direction, adjacent ones, in the longitudinal direction, of the third plurality of double octahedral structures sharing two common members, the third row being joined to each of the first and second rows in a vertical direction orthogonal to each of the longitudinal and transverse directions.

17. A concentrating solar collector assembly, comprising:

an octahedral space frame, including:

a plurality of double octahedral structures disposed in a first row in a longitudinal direction, adjacent ones of the plurality of double octahedral structures sharing two common members, the plurality of double octahedral structures collectively forming a V-shaped opening in the octahedral space frame, as seen when the octahedral space frame is viewed in the longitudinal direction,

each of the plurality of double octahedral structures including respective first and second single octahedron structures joined in a transverse direction and sharing three common members, the transverse direction being orthogonal to the longitudinal direction; and

a parabolic trough disposed in the V-shaped opening in the octahedral space frame.

18. The concentrating solar collector assembly of claim 17, the V-shaped opening having an internal angle greater than 0 degrees and less than or equal to 180 degrees.

19. The concentrating solar collector assembly of claims 18, further comprising a

receiver configured to carry a heat transfer fluid, the parabolic trough being configured to reflect light incident on the parabolic trough onto the receiver.

20. The concentrating solar collector assembly of claim 19, further comprising receiver support elements configured to structurally support the receiver.

21. The concentrating solar collector assembly of any one of claims 19-20, the receiver having an elongated axis extending in the longitudinal direction.

22. The concentrating solar collector assembly of any one of claims 19-21, further comprising a fluid distribution subsystem configured to circulate the heat transfer fluid through the receiver.

23. The concentrating solar collector assembly of any one of claims 17-22, each of the plurality of double octahedral structures of the octahedral space frame comprising twenty one members.

24. The concentrating solar collector assembly of claim 23, each of the twenty one members of each of the plurality of double octahedral structures having equal length.

25. The concentrating solar collector assembly of any one of claims 17-24, the octahedral space frame further including:

- a first axial chord joining each first single octahedron structure of the plurality of double octahedral structures in the longitudinal direction; and
- a second axial chord joining each second single octahedron structure of the plurality of double octahedral structures in the longitudinal direction.

26. The concentrating solar collector assembly of any one of claims 17-24, the octahedral space frame further including:

- a first plurality of axial chords joining each first single octahedron structure of the first plurality of double octahedral structures in the longitudinal direction; and
- a second plurality of axial chords joining each second single octahedron structure of the first plurality of double octahedral structures in the longitudinal direction.

27. The concentrating solar collector assembly of any of claim 17-26, the octahedral space frame further including:

- an end member assembly disposed at an end of the plurality of double octahedral structures, the end member assembly including:
 - one or more first end members connected to the first single octahedral structure of an end one of the plurality of double octahedral structures;
 - and
 - one or more second end members connected to the second single octahedral structure of the end one of the plurality of double octahedral structures.

28. The concentrating solar collector assembly of claim 27, the octahedral space frame further including a torque transfer assembly disposed at the end one of the plurality of double octahedral structures.

29. The concentrating solar collector assembly of claim 28, the torque transfer assembly including at least one torque transfer plate and a central torsion element.

30. The concentrating solar collector assembly of any one of claims 28 and 29, further comprising:

- a plurality of pylons configured to support the octahedral space frame and the parabolic trough; and
- a tracking subsystem configured to rotate the octahedral space frame and the parabolic trough with respect to the plurality of pylons, to track an incident light source.

31. A method for supporting a parabolic trough in a concentrating solar collector assembly, comprising:

- transferring weight of the parabolic trough to an octahedral space frame including a plurality of double octahedral structures disposed in a first row in a longitudinal direction, wherein (a) adjacent ones of the plurality of double octahedral structures share two common members and (b) each of the plurality of double octahedral structures includes respective first and second single octahedron structures joined in a transverse direction and sharing three common members, the transverse direction

being orthogonal to the longitudinal direction; and
transferring weight of the parabolic trough and the octahedral space frame to
a base surface via a plurality of pylons.

32. The method of claim 31, further comprising carrying torsional load while maintaining torsional stiffness.

33. The method of any one of claims 31 and 32, the base surface being a ground surface.

34. A method for capturing solar energy, comprising:
supporting a parabolic trough in a concentrating solar collector assembly
according to the method of any one of claims 31-33;
reflecting light incident on the parabolic trough onto a receiver; and
circulating a heat transfer fluid through the receiver.

35. The method of claim 34, further comprising rotating the parabolic trough and the octahedral space frame with respect to the plurality of pylons to track an incident light source.

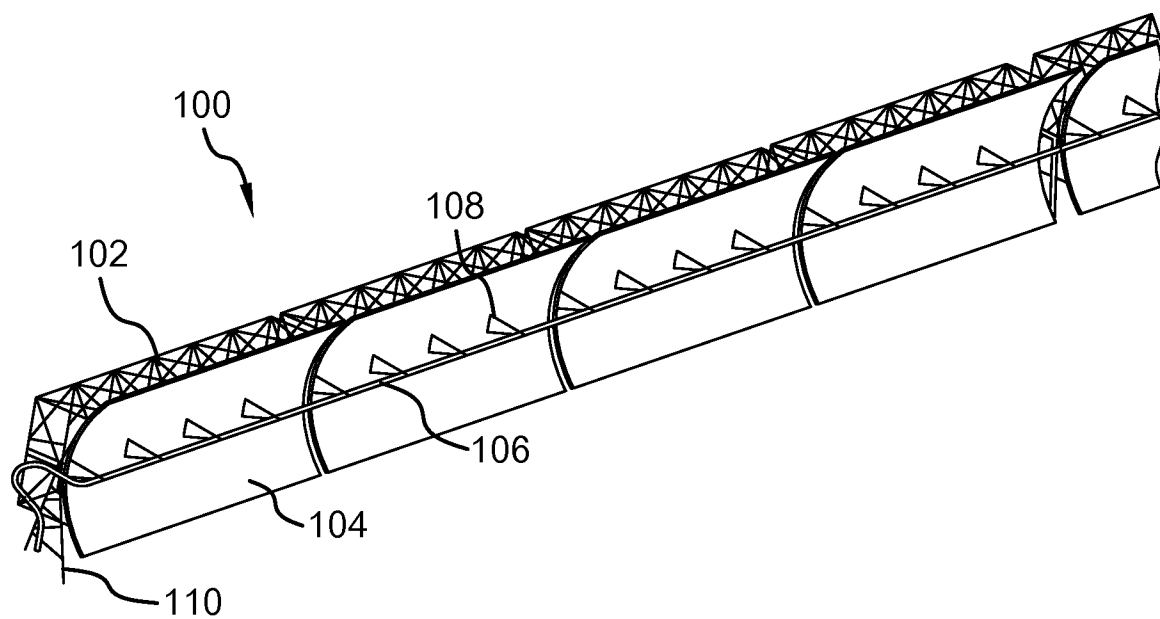


FIG.1

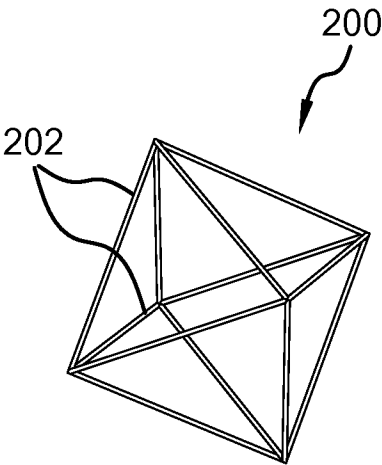


FIG. 2A

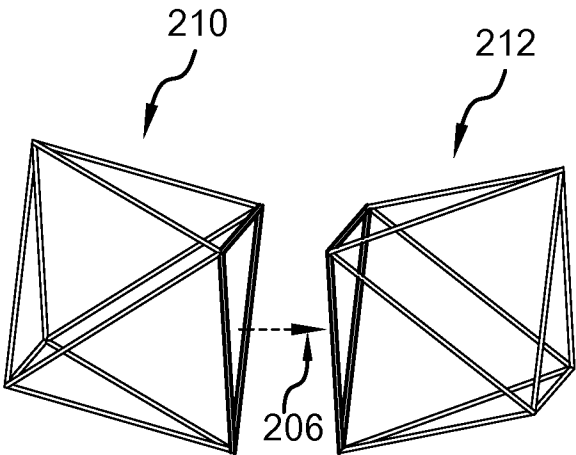


FIG. 2B

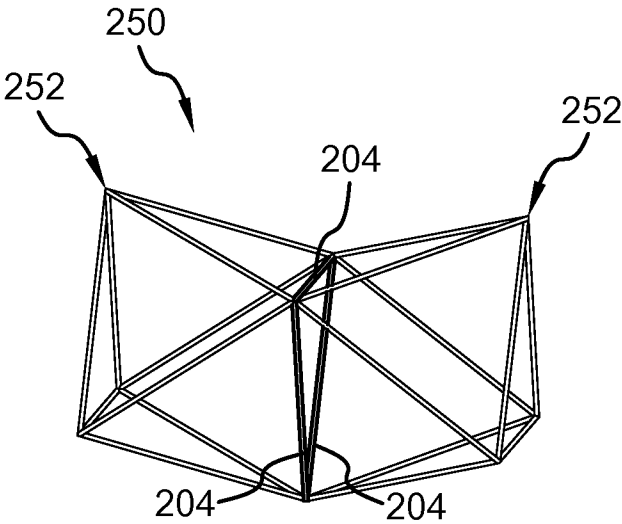


FIG. 2C

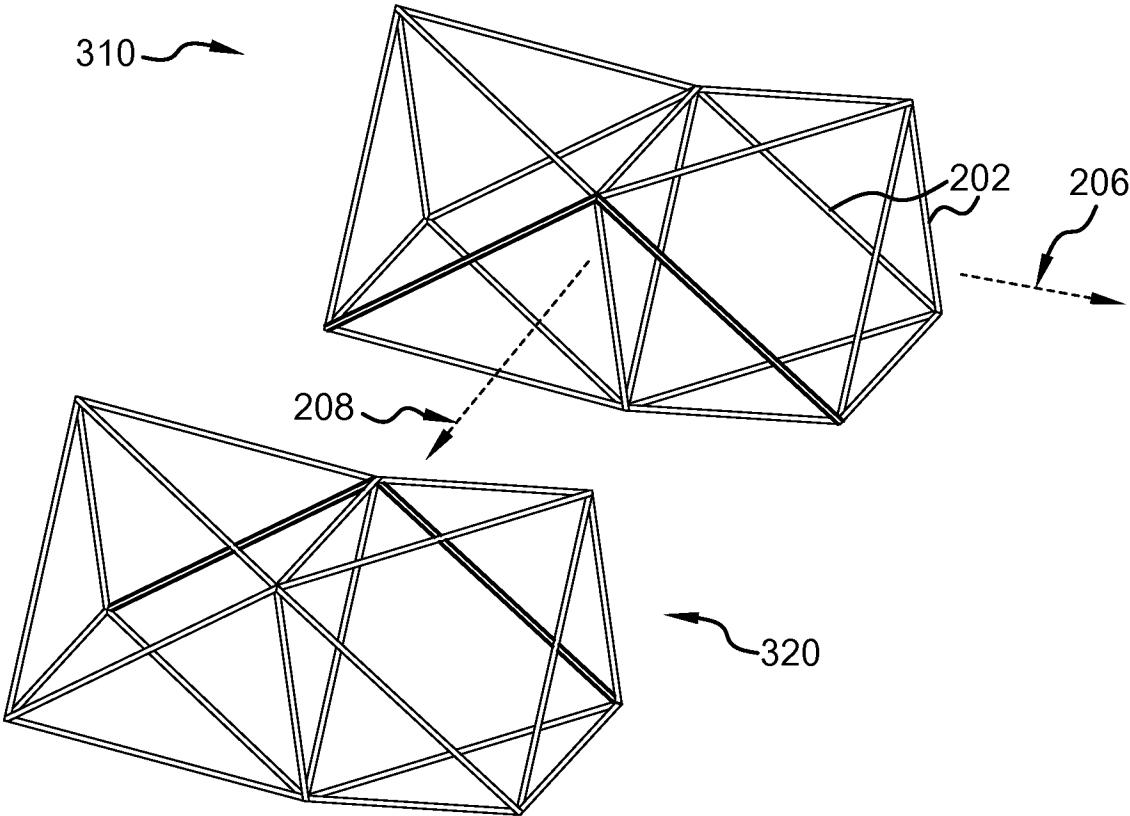


FIG.3A

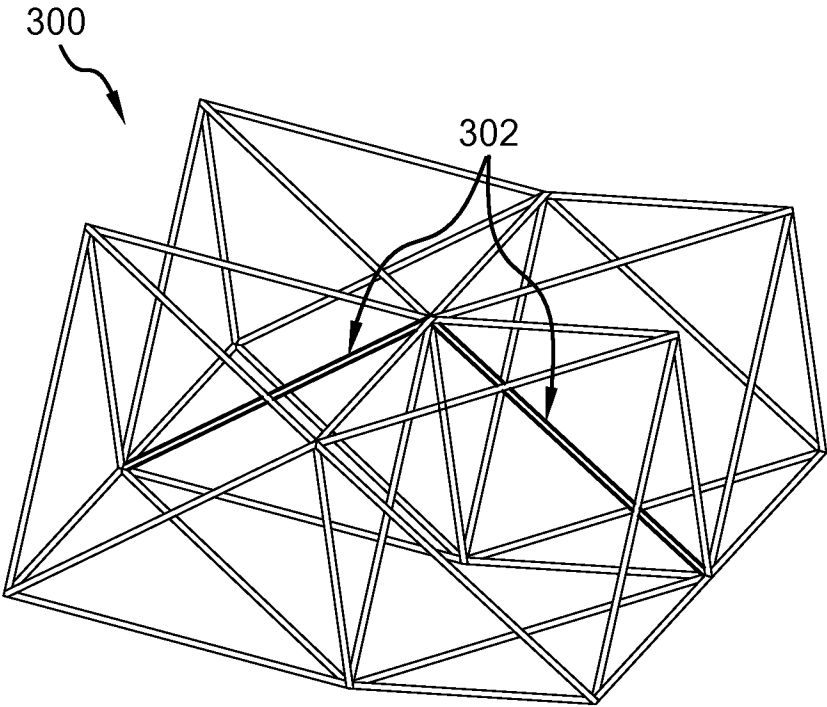


FIG.3B

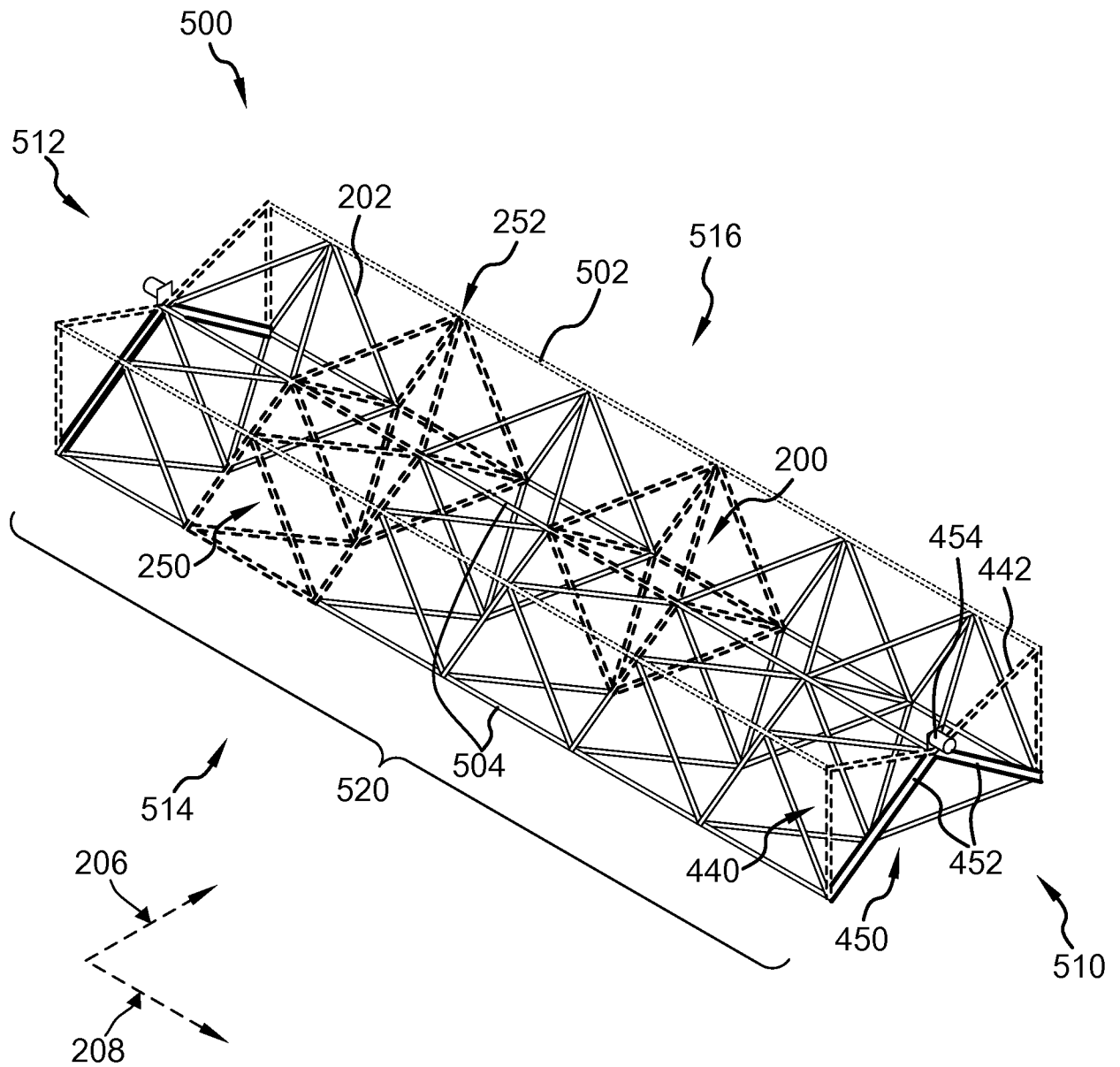


FIG.5

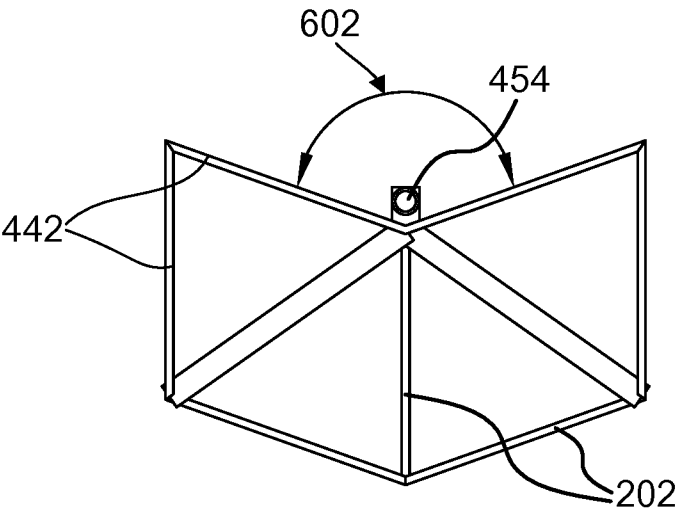


FIG. 6A

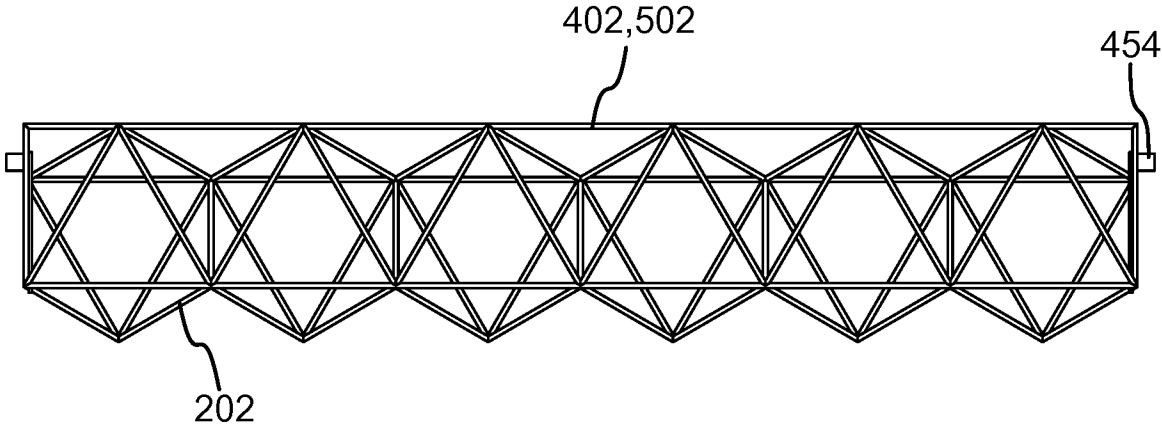


FIG. 6B

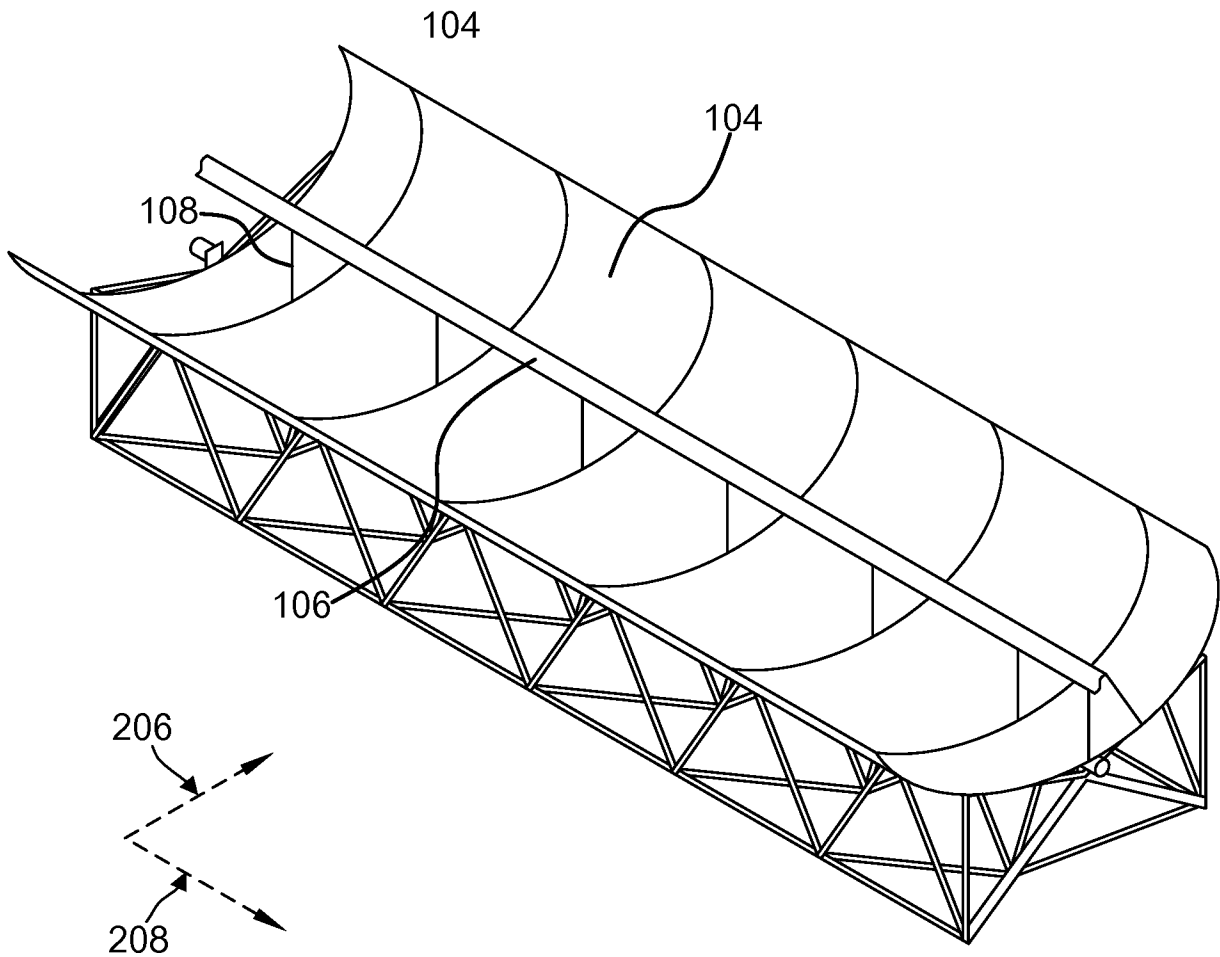


FIG.7

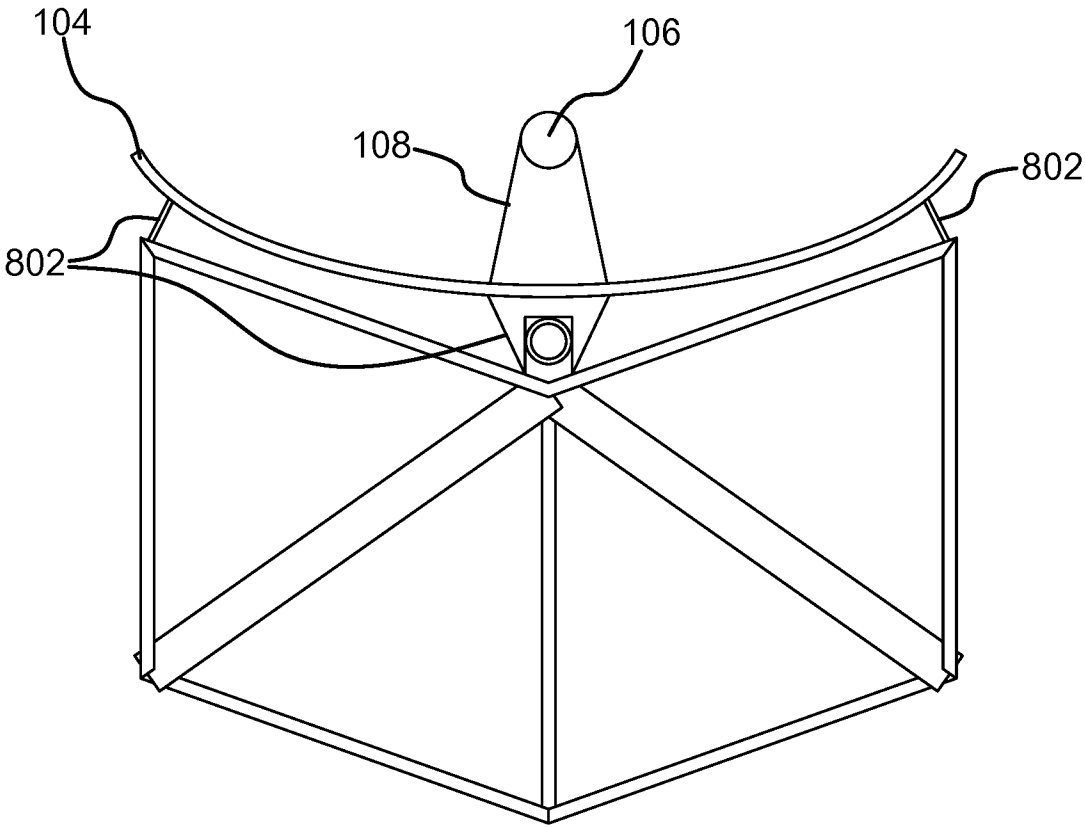


FIG.8

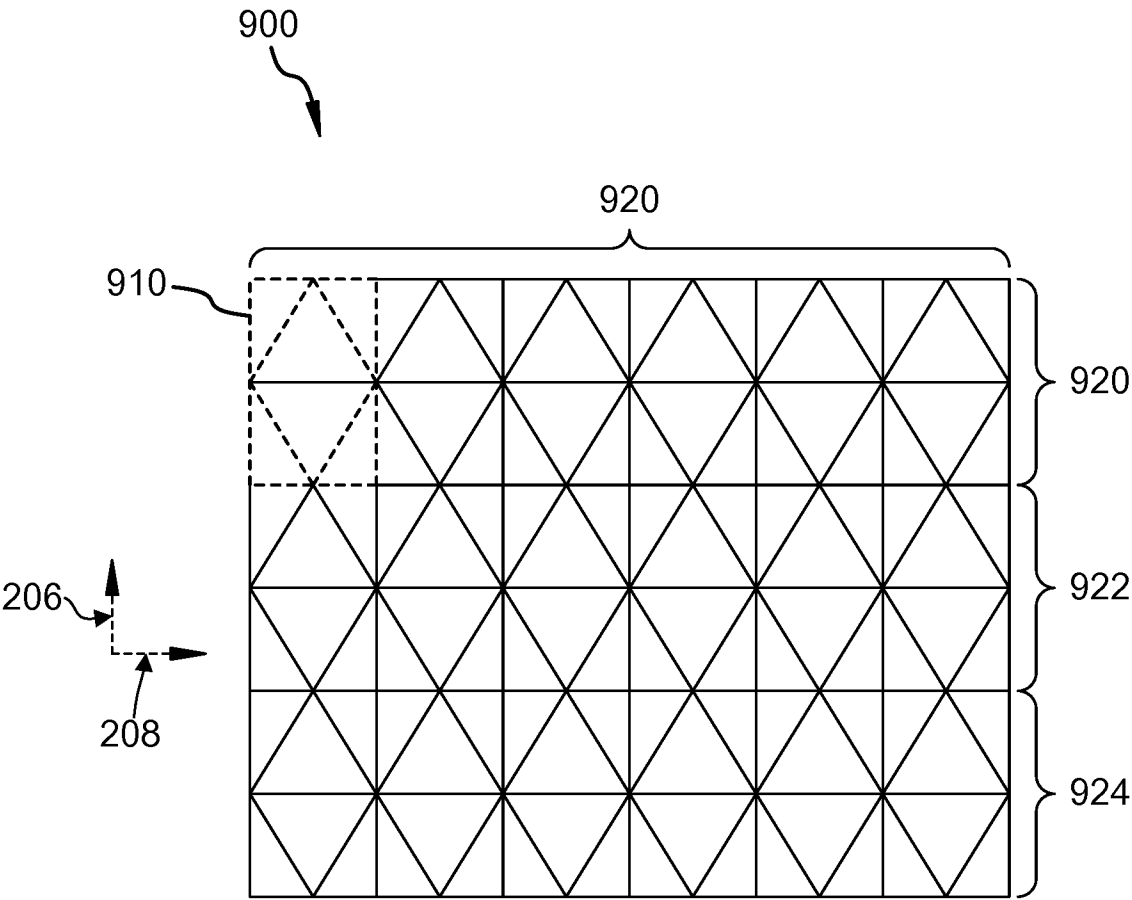


FIG.9A

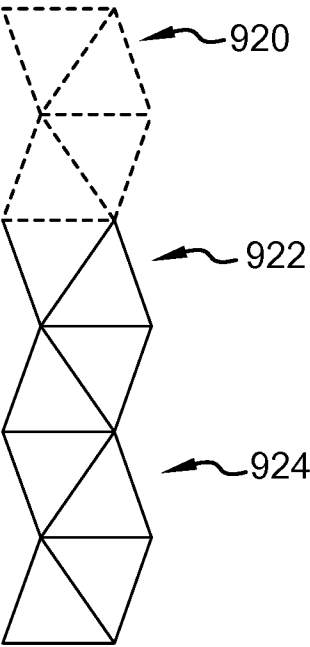


FIG.9B

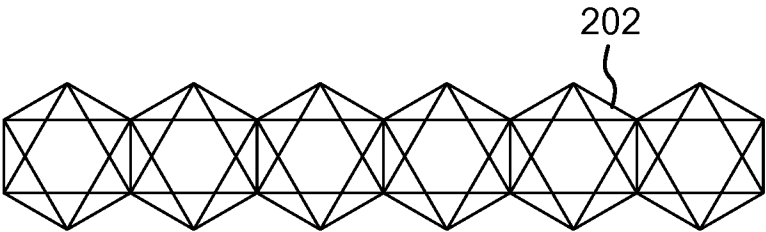


FIG.9C

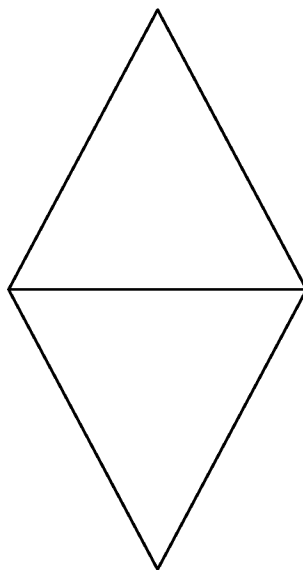


FIG.10A

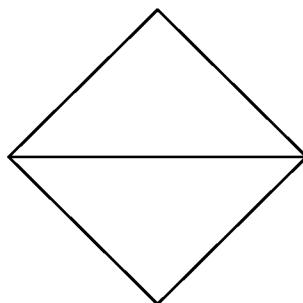


FIG.10B

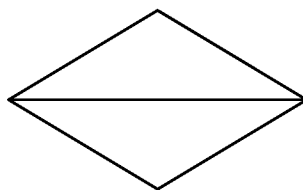


FIG.10C

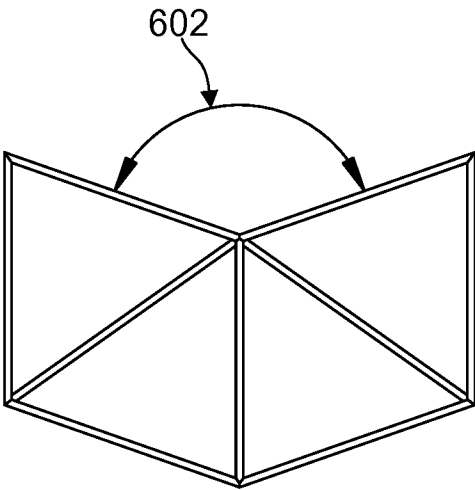


FIG.11A

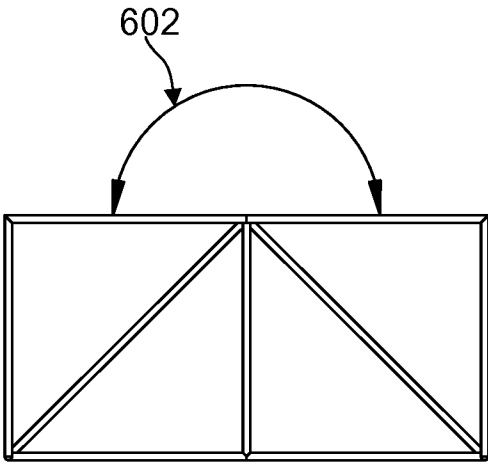


FIG.11B

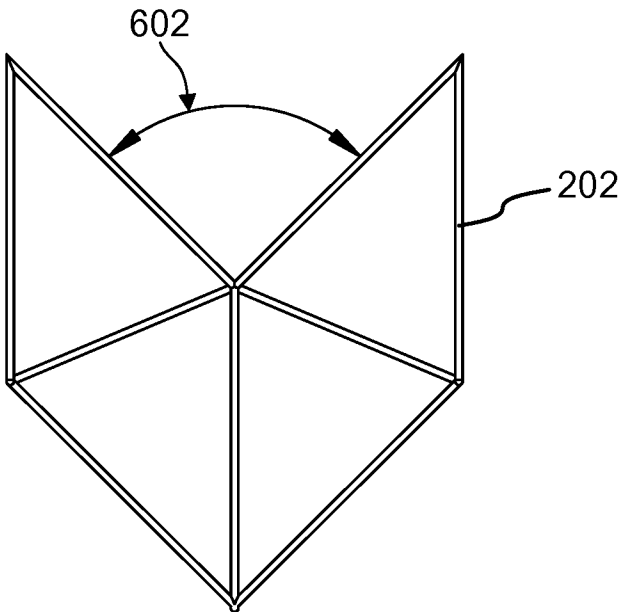


FIG.11C

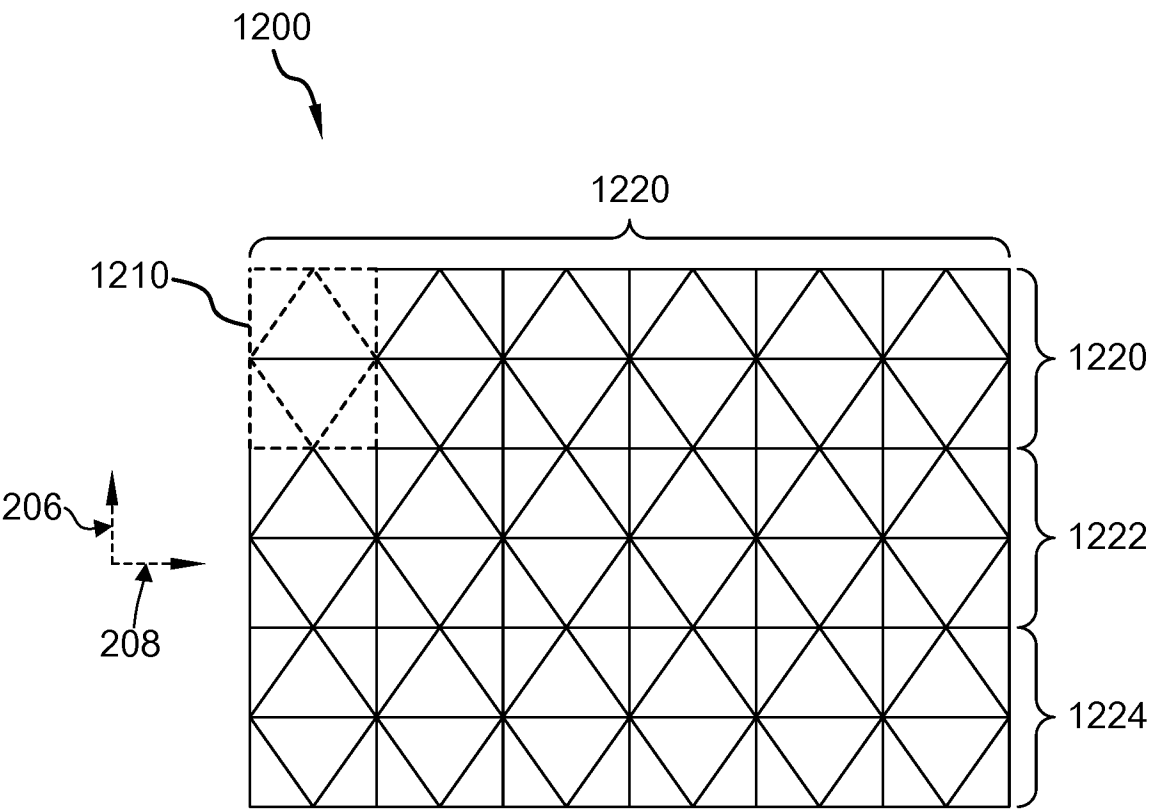


FIG.12A

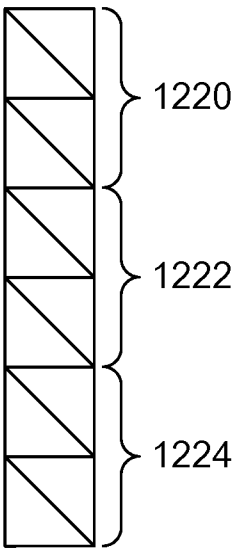


FIG.12B

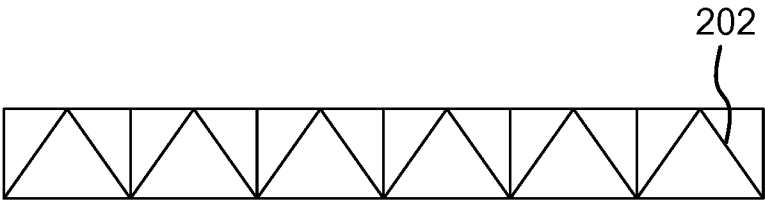
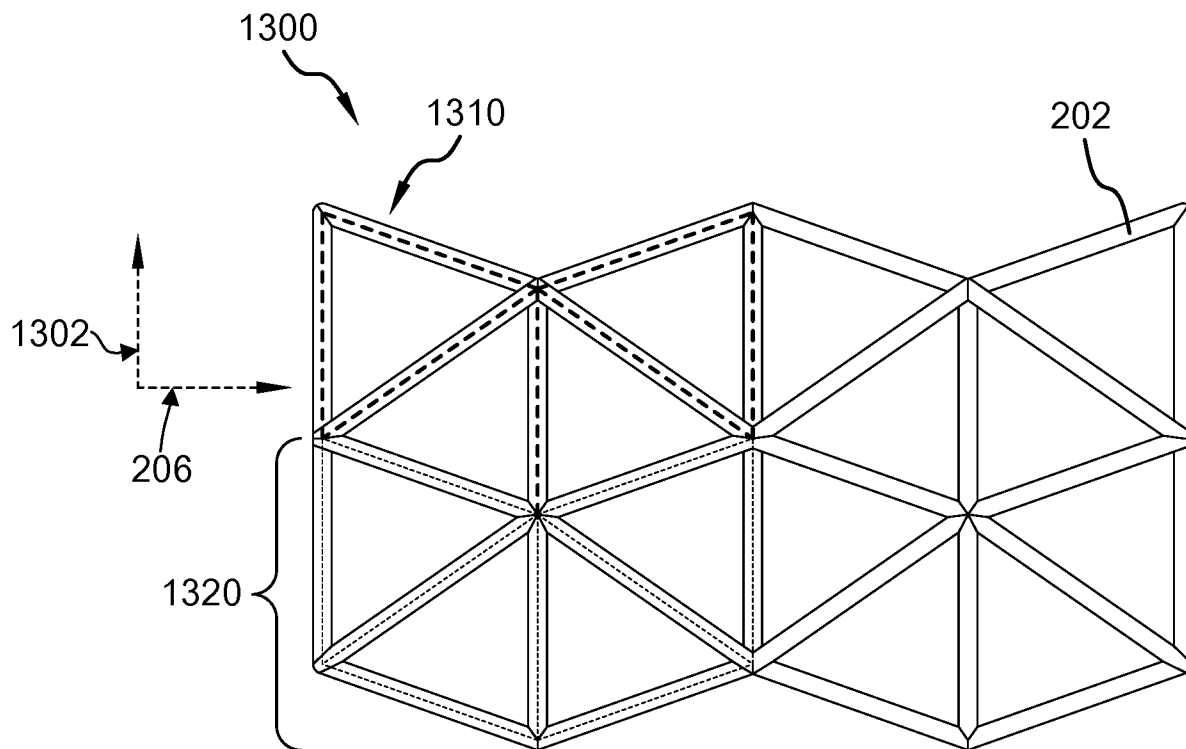
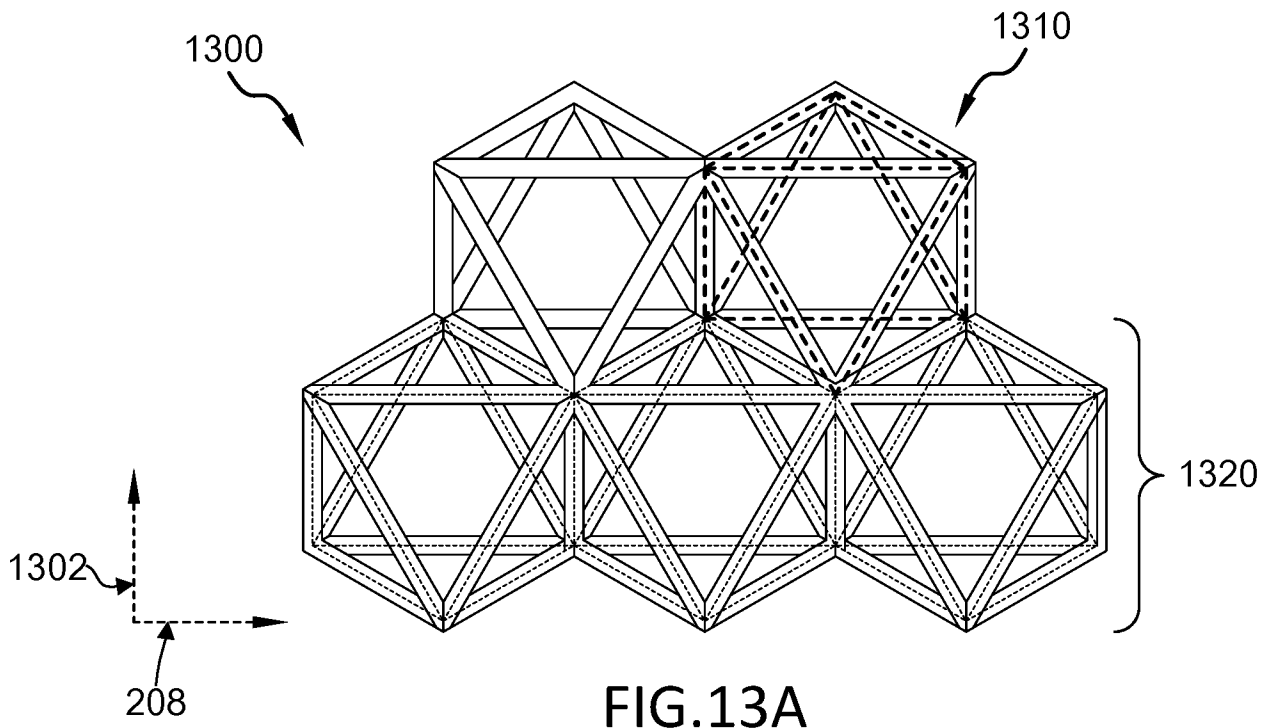


FIG.12C



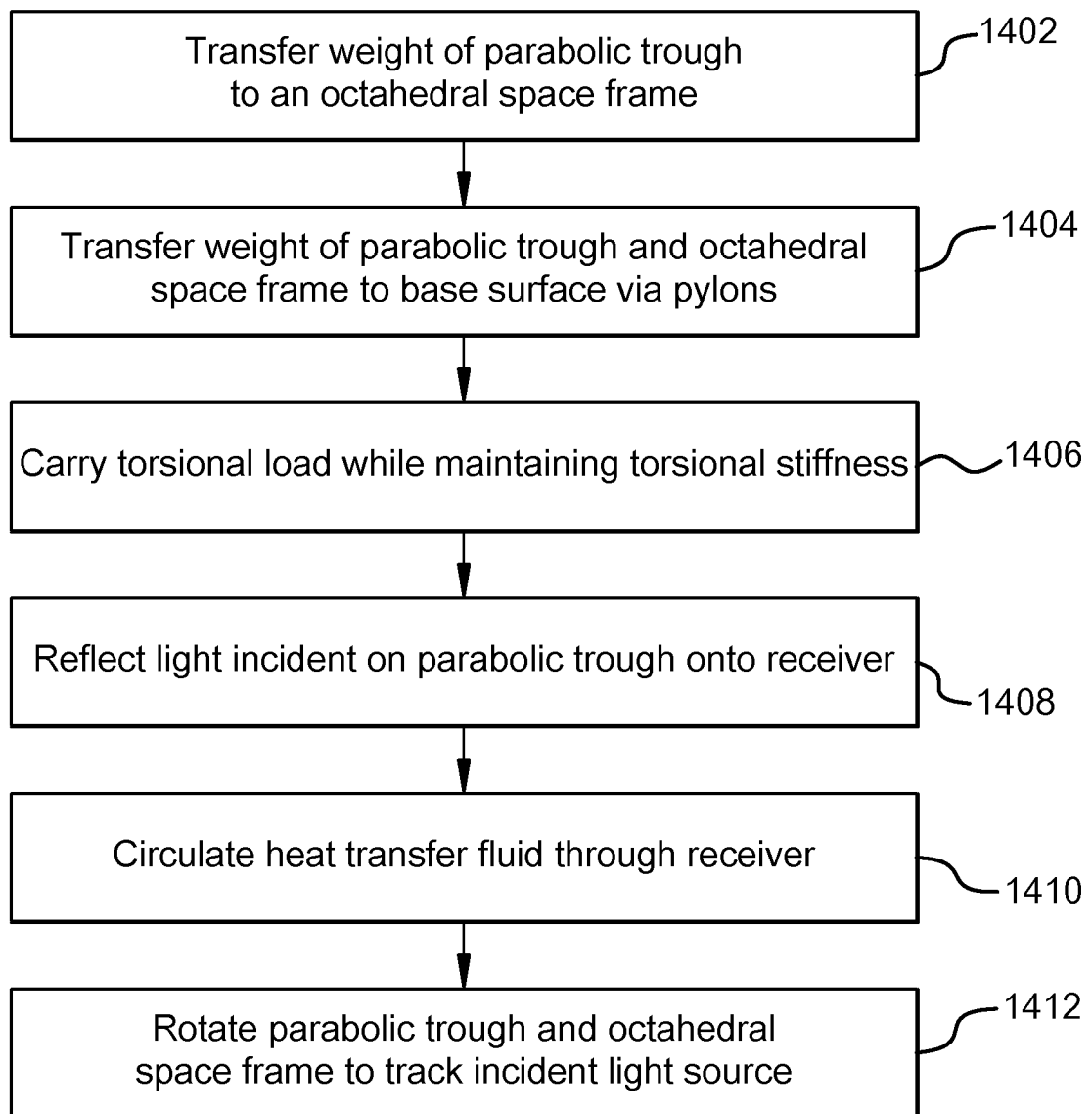


FIG.14

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 18/29647

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 8-16, 22-30, 34, 35
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This international Searching Authority found multiple inventions in this international application, as follows.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 18/29647

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - E04B 1/34, E04B 9/06, F03G 6/06, F24S 23/74, F24S 25/20, F24S 25/63, H01L 31/054 (2018.01)
 CPC - E04B 1/34, E04B 7/10, E04B 7/105, E04B 2001/1978, E04C 3/02, E04C 5/08, E04C 5/12, E04C 5/16, E04C 2003/0486, E04C 2003/0495, B60L 8/003, F03G 6/06, F03G 2006/061, F03G 2006/062, F24S 23/74, F24S 25/20, F24S 25/40, F24S 25/60, F24S 25/63, F24S 30/425, F24S 2020/12, F24S 2025/01, F24S 2025/018, F24S 2023/87, F24S 25/40, H01L 31/0547, Y02E 10/40, Y02E 10/45, Y02E 10/52, Y02E 10/47

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History Document

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

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2015/0062728 A1 (WERNER et al.) 05 March 2015 (05.03.2015), Figs. 2, 3; para [0005], [0059], [0070]	1-7, 17-21, 31-33
A	US 2011/0048405 A1 (KOETTER et al.) 03 March 2011 (03.03.2011), Fig. 2; para [0008], [0012], [0021], [0028]	1-7, 17-21, 31-33
A	US 2008/0204352 A1 (REYNOLDS et al.) 28 August 2008 (28.08.2008), Figs. 2, 20-24; para [0056], [0082], [0083]	1-7, 17-21, 31-33
A	WO 2008/002035 A1 (RYU) 03 January 2008 (03.01.2008), Fig. 4; para [33]	1-7, 17-21, 31-33
A	WO 96/09447 A1 (IVERSON) 28 March 1996 (28.03.1996), Figs. 1, 2; pg 3, ln 3-17; pg 8, ln 25 to pg 9, ln 17	1-7, 17-21, 31-33

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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

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

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

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

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

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Date of the actual completion of the international search

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Date of mailing of the international search report

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