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(54) Title: EARTH-PENETRATING EXPANSION ANCHOR

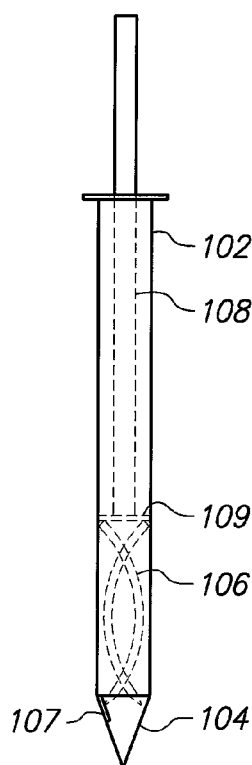


FIG. 1A

(57) Abstract: One embodiment relates to an earth-penetrating apparatus. The apparatus includes a pole (102, 202, 402, 502) with a hollow portion therein and a bottom end (104, 204, 404, 509) which is configured to be driven into ground. Anchoring parts (106, 206, 406, 504) are configured to be radially extendable from the pole. In addition, an expansion mechanism (108/109, 208, 407/408/410, 508/509) is configured to apply a force to the anchoring parts so as to radially extend the anchoring parts from the pole after the pole has been driven into the ground. Another embodiment relates to a solar collector arrangement that includes a plurality of earth-penetrating anchors. Other embodiments, aspects and features are also disclosed.



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EARTH-PENETRATING EXPANSION ANCHOR

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present disclosure relates generally to ground anchors, and more particularly, ground anchors used to support solar collector arrangements.

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2. Description of the Background Art

Photovoltaic arrays are used for a variety of purposes, including as a utility interactive power system, as a power supply for a remote or unmanned site, a cellular phone switch-site power supply, or a village power supply. These arrays can have a capacity from a few kilowatts to a hundred kilowatts or more, and are typically installed where there is a reasonably flat area with exposure to the sun for significant portions of the day.

In general terms, these solar collector assemblies have their solar collector modules, typically photovoltaic modules, supported on a frame. The frame is generally supported above the ground by vertical pier tubes. The vertical pier tubes are typically driven very deeply into the ground. The pier tubes may also be supported and stabilized by concrete footings.

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SUMMARY

One embodiment relates to an earth-penetrating apparatus. The apparatus includes a pole with a hollow portion therein and a bottom end which is configured to be driven into ground. Anchoring parts are configured to be
5 radially extendable from the pole. In addition, an expansion mechanism is configured to apply a force to the anchoring parts so as to radially extend the anchoring parts from the pole after the pole has been driven into the ground.

Another embodiment relates to a solar collector arrangement. The arrangement includes a plurality of earth-penetrating anchors which are driven
10 into ground. Each anchor includes (a) a pole with top and bottom ends, the pole having a hollow portion therein and a pointed tip at the bottom end which is configured to be driven into ground, (b) anchoring parts configured to be radially extendable from the pole, and (c) an expansion mechanism configured to apply a force to the anchoring parts so as to radially extend the anchoring parts from
15 the pole after the pole has been driven into the ground. The arrangement further includes a support structure coupled to the plurality of earth-penetrating anchors. An array of solar panels is attached to the support structure.

Other embodiments, aspects and features are also disclosed.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 (consisting of FIGS. 1A, 1B, 1C) is a schematic diagram depicting an earth-penetrating expansion apparatus and the operation thereof in accordance with a first embodiment of the invention.

FIG. 2 (consisting of FIGS. 2A, 2B, 2C, 2D and 2E) is a schematic diagram depicting an earth-penetrating expansion apparatus and the operation thereof in accordance with a second embodiment of the invention.

FIG. 3 is a close-up view of the deployed expansion mechanism of the earth-penetrating expansion apparatus shown in FIG. 2.

FIG. 4 (consisting of FIGS. 4A, 4B, 4C, 4D, and 4E) is a schematic diagram depicting an earth-penetrating expansion apparatus and the operation thereof in accordance with a third embodiment of the invention.

FIG. 5 (consisting of FIGS. 5A and 5B) is a schematic diagram depicting an earth-penetrating expansion apparatus and the operation thereof in accordance with a fourth embodiment of the invention.

FIG. 6 (consisting of FIGS. 6A and 6B) is a schematic diagram depicting a moment enhancing feature which may be added to various embodiments of the invention.

FIG. 7 depicts an example solar collector arrangement in accordance with an embodiment of the invention.

DETAILED DESCRIPTION

In the present disclosure, numerous specific details are provided, such as examples of apparatus, process parameters, materials, process steps, and structures, to provide a thorough understanding of embodiments of the invention. Persons of ordinary skill in the art will recognize, however, that the invention can be practiced without one or more of the specific details. In other instances, well-

known details are not shown or described to avoid obscuring aspects of the invention.

FIG. 1 is a schematic diagram depicting an earth-penetrating expansion apparatus and the operation thereof in accordance with a first embodiment of the invention. The apparatus includes a steel pole (or tube or cylinder) **102** with a hollow portion therein. The pole has a bottom end **104** which is configured to be driven into the ground. In this case, the bottom end of the pole comprises a pointed tip to be driven into the ground.

Anchoring parts **106** are configured to be radially extendable from the pole. As shown, the anchoring parts may comprise curved metal tines that may be extendable through corresponding holes **107** near the bottom end of the pole. Multiple anchoring parts are preferably configured. An exemplary embodiment may have two or three such anchoring parts and corresponding holes.

An expansion mechanism is configured to apply a force to the anchoring parts so as to radially extend the anchoring parts from the pole after the pole has been driven into the ground. As shown, the expansion mechanism may comprise an inner rod **108** which is coupled via a plate (flange) **109** to a top portion of the anchoring parts.

A sequence of three illustrative diagrams is shown in FIG. 1. The first diagram (FIG. 1A) shows the apparatus with the anchoring parts within the hollow portion of the pole, and the expansion mechanism not yet deployed. In this initial state, the bottom end of the pole may be driven into the ground.

The second diagram (FIG. 1B) shows the apparatus with the expansion mechanism in the midst of being deployed. As seen, the inner rod is being pushed down such that it presses down on the plate which forces anchoring parts to extend in a radial manner from the holes in the bottom end of the pole.

5 The third diagram (FIG. 1C) shows the apparatus with the expansion mechanism fully deployed. As shown, the inner rod is fully pushed down into the pole, and the anchoring parts are fully extended radially (laterally) into the earth. Advantageously, with the anchoring parts extended radially, the apparatus functions as an earth anchor which strongly resists both pull-out and lateral
10 forces.

The actuating mechanism in FIG. 1 is acts as a plunger under compression applying force to the anchoring part **106**. In an exemplary embodiment, the rod or plunger may be removable from the apparatus and may be re-used to deploy multiple anchors. This configuration may advantageously
15 further reduce material costs.

FIG. 2 is a schematic diagram depicting an earth-penetrating expansion apparatus and the operation thereof in accordance with a second embodiment of the invention. The apparatus includes a steel pole (or tube or cylinder) **202** with a hollow portion therein. The pole has a bottom end **204** which is configured to
20 be driven into the ground. In this case, the bottom end of the pole comprises a pointed tip to be driven into the ground.

Anchoring parts **206** are configured to be radially extendable from the pole. As shown, the anchoring parts may comprise pieces of the pointed tip of

the pole. In an exemplary embodiment, the pointed tip may be formed from three or more of the anchoring parts which may be coupled to the bottom of the pole using a hinge mechanism **207**.

An expansion mechanism is configured to apply a force to the anchoring parts so as to radially extend the anchoring parts from the pole after the pole has been driven into the ground. As shown, the expansion mechanism may comprise an inner rod **208** which is inserted into the hollow portion of the pole and pushed down to the bottom of the pole. The rod may itself have a pointed tip **210** on its bottom end. When the tip of the rod passes through the tip of the pole, the anchoring parts rotate on their hinges so as to become extended in a radial manner from the pole.

A sequence of five illustrative diagrams is shown in FIG. 2. The first diagram (FIG. 2A) shows the pole **202** positioned above the ground **201**. The tip **204** of the pole is to be driven into the ground for anchoring purposes. The second diagram (FIG. 2B) shows the pole after being driven into the ground. The third diagram (FIG. 2C) shows the inner rod **208** positioned so that its tip **210** is to be inserted into the hollow portion of the pole. The fourth diagram (FIG. 2D) shows the inner rod being pushed down through the pole. Finally, the fifth diagram (FIG. 2E) depicts the inner rod after being pushed down through the tip of the pole. As seen, this deploys the expansion mechanism so as to radially (laterally) extend the hinged anchoring parts **206** into the earth. Advantageously, with the anchoring parts extended radially, the apparatus functions as an earth anchor which strongly resists both pull-out and lateral forces.

FIG. 3 is a close-up view of the deployed expansion mechanism of the earth-penetrating expansion apparatus shown in FIG. 2. Shown are the anchoring parts **206** coupled to the pole **202** by way of the hinging mechanism **207**. The tip **210** of the inner rod **208** is shown after being pushed down through
5 the tip **204** of the pole **202** so as to push the anchoring parts out radially into the ground.

Similar to FIG. 1, the actuating mechanism in FIG. 2 acts as a plunger under compression applying force to the anchoring parts **206**. In an exemplary embodiment, the rod or plunger may be removable from the apparatus and may
10 be re-used to deploy multiple anchors. This configuration may advantageously further reduce material costs.

FIG. 4 is a schematic diagram depicting an earth-penetrating expansion apparatus and the operation thereof in accordance with a third embodiment of the invention. The apparatus includes a steel pole (or tube or cylinder) **402** with
15 a hollow portion therein. The pole has a bottom end **404** which is configured to be driven into the ground **401**. In this case, the bottom end of the pole comprises a pointed tip to be driven into the ground.

Anchoring parts **406** are configured to be radially extendable from the pole. As shown, the anchoring parts may comprise metal prongs. In an
20 exemplary embodiment, the metal prongs may be bent at both ends. In an initial configuration, a majority of each prong may be positioned within the hollow portion of the pole.

An expansion mechanism is configured to apply a force to the anchoring parts so as to radially extend the anchoring parts from the pole after the pole has been driven into the ground. As shown, the expansion mechanism may comprise, initially, one bent end of each prong which protrudes out of a
5 corresponding opening **407** in the side of the pole.

A sequence of five illustrative diagrams is shown in FIG. 4. The first diagram (FIG. 4A) shows the pole **402** being driven into the ground **401** (see the down arrow). The second diagram (FIG. 4B) shows the pole after being driven into the ground. In the first (FIG. 4A) and second (FIG. 4B) diagrams, one bent
10 end of each prong is shown protruding radially (laterally) from the pole while the remaining portion of each prong is within the pole (and hence not visible). The third diagram (FIG. 4C) is similar to the second diagram (FIG. 4B), but the portions of the anchoring parts **406** which lie within the pole and an actuating device **408** at a lower position within the pole are shown in the third diagram
15 (FIG. 4C). In one implementation, the actuating device **408** may be a ring which is configured so as to be capable of applying a force onto the anchoring parts **406** when a tension member **410** (such as a chain, or cable, or thin steel member) attached to the actuating device is pulled.

After the pole is driven into the ground to the desired depth, an upward
20 force is applied to the anchoring parts **406**, for example, by pulling upon the tension member **410** which is attached to the actuating device **408**. This upward force is represented by the up arrow in the diagram. The upward force activates the expansion mechanism. Due to the upward movement of the anchoring parts inside the pole, the prongs extend outward radially from the

pole. This happens because the holes in the side of the pole exert a downward and outward force on the protruding portion of each prong so as to effectively pull the prong out from within the pole. The fourth (FIG. 4D) diagram shows the prongs fully extended radially from the pole after the upward motion of the

5 anchoring parts. The fifth diagram (FIG. 4E) is the similar to the fourth diagram (FIG. 4D), but the portions of the anchoring parts **406** which lie within the pole and the actuating device **408** moved to a higher position within the pole are shown in the fifth diagram (FIG. 4E).

FIG. 5 is a schematic diagram depicting an earth-penetrating expansion

10 apparatus and the operation thereof in accordance with a fourth embodiment of the invention. The apparatus includes a steel sleeve (or pole or tube or cylinder) **502** with a hollow portion therein.

The sleeve has a bottom end which may comprise multiple prongs (segments) **504** that will later be deployed as anchoring parts. An expansion

15 mechanism is configured to apply a force to the metal prongs so as to radially extend them from the sleeve after the sleeve has been driven into the ground **501**. As shown, the expansion mechanism may comprise a bolt **508** with a larger bulbous portion **509** at a bottom end. A nut **503** may be attached to the top end of the sleeve. A top end of the bolt may be screwed through the nut

20 such that the bulbous end of the bolt is near to the prongs at the bottom of the sleeve.

Two illustrative diagrams are shown in FIG. 5. The first diagram (FIG. 5A) shows the apparatus after the sleeve has been driven into the ground. The second diagram (FIG. 5B) shows the apparatus after the bolt has been screwed

upward to engage the expansion mechanism. The expansion mechanism is engaged when the upward movement of the bulbous end of the bolt forces the ends of the prongs to go outward in a radial direction away from the sleeve. In other words, the actuating mechanism in FIG. 5 is a threaded rod, or partially
5 threaded rod, when put under tension by threading a nut forces the prongs to extend radially.

FIG. 6 is a schematic diagram depicting a moment enhancing feature which may be added to various embodiments of the invention. Shown are two views (FIG. 6A and FIG. 6B) of an apparatus with radial fins **604** configured on
10 an outer pole (or sleeve or cylinder or tube) **602**. Note that these fins act as a moment enhancing feature which may be added to any of the embodiments described above.

FIG. 7 depicts an example solar collector arrangement **10** in accordance with an embodiment of the invention. In this view, a single row **11** is shown, but
15 the array can comprise several rows **11** joined end to end, and can comprise any number of such rows side by side. A row of solar panels **14**, i.e., photovoltaic modules, is attached onto a torsion tube **12**.

In this example arrangement, the row has sixty panels or modules **14**, i.e., thirty sets of two modules. There are four vertical pier tubes **16**, which can be
20 round or square cross section, as desired, each supported in the earth. Each pier tube **16** may comprise the outer tube (or pole or cylinder) of an embodiment of the earth-penetrating expansion anchor disclosed herein. Alternatively, each pier tube **16** may be firmly attached to an earth-penetrating expansion anchor.

At a top end of each pier tube **16** may be a pier cap weldment **20**, which may have a transverse square tubular sleeve that fits the profile of the torsion tube **12**. The pier caps **20** on the pier tubes **16** may be aligned so that the torsion tube **12** threads through them. There may be multiple support rails or panel rails **22** attached onto the torsion tube **12**, and these rails **22** may be arranged across tube at right angles to the tube axis and may be spaced apart the width of one panel or module **14**.

Conventional pier tubes for a typical solar array installation may be 18 feet or so in length with about 12 to 14 feet embedded into the earth (depending on conditions, such as the soil type). The cost of these long conventional pier tubes and the installation thereof is substantial. If concrete footings are used to support the pier tubes, then additional labor and material costs are required.

In accordance with embodiments of the present invention, the radially extendable portions of the anchors reduces necessary lengths of the pier tubes embedded in the earth. Using the expansion anchors as disclosed herein reduces the necessary length of the pier tubes, such that, for example, only about 4 to 8 feet of length needs to be embedded in the earth, without the use of concrete footings. This reduces the overall length of the pier tubes to be 8 to 12 feet, and may lower material and installation costs.

Existing screw or helical type anchors include those made by Krinner GmbH of Strasskirchen, Germany and Terrafix GmbH of Eschenbach, Germany. However, neither of these products deploy or change state after they are inserted into the ground. Moreover, in some cases, costly dedicated machinery is required for installation of these anchors.

While specific embodiments of the present invention have been provided, it is to be understood that these embodiments are for illustration purposes and not limiting. Many additional embodiments will be apparent to persons of ordinary skill in the art reading this disclosure.

CLAIMS

What is claimed is:

1. An earth-penetrating apparatus comprising:
 - 5 a pole with a hollow portion therein and a bottom end which is configured to be driven into ground;
anchoring parts configured to be radially extendable from the pole;
an expansion mechanism configured to apply a force to the anchoring parts so as to radially extend the anchoring parts from the pole after the pole has
10 been driven into the ground.
2. The apparatus of claim 1, wherein the expansion mechanism comprises a rod configured to be pushed down through an opening in a top end of the pole into said hollow portion so as to apply said force to radially extend the anchoring
15 parts.
3. The apparatus of claim 2, wherein the rod is coupled to a plate which is connected to the anchoring parts.
- 20 4. The apparatus of claim 2, wherein the rod is removable so as to be usable to deploy multiple earth-penetrating apparatus.

5. The apparatus of claim 2, wherein the anchoring parts comprise curved tines.

5 6. The apparatus of claim 5, further comprising holes configured such that applying said force radially extends the curved tines out through the holes into the ground.

7. The apparatus of claim 2, wherein the anchoring parts comprises tip
10 pieces that form the bottom end of the pole.

8. The apparatus of claim 7, wherein the rod is further configured to be pushed down through a center of the tip pieces so as to cause the tip pieces to radially extend.

15

9. The apparatus of claim 1, wherein the anchoring parts are configured to be partially within the pole and partially outside of the pole such that the anchoring parts radially extend from the pole when a force is applied to the anchoring parts within the pole by the expansion mechanism.

20

10. The apparatus of claim 9, wherein the expansion mechanism comprises a tension member that pulls an actuating device upwards so as to force the anchoring parts out to extend radially from holes in the side of the pole.

5

11. The apparatus of claim 1, wherein the anchoring parts are configured at the bottom end of the pole, and the expansion mechanism comprises a bolt with a larger portion that extends from the bottom end of the pole.

10 12. The apparatus of claim 11, the bolt is configured to be screwed upward so that the larger portion moves into the bottom end of the pole and radially extends the anchoring parts into the ground.

13. The apparatus of claim 1, wherein the pole is between 8 to 12 feet in
15 length.

14. The apparatus of claim 1, wherein the radial extension of the anchor parts into the ground substantially increases a resistance of the apparatus to a pull-out force.

20

15. The apparatus of claim 1, further comprising a plurality of radial fins extending from the pole.

16. A solar collector arrangement comprising:

a plurality of earth-penetrating anchors which are driven into ground, each anchor including (a) a pole with top and bottom ends, the pole having a hollow
5 portion therein and a pointed tip at the bottom end which is configured to be driven into ground, (b) anchoring parts configured to be radially extendable from the pole, and (c) an expansion mechanism configured to apply a force to the anchoring parts so as to radially extend the anchoring parts from the pole after the pole has been driven into the ground;

10 a support structure coupled to the plurality of earth-penetrating anchors;
and

an array of solar panels attached to the support structure.

17. The solar collector arrangement of claim 16, wherein the poles of the
15 earth-penetrating anchors are between 8 to 10 feet in length.

18. The solar collector arrangement of claim 16, wherein the radial extension of the anchor parts into the ground from the poles of the earth-penetrating anchors substantially increases resistance of the poles to a pull-out force.

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19. The solar collector arrangement of claim 16, further comprising a plurality of radial fins extending from the poles of the earth-penetrating anchors.

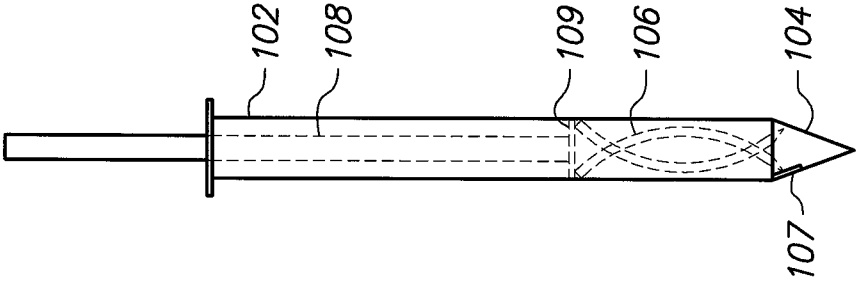


FIG. 1A

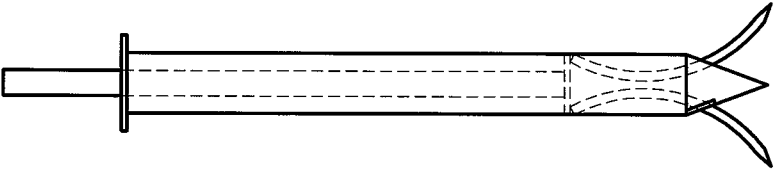


FIG. 1B

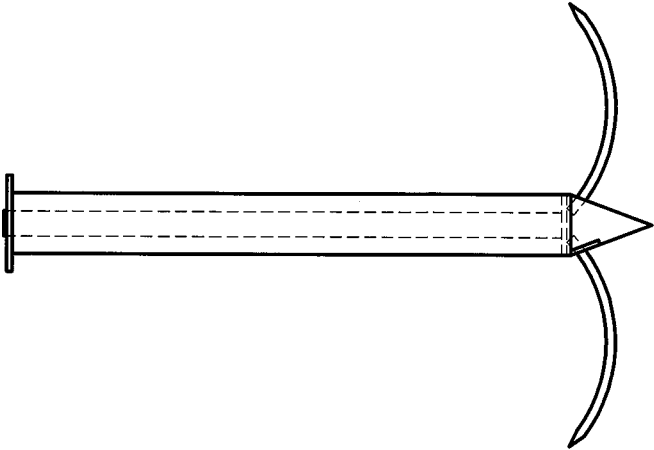


FIG. 1C

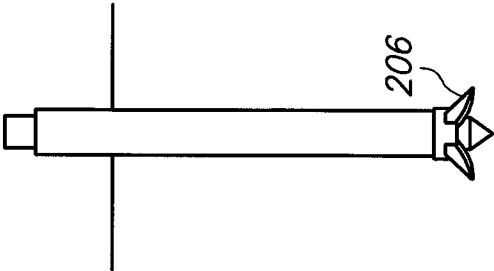
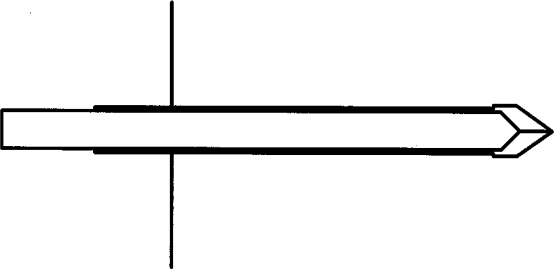
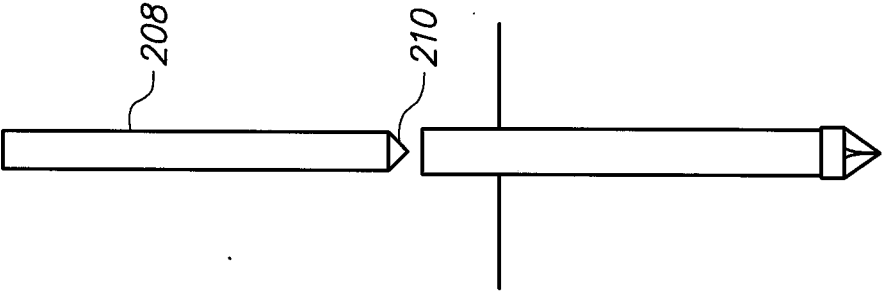
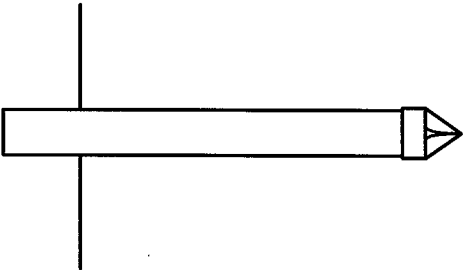
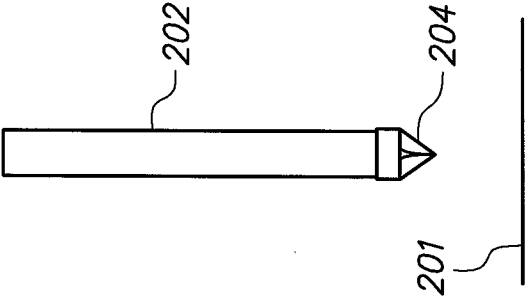


FIG. 2A FIG. 2B FIG. 2C FIG. 2D FIG. 2E

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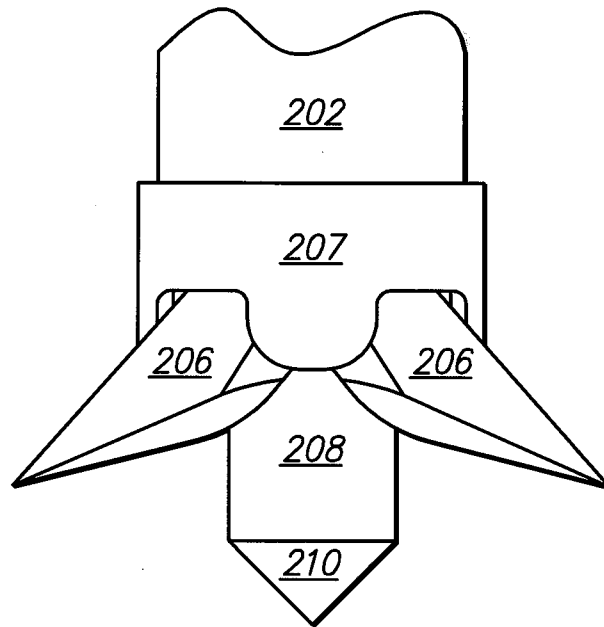


FIG. 3

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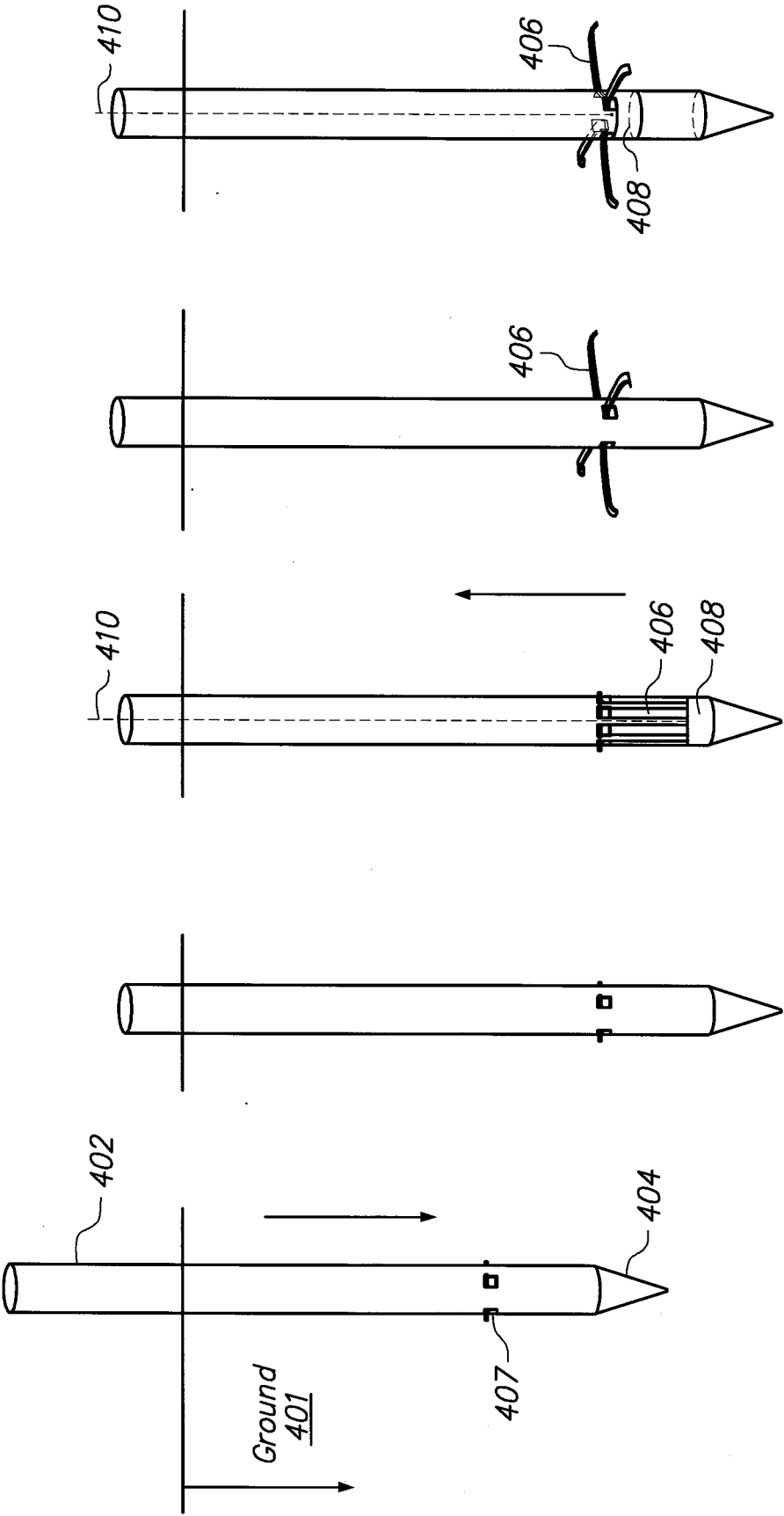


FIG. 4E

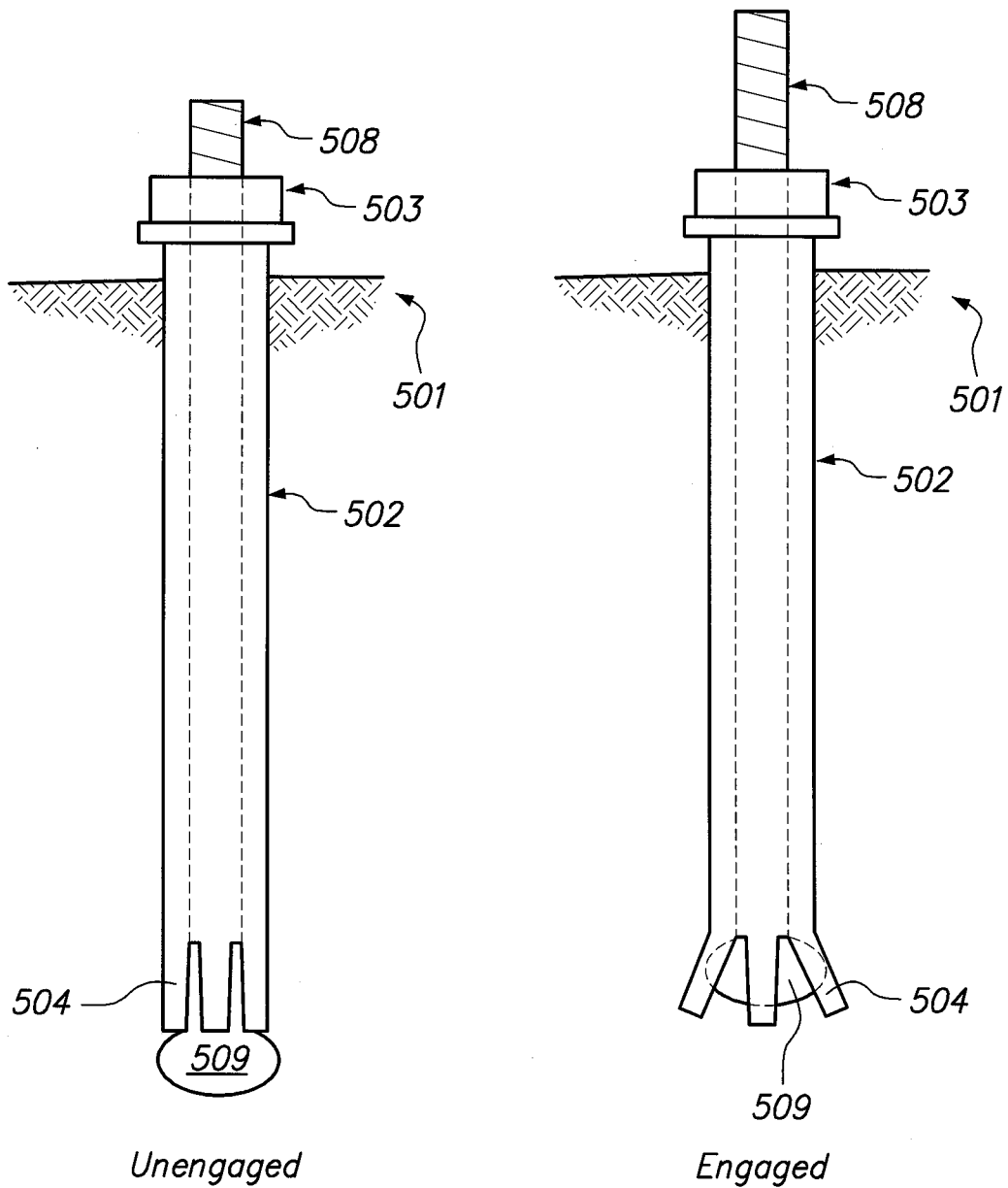
FIG. 4D

FIG. 4C

FIG. 4B

FIG. 4A

5/7

**FIG. 5A****FIG. 5B**

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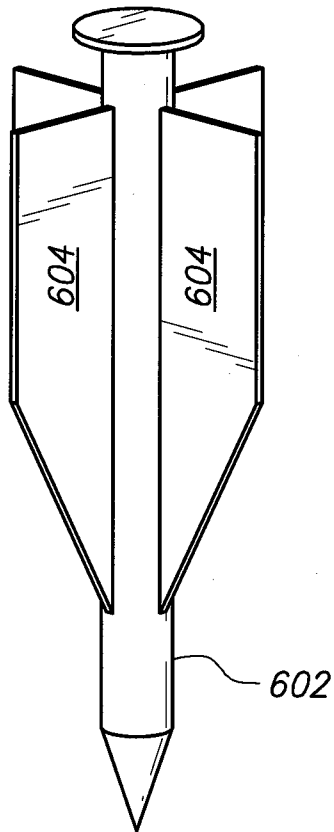


FIG. 6A

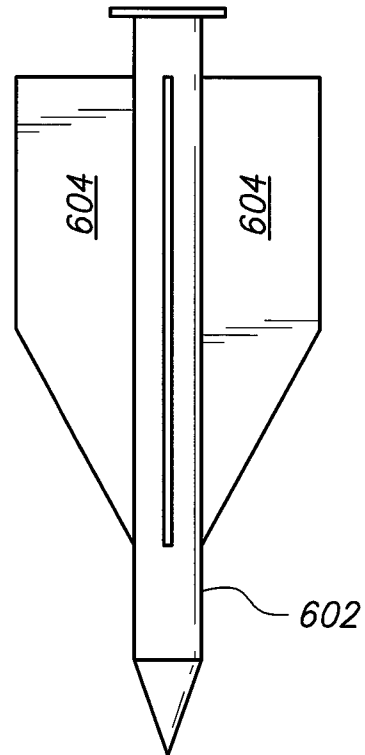
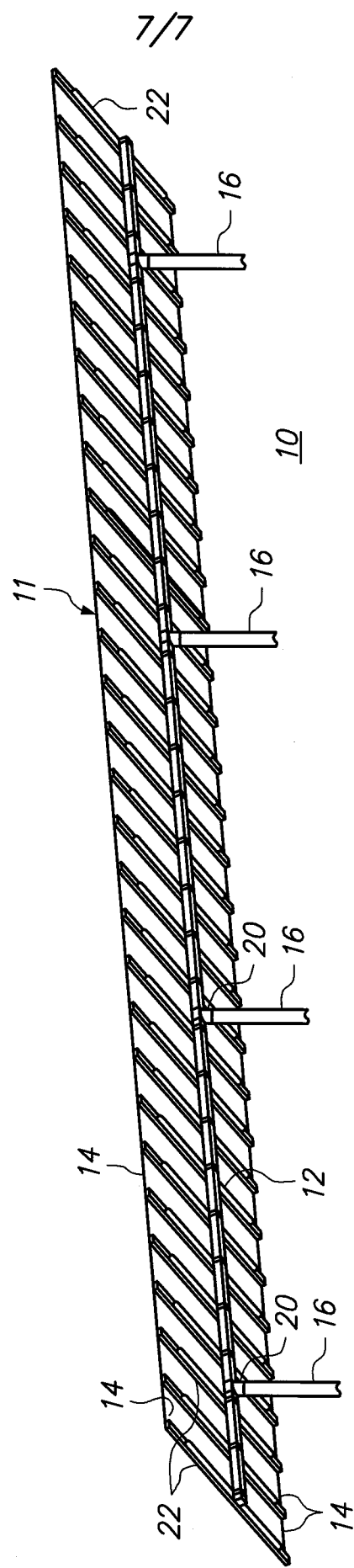


FIG. 6B

FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2009/067364

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - E02D 5/80 (2010.01)

USPC - 52/155

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - E02D 5/80 (2010.01)

USPC - 52/155, 156, 158, 159, 160, 161, 162, 163, 165; 135/118; 248/156; 405/237

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

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

USPTO EAST System (US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT), PatBase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3,680,274 A (DEIKE) 01 August 1972 (01.08.1972) entire document	1-3, 14
X	US 727,335 A (FISHER) 05 May 1903 (05.05.1903) entire document	1, 2, 4-6, 14
X	US 978,505 A (STEWART) 13 December 1910 (13.12.1910) entire document	1, 2, 4, 7, 8, 14
X	US 2007/0017166 A1 (NICOLET) 25 January 2007 (25.01.2007) entire document	1, 9, 10, 14
X	US 3,797,260 A (WEBB) 19 March 1974 (19.03.1974) entire document	1, 11-15

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



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

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Date of the actual completion of the international search

01 April 2010

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13 APR 2010

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Authorized officer:

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PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2009/067364

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.:
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:

Group I, claims 1-15 are drawn to an earth penetrating apparatus.

Group II, claims 16-19 are drawn to a solar collector arrangement.

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.:
1-15

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.