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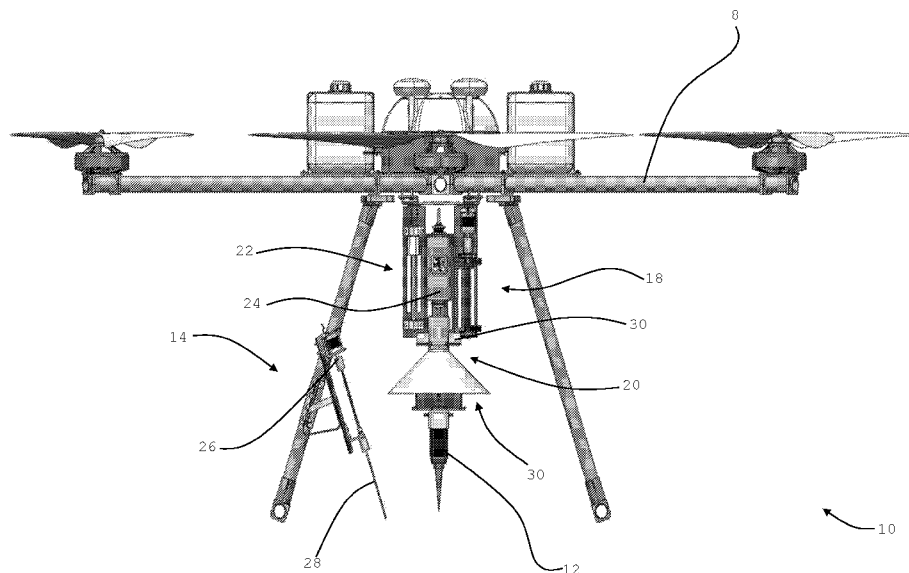


Figure 1.

(57) Abstract: Provided is a drone geophone installation arrangement (10) comprising a drone (8) configured to transport a geophone (12), and an anchor arrangement (14) configured to selectively and releasably anchor said drone (8) to a surface (16). Also included is a geophone implantation assembly (18) configured to implant the geophone (12) into said surface (16), said implantation assembly (18) comprising i) a geophone receptacle (20) configured to releasably receive the geophone (12), ii) a translation carriage (22) configured to urge said geophone receptacle (20) into said surface (16), and iii) a pulsator (24) configured to apply at least one implantation pulse to said geophone receptacle (20) to facilitate implantation of the geophone (12) into the surface (16) while the drone (8) is anchored thereto. An associated geophone installation method is also described.

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DRONE GEOPHONE INSTALLATION ARRANGEMENT

TECHNICAL FIELD

[0001] This invention broadly relates to the field of geophysics and more specifically to a drone geophone installation arrangement and associated geophone installation method.

BACKGROUND ART

[0002] The following discussion of the background art is intended to facilitate an understanding of the present invention only. The discussion is not an acknowledgement or admission that any of the material referred to is or was part of the common general knowledge as at the priority date of the application.

[0003] As is known in the art, a geophone is an acoustic detector device that converts ground movement or vibrations into an electrical signal which can be analysed for seismic information.

[0004] Geophones are often used in reflection seismology to record the energy waves reflected by subsurface geology. Geophones are typically very sensitive devices which can respond to distant ground tremors. These small signals can be drowned by larger signals from sources local to the geophone. For this reason, geophones are typically deployed in an array over a geographic area, so that it is possible to recover small signals by correlating signals from several geophones.

[0005] Signals which are registered only at one or some of the geophones in the array can generally be attributed to unwanted, local events and thus discarded. However, it can be assumed that small signals that register uniformly at all geophones in the array can be attributed to a distant and therefore significant event.

[0006] The Applicant has identified a shortcoming in the art of deploying geophones, such as in an array comprising a plurality of geophones, over a desired geographic area, which can be an arduous and time-consuming task, particularly where the geographic area is inaccessible, inhospitable and/or difficult to navigate. The current invention was conceived with this shortcoming in mind.

SUMMARY OF THE INVENTION

[0007] The skilled addressee is to appreciate that reference herein to a 'drone' broadly includes reference to any suitable unmanned vehicle, such as an aircraft or land vehicle, that may be guided remotely and/or operate autonomously to reach a particular geographic location with a predetermined load or cargo, typically at least one geophone.

[0008] According to a first aspect of the invention there is provided a drone geophone installation arrangement comprising:

- a drone configured to transport a geophone;
- an anchor arrangement configured to selectively and releasably anchor said drone to a surface; and
- a geophone implantation assembly configured to implant the geophone into said surface, said implantation assembly comprising a:

i) a geophone receptacle configured to releasably receive a geophone;

ii) a translation carriage configured to urge said geophone receptacle into said surface; and

iii) a pulsator configured to apply at least one implantation pulse to said geophone receptacle to facilitate implantation of the geophone into the surface while the drone is anchored thereto, after which the geophone is released from the receptacle and the drone is able to depart.

[0009] Typically, the installation arrangement comprises a controller arranged in signal communication with the anchor arrangement and the geophone implantation assembly, said controller configured to control synergistic operation of said arrangement and assembly to control implantation of the geophone into the surface.

[0010] Typically, the processor comprises any suitable processor or microcontroller configured to receive input, perform logical and arithmetical operations on a suitable instruction set, and provide output, as well as transitory and/or non-transitory electronic storage.

[0011] In an embodiment, the drone comprises a multicopter, such as a quadcopter.

[0012] In an embodiment, the anchor arrangement comprises a deployable drill fast with the drone and configured to deploy and drill a drill bit into the surface in order to anchor said drone to the surface.

[0013] Typically, the drill is configured to drill the drill bit at an angle into the surface relative to a direction in

which the implantation pulse is applied in order to facilitate anchoring the drone to the surface during geophone implantation.

[0014] In an embodiment, the implantation pulse is applied substantially vertically and the drill angle is between 30° and 60° from the vertical.

[0015] In an embodiment, the geophone receptacle comprises a geophone socket shaped and configured to receive a portion of the geophone, said socket including a lock configured to releasably lock said portion into the socket.

[0016] In an embodiment, the translation carriage comprises a linear actuator suspended below the drone and having a predetermined translation distance determined by means of limit switches and/or sensors.

[0017] In an embodiment, the translation carriage is configured to lower the geophone receptacle onto the surface until a predetermined amount of resistance to translation occurs.

[0018] In an embodiment, the pulsator is configured to activate once the predetermined amount of resistance to translation occurs.

[0019] In an embodiment, the pulsator comprises a solenoid actuator configured to apply the at least one implantation pulse once activated.

[0020] In an embodiment, the translation carriage is configured to lower the geophone receptacle onto the surface

until the predetermined amount of resistance to translation occurs after each activation of the pulsator, until a maximum translation distance is reached.

[0021] Typically, the geophone receptacle is configured to release the geophone once the maximum translation distance is reached.

[0022] Typically, the translation carriage is configured to retract to a minimum translation distance after the geophone is released from the geophone receptacle.

[0023] Typically, the anchor assembly is configured to release the drone from the surface after the geophone is released from the geophone receptacle following implantation.

[0024] According to a second aspect of the invention there is provided a geophone installation method comprising the steps of:

- providing a drone configured to transport a geophone;
- selectively and releasably anchoring said drone to a surface by means of an anchor arrangement;
- urging said geophone into the surface via a translation carriage having a geophone receptacle in which the geophone is received;
- applying at least one implantation pulse via a pulsator to said geophone receptacle as said geophone receptacle is urged into the surface while the drone is anchored; and
- releasing the geophone from the geophone receptacle once implanted so that the drone is able to depart.

[0025] In an embodiment, the drone comprises a multicopter, such as a quadcopter.

[0026] In an embodiment, the step of anchoring the drone comprises deploying a drill fast with the drone and drilling a drill bit into the surface in order to anchor said drone to the surface.

[0027] Typically, the step of drilling is performed at an angle relative to a direction in which the implantation pulse is applied in order to facilitate anchoring the drone to the surface during geophone implantation.

[0028] In an embodiment, the implantation pulse is applied substantially vertically and the drill angle is between 30° and 60° from the vertical.

[0029] In an embodiment, the step of urging via the translation carriage is performed by a linear actuator suspended below the drone and having a predetermined translation distance determined by means of limit switches.

[0030] In an embodiment, the step of urging is performed via the translation carriage lowering the geophone receptacle onto the surface until a predetermined amount of resistance to translation occurs.

[0031] In an embodiment, the step of applying at least one implantation pulse is performed by the pulsator activating once the predetermined amount of resistance to translation occurs.

[0032] In an embodiment, the step of urging is performed by the translation carriage lowering the geophone receptacle onto the surface until the predetermined amount of resistance to

translation occurs after each activation of the pulsator, until a maximum translation distance is reached.

[0033] Typically, the step of releasing the geophone from the geophone receptacle is performed by the geophone receptacle releasing the geophone once the maximum translation distance is reached, said geophone receptacle comprising a geophone socket shaped and configured to receive a portion of the geophone and including a lock configured to releasably lock said portion into the socket.

[0034] Typically, the method includes the step of retracting the translation carriage to a minimum translation distance after the geophone is released from the geophone receptacle.

[0035] Typically, the method includes the step of the anchor assembly releasing the drone from the surface after the geophone is released from the geophone receptacle.

[0036] In an embodiment, the method includes the step of retrieving the implanted geophone by the drone returning thereto and anchoring the drone with the anchor arrangement, receiving the geophone into the geophone receptacle, translating the translation carriage with geophone from the maximum to minimum translation distance, and releasing the drone from the surface so that the drone is able to depart with the geophone.

[0037] According to a third aspect of the invention there is provided a method of installing a geophone comprising the step of implanting a geophone with a drone geophone

installation arrangement in accordance with the first aspect of the invention above.

[0038] According to a further aspect of the invention there is provided a drone geophone installation arrangement and a geophone installation method, substantially as herein described and/or illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

The description will be made with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic front-view representation of one example of a drone geophone installation arrangement, in accordance with aspects of the present invention;

Figure 2 is a diagrammatic representation of the implantation assembly of the drone geophone installation arrangement of Figure 1;

Figure 3 is diagrammatic representation of the anchor arrangement of the drone geophone installation arrangement of Figure 1;

Figure 4 is a diagrammatic representation of the drone geophone installation arrangement of Figure 1 anchored to a surface;

Figure 5 is a diagrammatic representation of the drone geophone installation arrangement of Figure 4 showing the implantation of the geophone into the surface;

Figure 6 is a closer-view diagrammatic representation of the geophone implantation into the surface;

Figure 7 is a diagrammatic representation of the drone geophone installation arrangement of Figure 5 showing the geophone fully implanted into the surface;

Figure 8 is a diagrammatic representation of the drone geophone installation arrangement of Figure 7 showing the implanted geophone with the anchor arrangement released;

Figure 9 is diagrammatic representation of the drone geophone installation arrangement of Figure 8 showing the implanted geophone with the drone departing;

Figure 10 is a closer-view diagrammatic representations of the geophone receptacle showing a geophone socket with locks; and

Figures 11 and 12 are diagrammatic representations of the geophone implantation assembly of the drone geophone installation arrangement of Figure 1.

DETAILED DESCRIPTION OF EMBODIMENTS

[0039] Further features of the present invention are more fully described in the following description of several non-limiting embodiments thereof. This description is included solely for the purposes of exemplifying the present invention to the skilled addressee. It should not be understood as a restriction on the broad summary, disclosure or description of the invention as set out above.

[0040] In the figures, incorporated to illustrate features of the example embodiment or embodiments, like reference numerals are used to identify like parts throughout. Additionally, features, mechanisms and aspects well-known and understood in the art will not be described in detail, as such features, mechanisms and aspects will be within the understanding of the skilled addressee.

[0041] With reference now to the accompanying figures, there is broadly shown one embodiment of a drone geophone installation arrangement 10. Such an arrangement 10 finds particular application in the installation and implantation of a geophone at a desired geographic location, as is known in the art of geophysics. Drone geophone installation arrangement 10 generally comprises drone 8, an anchor arrangement 14, and a geophone implantation assembly 18 to facilitate implantation of a geophone 12 into a surface 16. Such a surface 16 typically comprises a ground surface at a desired geographic location.

[0042] As mentioned above, while the exemplified embodiment shows the drone 8 as a multicopter, such as a quadcopter, the skilled addressee is to appreciate that other forms or drones are apposite, as required. For example, land vehicles may also be used, or the like. Accordingly, drone 8 may include any suitable drone configured to transport a geophone 12.

[0043] The skilled addressee is to appreciate that arrangement 10 typically includes some manner of controller (not shown) which is arranged in signal communication with the anchor arrangement 14 and the geophone implantation assembly 18 and is configured to control synergistic operation of these components to control implantation of the geophone 12 into the surface 16, as described below. Such a controller may include

any suitable microcontroller or processor, as is known in the art, and may also be configured to control the drone 8.

[0044] Arrangement 10 also includes anchor arrangement 14 which is generally configured to selectively and releasably anchor said drone 8 to surface 16. In the exemplified embodiment, the anchor arrangement 14 comprises a deployable drill 26 which is fast with the drone 8 and is configured to deploy and drill a drill bit 28 into the surface 16 in order to anchor the drone 8 to the surface 16. Typically, the drill 26 is configured to drill the drill bit 28 into the surface 16 at an angle relative to a direction along which an implantation pulse is applied by a pulsator 24, as described below, in order to facilitate such anchoring. In an embodiment, the drill angle is between 30° and 60° from the vertical, but variations hereon are possible and within the scope of the present invention. For example, if an implantation pulse is applied generally vertically, i.e. transverse to the surface 16, drilling into the surface 16 at an angle allows the anchor arrangement 14 to keep the drill in place against such implantation impulse(s).

[0045] Arrangement 10 further includes geophone implantation assembly 18 which is configured to implant the geophone 12 into the surface 16. The implantation assembly 18 generally comprises a geophone receptacle 20 which is configured to releasably receive the geophone 12. Such geophone receptacle 20 may be shaped and dimensioned according to geophone requirements. The geophone receptacle 20 generally comprises a geophone socket 30 which is shaped and configured to receive a portion of the geophone 12, as shown, said socket 30 including a lock 32 which is configured to releasably lock said portion into the socket 30. Lock 32 may be configured to interact directly with geophone 12, or geophone 12 may be

fitted with a particular lock interacting member 12.1, such as a suitable plastic adaptor or cap 12.1, or the like.

[0046] Implantation assembly 18 also includes a translation carriage 22 which is generally configured to urge the geophone 12 within the geophone receptacle 20 into the surface 16, as well as a pulsator 24 which is configured to apply at least one implantation pulse to said geophone 12 within the geophone receptacle 20 in order to facilitate implantation of the geophone 12 into the surface 16 while the drone 8 is anchored to the surface 16.

[0047] The skilled addressee is to appreciate that implantation forces resulting from the urging along with the application of implantation pulses requires offset in order function and not to destabilise drone 8. For this reason, anchor arrangement 14 is typically used to provide a stable platform in the anchored drone 8 against which such implantation forces are able to act to facilitate in implanting of the geophone 12.

[0048] The translation carriage 22 generally comprises a linear actuator suspended below the drone 8, as shown, and having a predetermined translation distance 34 determined by means of suitable limit switches and/or sensors, or the like. Such translation carriage 22 typically defines a minimum translation distance 34.1, where the geophone receptacle 20 is proximate the drone 8, and a maximum translation distance 34.2, where the geophone receptacle 20 is distal from the drone 8.

[0049] When in use, the translation carriage 22 is generally configured to lower the geophone receptacle 20 with geophone 12 onto or into the surface 16 until a predetermined amount of

resistance to such translation occurs, typically sensed by the controller. Once such predetermined amount of resistance to translation occurs or is detected, the pulsator 24 is typically activated in order to percussively 'hammer' or force the geophone deeper into the surface 16 via an implantation impulse. In an embodiment, the pulsator 24 comprises a solenoid actuator configured to apply the implantation pulse once activated, but variations hereon are possible and within the scope of the present invention.

[0050] An example hereof is shown in Figure 6, where an implantation end 40 (typically a stake or point of the geophone 12) is urged via translation carriage 22 until the predetermined amount of resistance to such translation occurs at point 36, after which the pulsator 24 is activated to drive point 40 downwards to point 38 via at least one implantation impulse. Once such implantation impulse has been applied, the translation carriage 22 is able to urge the point 40 downwards again until the predetermined amount of resistance to such translation occurs again, at which point the implantation impulse(s) is applied again, driving the geophone 12 sequentially lower into the surface 16 until fully implanted.

[0051] Accordingly, the translation carriage 22 is typically configured to lower the geophone receptacle 20 with geophone 12 into the surface 16 until the predetermined amount of resistance to translation occurs after each activation of the pulsator, until a maximum translation distance 34.2 is reached, where the geophone 12 is fully implanted as required.

[0052] Once implanted, the geophone receptacle 20 is typically configured to release the geophone 12 once the maximum translation distance 34.2 is reached. The translation

carriage 22 is also generally configured to retract to the minimum translation distance 34.1 after the geophone 12 is released from the geophone receptacle 20. Similarly, the anchor arrangement 14 is also configured to release the drone 8 from the surface 16 after the geophone 12 is released from the geophone receptacle 20 so that the drone 8 is able to depart.

[0053] The present invention also includes an associated geophone installation method which generally comprises the steps of providing the drone 8 which is configured to transport the geophone 12; selectively and releasably anchoring said drone 8 to the surface 16 by means of the anchor arrangement 14; urging the geophone 12 into the surface 16 via the translation carriage 22 having the geophone receptacle 20 in which the geophone 12 is received; and applying at least one implantation pulse via the pulsator 24 to said geophone 12 within receptacle 20 as the geophone receptacle 20 is urged into the surface 16. Lastly, the method generally includes the step of releasing the geophone 12 from the geophone receptacle 20 once implanted, as described, so that the drone 8 is able to depart.

[0054] In an embodiment, the method may include a step of retrieving the implanted geophone 12 by the drone 8 returning thereto and anchoring the drone with the anchor arrangement 14, receiving the geophone 12 into the geophone receptacle 20, translating the translation carriage 22 with geophone from the maximum 34.2 to minimum 34.1 translation distance, and releasing the drone 8 from the surface 16 so that the drone 8 is able to depart with the geophone 12.

[0055] The skilled addressee is to appreciate that, while the present invention has been exemplified in relation to the

implantation of geophones in particular, the installation arrangement 10 may easily be adapted for the implantation of other things, including other sensors, plants, seeds, etc. Accordingly, variations on the implantation of things via analogous aspects and techniques are expressly included in the scope of the present invention.

[0056] Applicant believes it particularly advantageous that the present invention provides for drone geophone installation arrangement 10 which finds particular application in autonomously deploying a plurality of geophones quickly and efficiently in a desired geographic area which may be inaccessible, inhospitable and/or difficult to navigate.

[0057] Optional embodiments of the present invention may also be said to broadly consist in the parts, elements and features referred to or indicated herein, individually or collectively, in any or all combinations of two or more of the parts, elements or features, and wherein specific integers are mentioned herein which have known equivalents in the art to which the invention relates, such known equivalents are deemed to be incorporated herein as if individually set forth. In the example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail, as such will be readily understood by the skilled addressee.

[0058] The use of the terms "a", "an", "said", "the", and/or similar referents in the context of describing various embodiments (especially in the context of the claimed subject matter) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having,"

"including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. No language in the specification should be construed as indicating any non-claimed subject matter as essential to the practice of the claimed subject matter.

[0059] Spatially relative terms, such as "inner," "outer," "beneath," "below," "lower," "above," "upper," and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the example term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0060] It is to be appreciated that reference to "one example" or "an example" of the invention, or similar exemplary language (e.g., "such as") herein, is not made in an exclusive sense. Various substantially and specifically practical and useful exemplary embodiments of the claimed subject matter are described herein, textually and/or graphically, for carrying out the claimed subject matter.

[0061] Accordingly, one example may exemplify certain aspects of the invention, whilst other aspects are exemplified in a different example. These examples are intended to assist the skilled person in performing the invention and are not intended to limit the overall scope of the invention in any way unless the context clearly indicates otherwise.

[0062] Variations (e.g. modifications and/or enhancements) of one or more embodiments described herein might become apparent to those of ordinary skill in the art upon reading this application. The inventor(s) expects skilled artisans to employ such variations as appropriate, and the inventor(s) intends for the claimed subject matter to be practiced other than as specifically described herein.

[0063] Any method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

CLAIMS

1. A drone geophone installation arrangement comprising:

a drone configured to transport a geophone;

an anchor arrangement configured to selectively and releasably anchor said drone to a surface; and

a geophone implantation assembly configured to implant the geophone into said surface, said implantation assembly comprising a:

i) a geophone receptacle configured to releasably receive a geophone;

ii) a translation carriage configured to urge said geophone receptacle into said surface; and

iii) a pulsator configured to apply at least one implantation pulse to said geophone receptacle to facilitate implantation of the geophone into the surface while the drone is anchored thereto, after which the geophone is released from the receptacle and the drone is able to depart.

2. The arrangement of claim 1, which comprises a controller arranged in signal communication with the anchor arrangement and the geophone implantation assembly, said controller configured to control synergistic operation of said arrangement and assembly to control implantation of the geophone into the surface.

3. The arrangement of either of claims 1 or 2, wherein the drone comprises a multicopter, such as a quadcopter.

4. The arrangement of any of claims 1 to 3, wherein the anchor arrangement comprises a deployable drill fast with the

drone and configured to deploy and drill a drill bit into the surface in order to anchor said drone to the surface.

5. The arrangement of claim 4, wherein the drill is configured to drill the drill bit at an angle into the surface relative to a direction in which the implantation pulse is applied in order to facilitate anchoring the drone to the surface during geophone implantation.

6. The arrangement of claim 5, wherein the implantation pulse is applied substantially vertically and the drill angle is between 30° and 60° from the vertical.

7. The arrangement of any of claims 1 to 6, wherein the geophone receptacle comprises a geophone socket shaped and configured to receive a portion of the geophone, said socket including a lock configured to releasably lock said portion into the socket.

8. The arrangement of any of claims 1 to 7, wherein the translation carriage comprises a linear actuator suspended below the drone and having a predetermined translation distance determined by means of limit switches and/or sensors.

9. The arrangement of any of claims 1 to 8, wherein the translation carriage is configured to lower the geophone receptacle onto the surface until a predetermined amount of resistance to translation occurs.

10. The arrangement of claim 9, wherein the pulsator is configured to activate once the predetermined amount of resistance to translation occurs.

11. The arrangement of any of claims 1 to 10, wherein the pulsator comprises a solenoid actuator configured to apply the at least one implantation pulse once activated.

12. The arrangement of either of claims 9 or 10, wherein the translation carriage is configured to lower the geophone receptacle onto the surface until the predetermined amount of resistance to translation occurs after each activation of the pulsator, until a maximum translation distance is reached.

13. The arrangement of claim 12, wherein the geophone receptacle is configured to release the geophone once the maximum translation distance is reached.

14. The arrangement of any of claims 1 to 13, wherein the translation carriage is configured to retract to a minimum translation distance after the geophone is released from the geophone receptacle.

15. The arrangement of any of claims 1 to 14, wherein the anchor assembly is configured to release the drone from the surface after the geophone is released from the geophone receptacle following implantation so that the drone is able to depart.

16. A geophone installation method comprising the steps of:

- providing a drone configured to transport a geophone;
- selectively and releasably anchoring said drone to a surface by means of an anchor arrangement;
- urging said geophone into the surface via a translation carriage having a geophone receptacle in which the geophone is received;

applying at least one implantation pulse via a pulsator to said geophone receptacle as said geophone receptacle is urged into the surface while the drone is anchored; and

releasing the geophone from the geophone receptacle once implanted so that the drone is able to depart.

17. The method of claim 16, wherein the drone comprises a multicopter, such as a quadcopter.

18. The method of either of claims 16 or 17, wherein the step of anchoring the drone comprises deploying a drill fast with the drone and drilling a drill bit into the surface in order to anchor said drone to the surface.

19. The method of claim 18, wherein the step of drilling is performed at an angle relative to a direction in which the implantation pulse is applied in order to facilitate anchoring the drone to the surface during geophone implantation.

20. The method of claim 19, wherein the implantation pulse is applied substantially vertically and the drill angle is between 30° and 60° from the vertical.

21. The method of any of claims 16 to 20, wherein the step of urging via the translation carriage is performed by a linear actuator suspended below the drone and having a predetermined translation distance determined by means of limit switches and/or sensors.

22. The method of any of claims 16 to 21, wherein the step of urging is performed via the translation carriage lowering the geophone receptacle onto the surface until a predetermined amount of resistance to translation occurs.

23. The method of claim 22, wherein the step of applying at least one implantation pulse is performed by the pulsator activating once the predetermined amount of resistance to translation occurs.

24. The method of either of claims 22 or 23, wherein the step of urging is performed by the translation carriage lowering the geophone receptacle onto the surface until the predetermined amount of resistance to translation occurs after each activation of the pulsator, until a maximum translation distance is reached.

25. The method of claim 24, wherein the step of releasing the geophone from the geophone receptacle is performed by the geophone receptacle releasing the geophone once the maximum translation distance is reached, said geophone receptacle comprising a geophone socket shaped and configured to receive a portion of the geophone and including a lock configured to releasably lock said portion into the socket.

26. The method of any of claims 16 to 25, which includes the step of retracting the translation carriage to a minimum translation distance after the geophone is released from the geophone receptacle.

27. The method of any of claims 16 to 26, which includes the step of the anchor assembly releasing the drone from the surface after the geophone is released from the geophone receptacle so that the drone is able to depart.

28. The method of any of claims 16 to 27, which includes the step of retrieving the implanted geophone by the drone

returning thereto and anchoring the drone with the anchor arrangement, receiving the geophone into the geophone receptacle, translating the translation carriage with geophone from the maximum to minimum translation distance, and releasing the drone from the surface so that the drone is able to depart with the geophone.

29. A method of installing a geophone comprising the step of implanting a geophone with a drone geophone installation arrangement in accordance with any of claims 1 to 15.

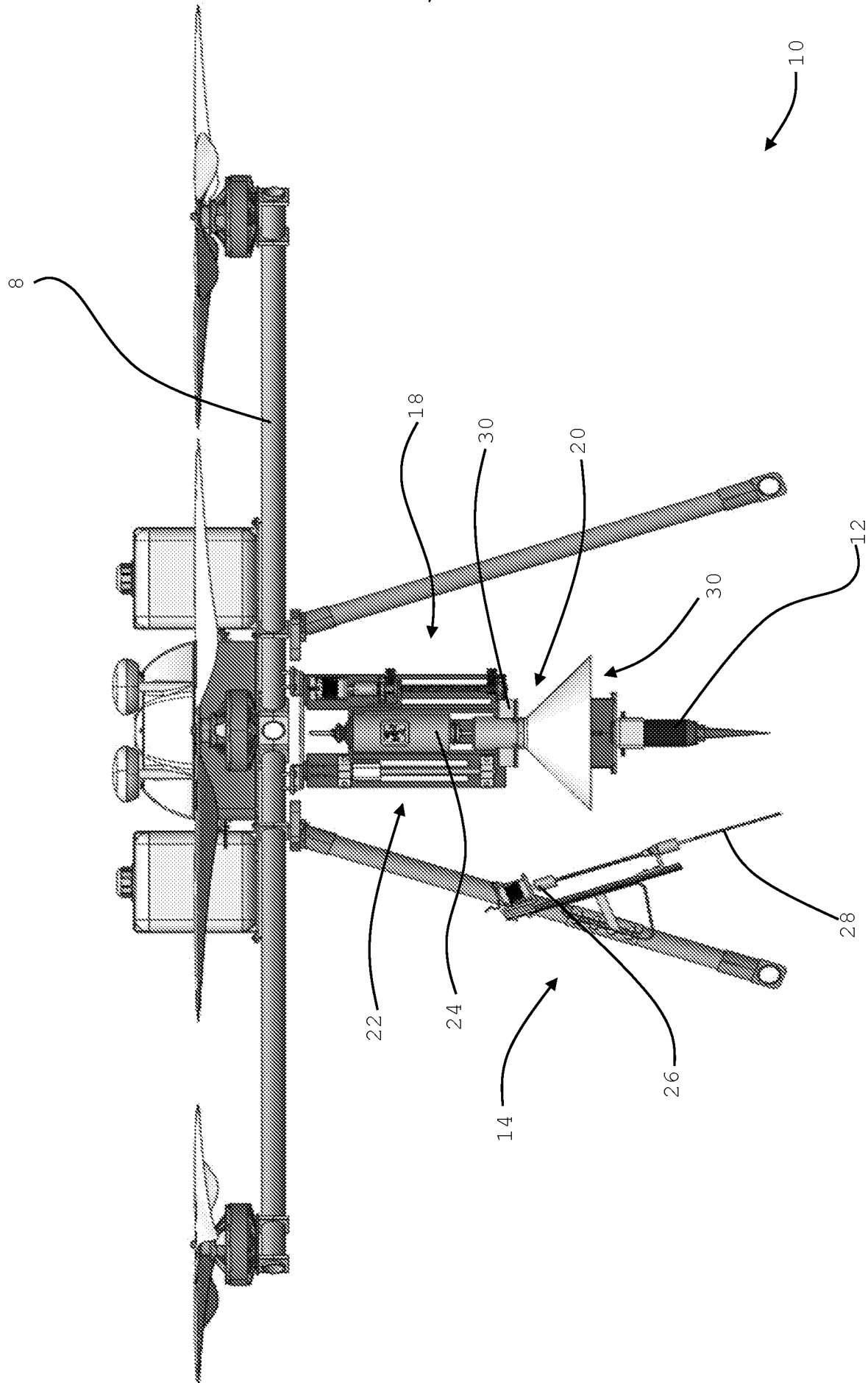


Figure 1.

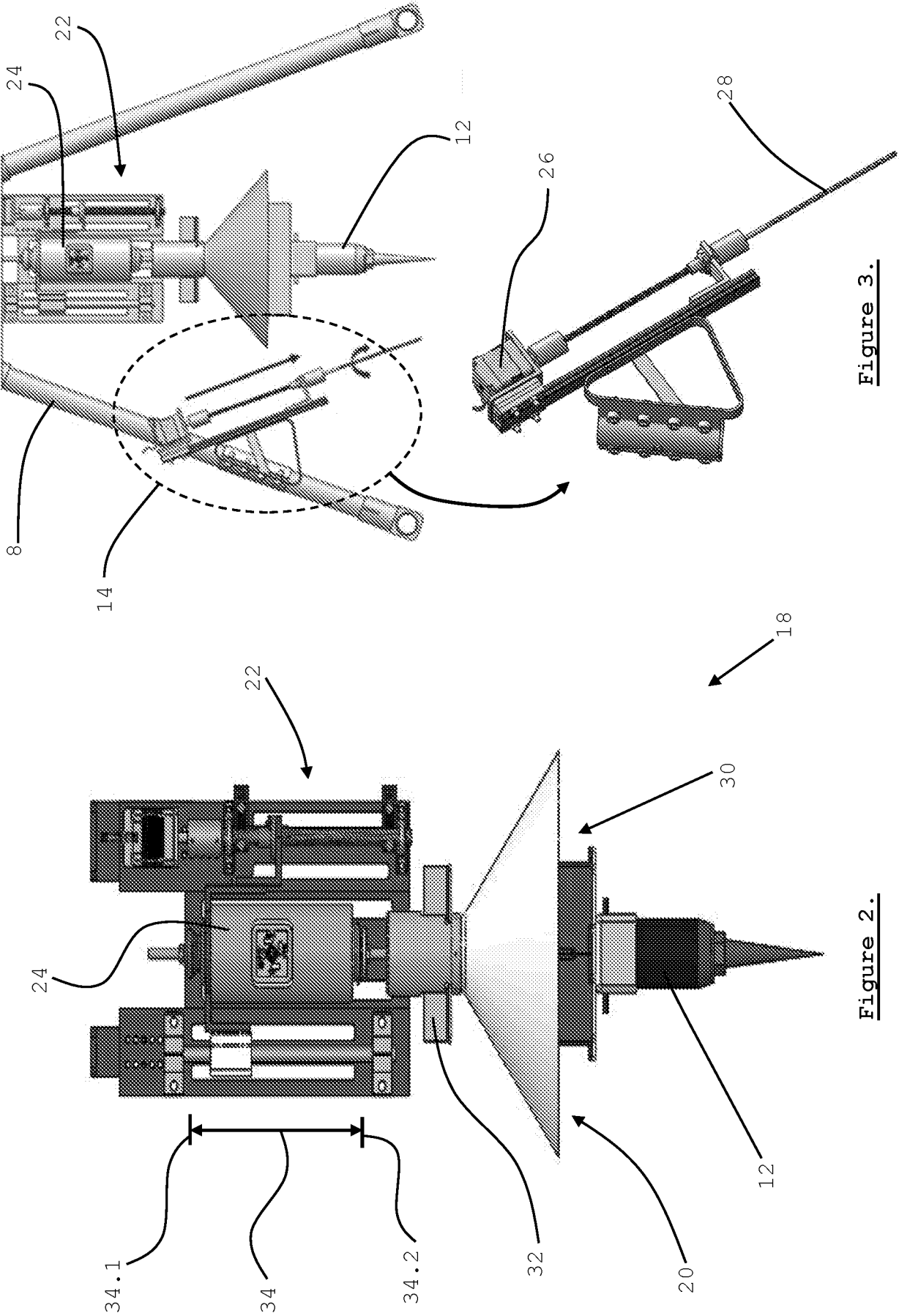


Figure 3.

Figure 2.

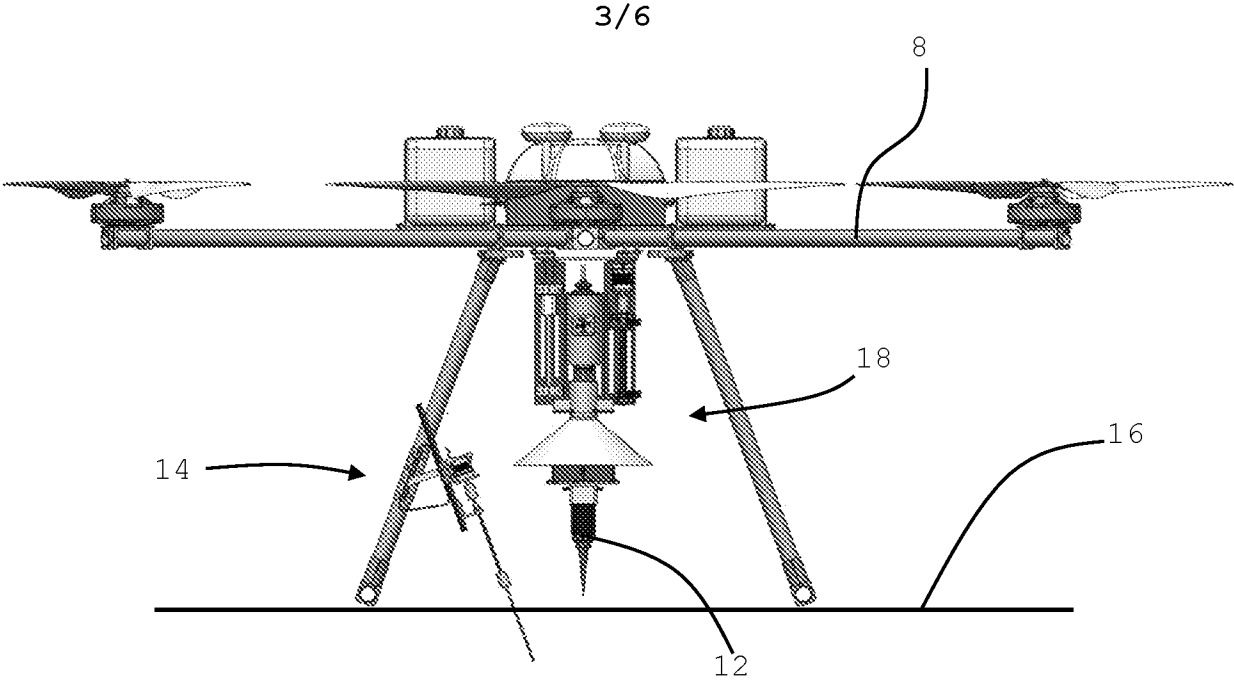


Figure 4.

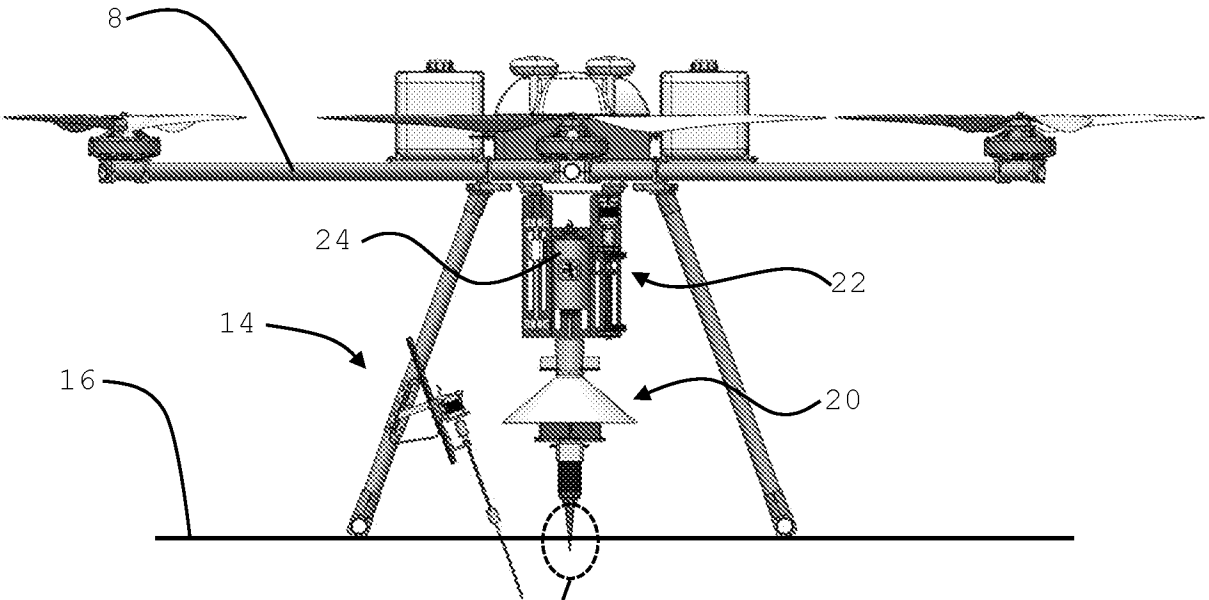


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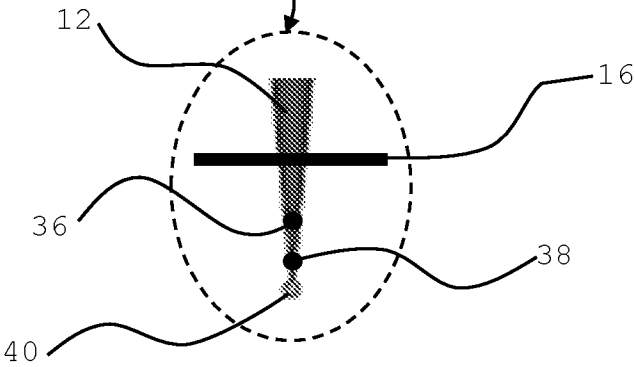


Figure 6.

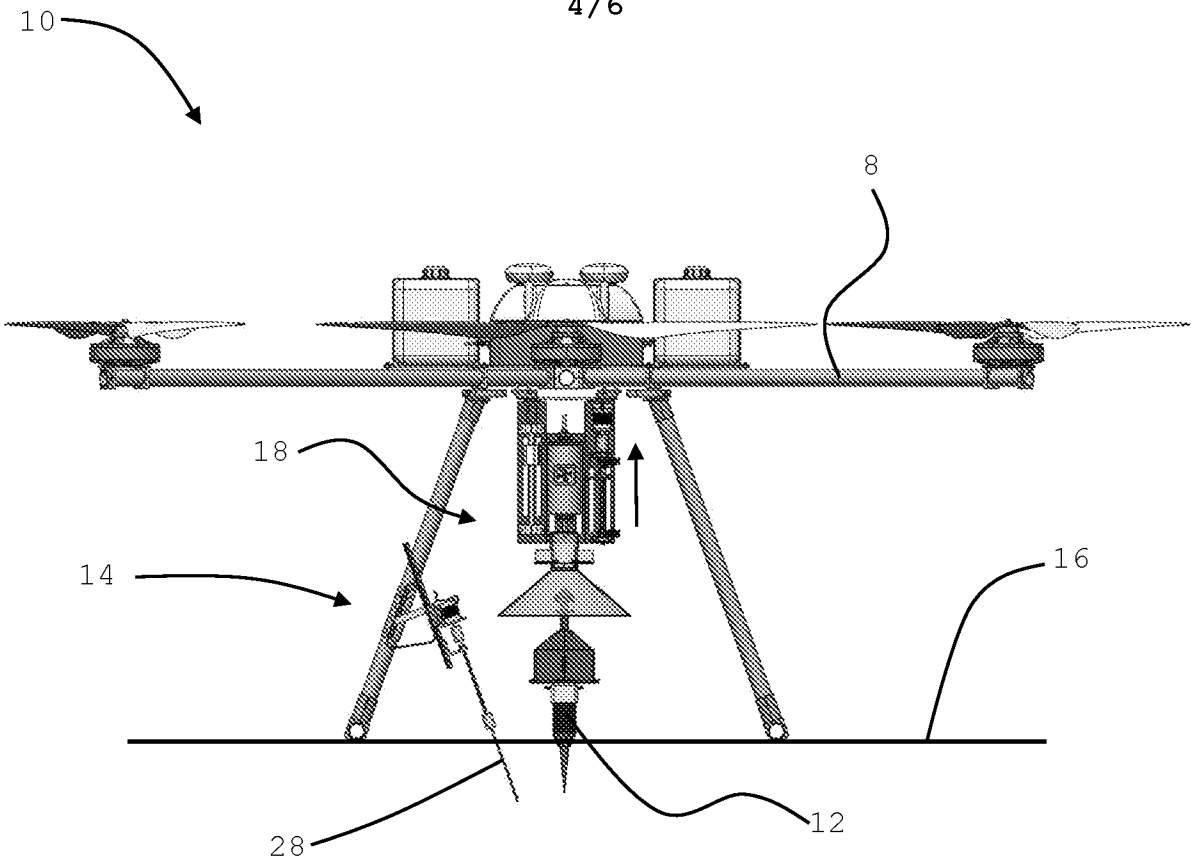


Figure 7.

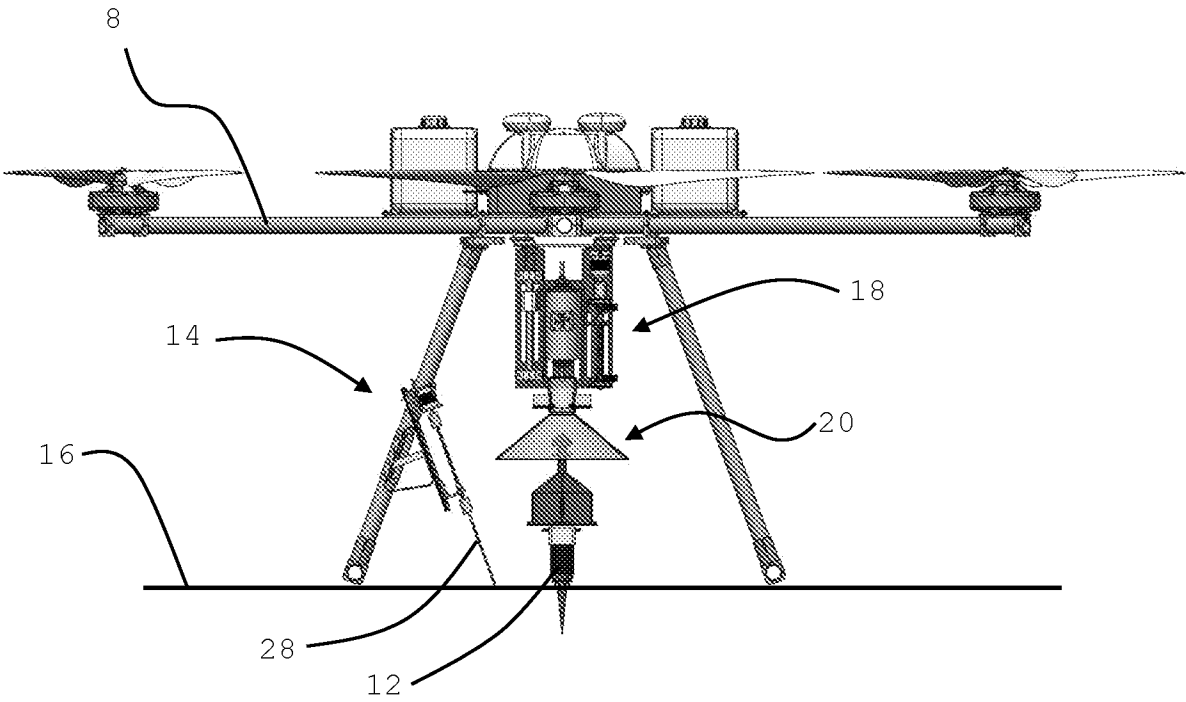


Figure 8.

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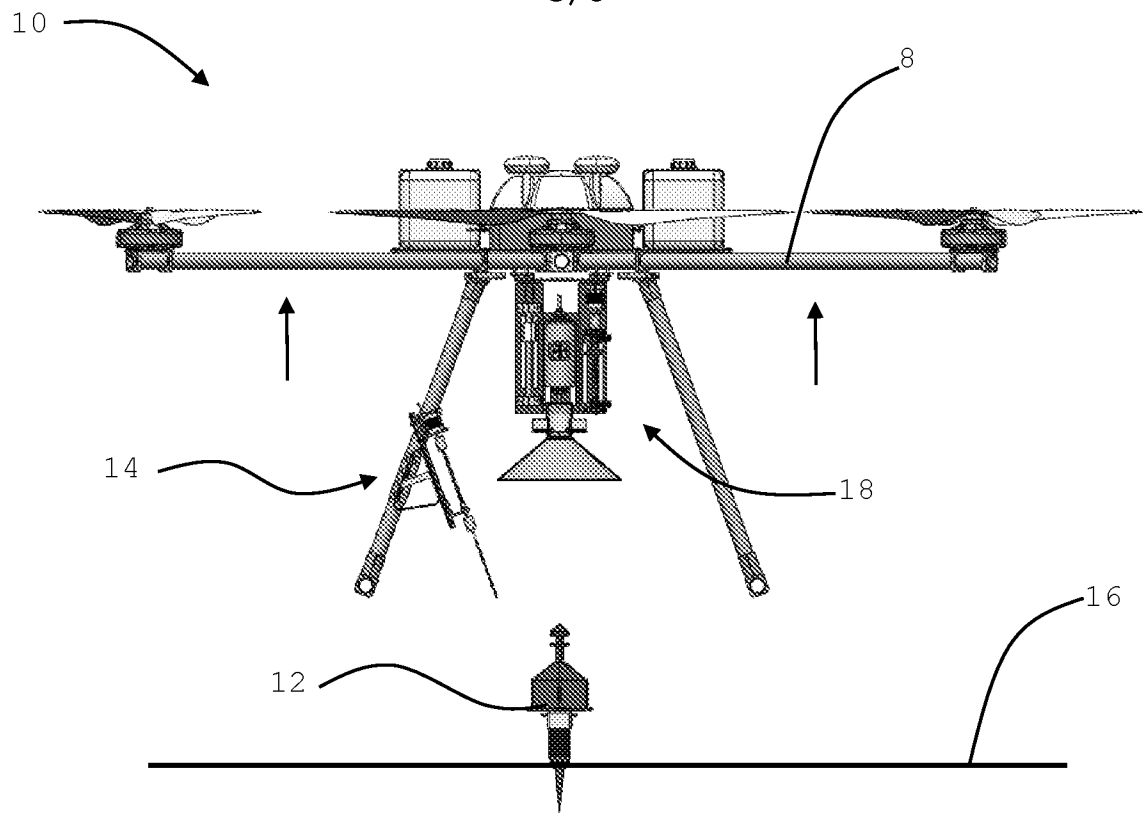


Figure 9.

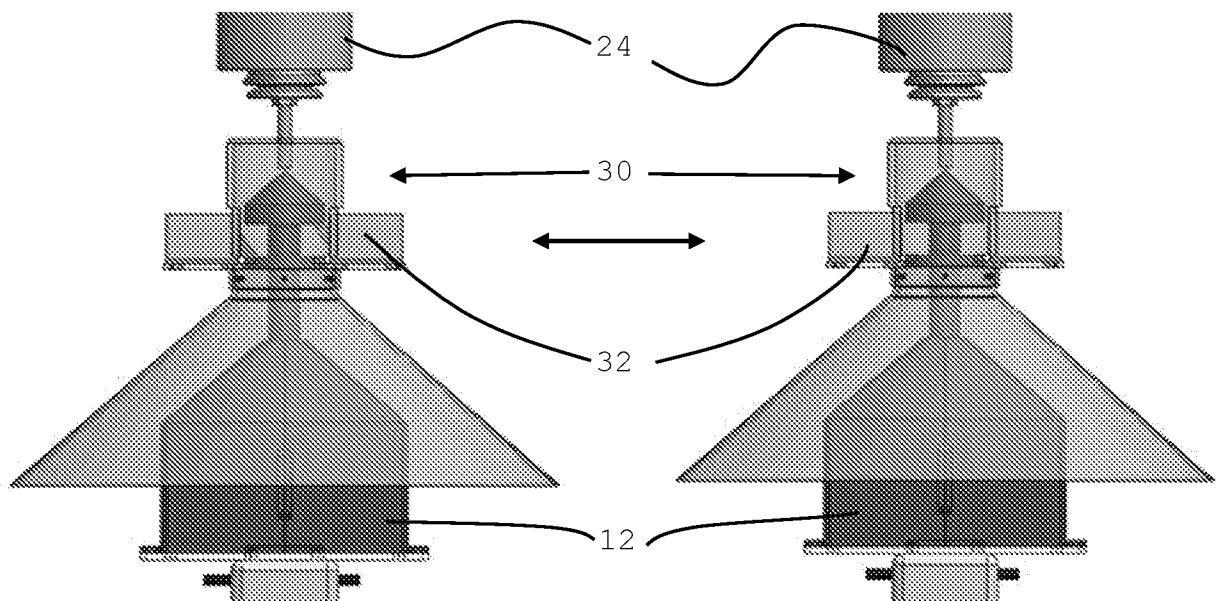


Figure 10.

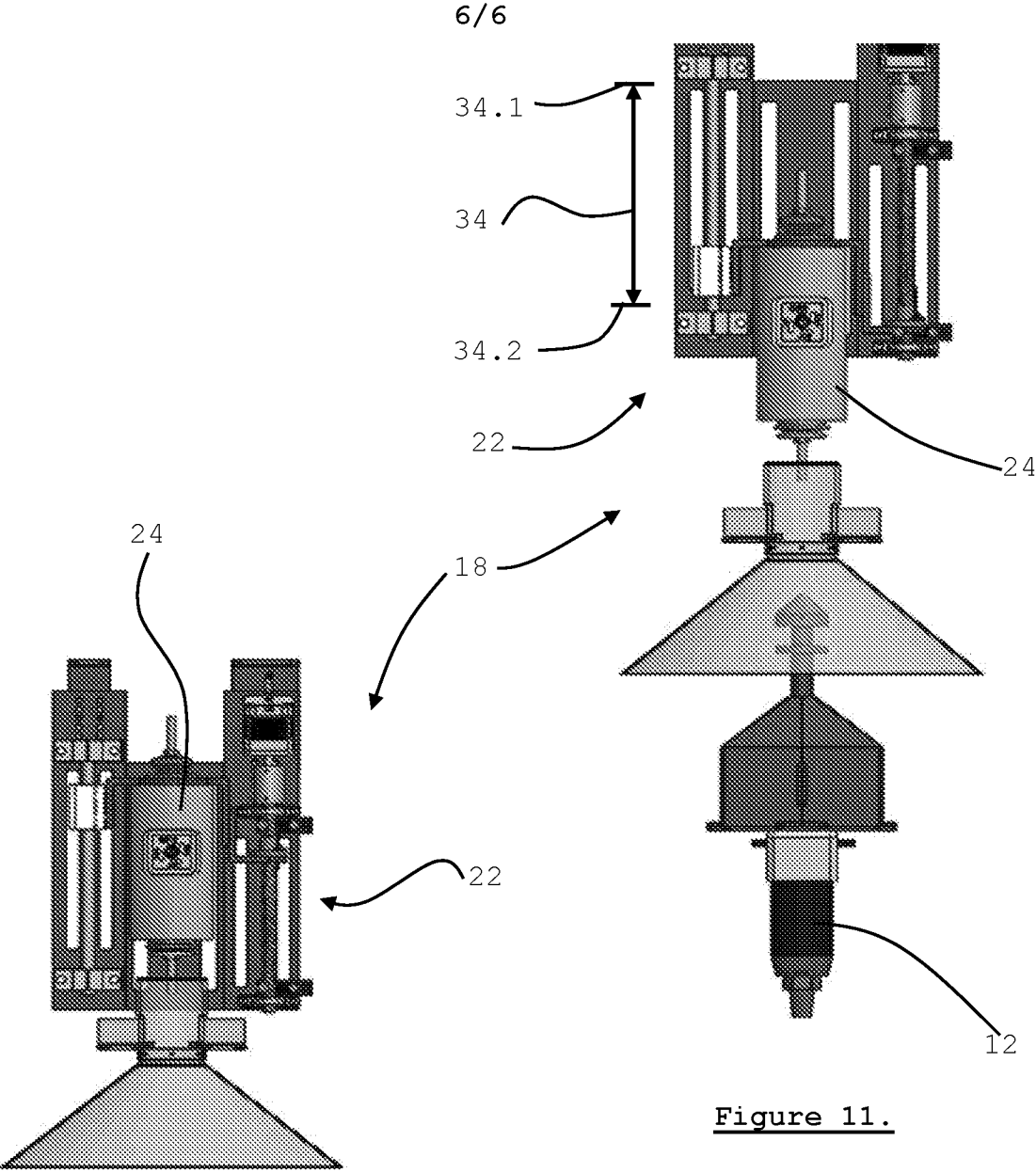


Figure 11.

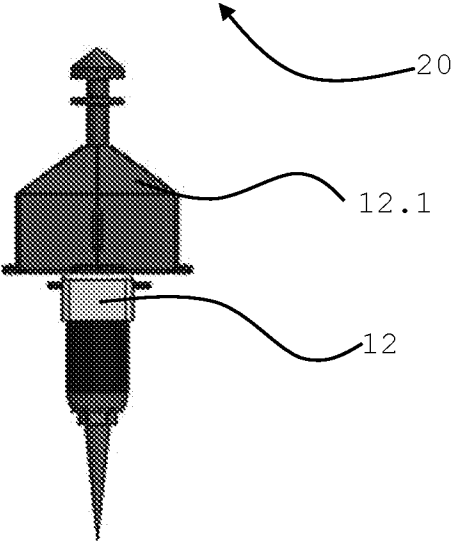


Figure 12.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2022/050785

A. CLASSIFICATION OF SUBJECT MATTER

G01R 1/04 (2006.01) G01V 1/16 (2006.01) G01V 1/20 (2006.01) G01V 1/38 (2006.01) G06Q 50/02 (2012.01)
B64C 39/02 (2006.01) B64D 47/00 (2006.01)

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)

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)

PATENW (WPIAP, EPODOC, TXTE) IPC/CPC: G01V1/16, B64C39/02, B64C2201/00, B64D47/00, G01V2210/16 & keywords: DRONE, GEOPHONE, IMPLANT and other terms and phrases. GOOGLE & GOOGLE PATENTS keywords: DRONE, GEOPHONE, INSERT, GROUND, CARRIAGE, PULSATOR, RECEPTACLE, ANCHOR and other terms and phrases. Applicant(s)/Inventor(s) names searched in DOCDB, DWIP and internal databases provided by IP Australia.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

☒ 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	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"D" document cited by the applicant in the international application	"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
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search
2 September 2022

Date of mailing of the international search report
02 September 2022

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INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/AU2022/050785
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/0307525 A1 (CGG Services SA) 16 October 2014 Whole document, especially abstract, paragraphs [0024]-[0029], Figs.2a, 2b.	1-12, 14-24, 26-29
X	Robert Stewart et al: "AN UNMANNED AERIAL VEHICLE WITH VIBRATION SENSING ABILITY (SEISMIC DRONE)", Society of Exploration Geophysicists International Exposition and 86th Annual Meeting (SEG DALLAS 2016), Dallas, Texas, USA, 16 - 21 October 2016, p.225-229. Whole document, especially sections Summary, Introduction, Platform Design, Figs.1-9.	1-12, 14-24, 26-29
A	US 2020/0183029 A1 (TOTAL, SA.) 11 June 2020 Whole document, especially abstract, Figs.2-5	1-29
A	US 2013/0308426 A1 (THE BOEING COMPANY) 21 November 2013 Whole document, especially abstract, Figs.3-9.	1-29

INTERNATIONAL SEARCH REPORT Information on patent family members		International application No. PCT/AU2022/050785	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
US 2014/0307525 A1	16 October 2014	US 2014307525 A1	16 Oct 2014
		CA 2908563 A1	16 Oct 2014
		EP 2984505 A2	17 Feb 2016
		WO 2014166937 A2	16 Oct 2014
US 2020/0183029 A1	11 June 2020	US 2020183029 A1	11 Jun 2020
		EP 3635443 A1	15 Apr 2020
		WO 2018224620 A1	13 Dec 2018
US 2013/0308426 A1	21 November 2013	US 2013308426 A1	21 Nov 2013
		US 9234973 B2	12 Jan 2016
		EP 2664945 A1	20 Nov 2013
		EP 2664945 B1	08 Jul 2015
End of Annex			
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001. Form PCT/ISA/210 (Family Annex)(July 2019)			