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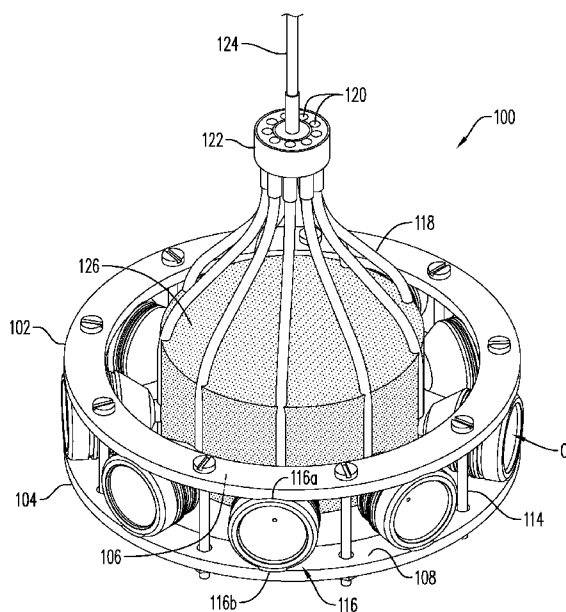


FIG. 1

(57) Abstract: A holder (100) for shaped charges (C) is shown and described. The charge holder (100) facilitates a high shot density for use with a perforating gun (130). The shaped charges (C) are arranged to direct explosive force axially outward from a perforating gun (130). The plurality of radially spaced charges (C) are designed to result in an annular ring of blast effect in any metal tubing associated with the oil/ gas extraction operation as well as any concrete conduits in which the tubing is disposed.



HIGH SHOT DENSITY CHARGE HOLDER FOR PERFORATING GUN

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 62/585,125, filed Nov. 13, 2017, which is incorporated herein by reference in its entirety.

FIELD OF THE DISCLOSURE

[0002] The present disclosure is directed to a holder for shaped charges. Specifically, the present disclosure is directed to a high shot density shaped charge holder for use with a perforating gun.

BRIEF DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0003] According to an aspect of the present invention, a shaped charge holder for a perforating gun comprises five or more shaped charges, each shaped charge having a detonation end and a firing end. One or more charge detonating cords is attached to the detonation end of the shaped charges, each charge detonating cord has a booster attached thereto. The shaped charges are arranged in a circular plane having a center with the detonation end and firing end of each shaped charge coaxially aligned, the detonation ends point toward the center of the circular plane and the firing ends point away from the center. A single main detonating cord is attached to each charge detonating cord with the booster between the main detonating cord and each charge detonating cord. The shaped charges are arranged such that the radial distance between each successive shaped charge holder is constant. The charge detonating cord may be arranged in a circle coplanar with the shaped charge circular plane and is attached to the detonation ends of every shaped charge.

[0004] According to another aspect, a shaped charge holder for a perforating gun generally includes a pair of opposed plates, each of which includes a plurality of indentations for receiving shaped charges in a coplanar, axially-oriented configuration. The shaped charge holder also includes at least one fastener for affixing the opposed plates to one another.

[0005] According to another aspect, each shaped charge within the holder is connected to its own detonating cord to enable a simultaneous initiation of all charges in one plane. The detonating cords might have a bi-directional booster at one end. The boosters or cords are connected to one another at a hub, which is connected to a single initiation explosive, like a main

detonating cord, a single detonator or a single bi-directional booster charge. Since all detonating cords, which are connected to a shaped charge are connected at the same initiation explosive body, the shaped charges are detonated substantially simultaneously. This helps to reduce the cost and variability associated with assemblies that include multiple detonators connected to multiple detonating cords, such as those described in US Patent Application Publication No. US2017/058649.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The following description will be made by reference to specific embodiments thereof that are illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments thereof and are not therefore to be considered to be limiting of its scope, exemplary embodiments will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

[0007] FIG. 1 is a perspective view of a shaped charge holder and a hub according to one aspect of the present disclosure, including nine shaped charges;

[0008] FIG. 2 is a top plan view of the shaped charge holder and the hub of FIG. 1, including the shaped charges;

[0009] FIG. 3 is a bottom plan view of the shaped charge holder of FIG. 1, including the shaped charges;

[0010] FIG. 4 is a perspective view of the shaped charge holder disposed in combination with a sub, including six shaped charges with three charges not shown;

[0011] FIG. 5 is a perspective view of a perforating gun;

[0012] FIG. 6 is a cross-sectional side view of the perforating gun of FIG. 5 taken along line 6-6, the perforating gun having disposed within a shaped charge holder and hub according to the present disclosure;

[0013] FIG. 7 is a perspective view of a shaped charge holder and a hub according to an alternative aspect of the present disclosure; and

[0014] FIG. 8 is a perspective view of a shaped charge holder and a hub according to an alternative aspect of the present disclosure.

DETAILED DESCRIPTION

[0015] FIGS. 1-4 schematically illustrate a shaped charge holder 100 generally including a pair of disks or plates 102, 104 (e.g., a first plate 102 and a second plate 104) in a facing relationship with one another. Each plate 102, 104 has a respective interior side 106 (hidden from view), 108 (i.e., surface or face) and a respective exterior side 110, 112 (i.e., surface or face) opposite one another. In an embodiment, at least one of the plates 102, 104 may be an annular plate having an opening extending therethrough. The opening may receive a hub or detonating cord holder 122, as will be described in further detail hereinbelow.

[0016] Still viewing FIGS. 1-4, the shaped charge holder 100 is adapted to receive a plurality of shaped charges C (only one of which is labeled) between the plates 102, 104. When seated in the holder 100, the charges C generally face radially outwardly from a center of the holder 100, with the charges C all being in a coplanar configuration.

[0017] The shaped charge holder 100 may include at least one fastener, or in this example, a plurality of fasteners 114 (only one of which is labeled), such as screws, for attaching the first and second plates 102, 104 to one another. The fasteners 114 may be tightened so that the interior side 106, 108 of each plate 102, 104 is urged tightly against the surface of the shaped charges C.

[0018] The interior side 106, 108 of each plate 102, 104 may also include a plurality of respective depressions or indentations 116a (hidden from view), 116b (best seen in FIG. 4) for receiving the shaped charges C. Such depressions or indentations 116a, 116b may have a generally curved shape, and may be formed (e.g., milled or molded) to closely conform to the shape and/or contours of the exterior surface S of the shaped charges C. When the plates 102, 104 are configured in an opposed relationship with the depressions or indentations 116a, 116b in register with one another, each pair of depressions or indentations 116a, 116b collectively define a holder 116 for a shaped charge C.

[0019] As shown throughout the figures, each shaped charge C is connected to an individual detonating cord 118 (only one of which is labeled). A free end 120 of each detonating cord is connected to a booster, which is received within a splitter or upper cord holder 122, which in

turn, is connected to a main (i.e., initiation) explosive, such as at least one of a receiver booster, detonator and detonating cord 124. The main detonating cord 124 is connected to a single detonator (not shown). When the detonator is activated, the shaped charges C are initiated substantially simultaneously (i.e., in a parallel sequence). Any suitable detonator may be used, for example, an RF safe detonator, resistorized detonator, or a receiver booster. The use of a single detonator helps to reduce the cost and undesirable variability associated with multi-detonator assemblies.

[0020] The shaped charge holder 100 may also include a spacer or separator 126 generally centrally located between the charges C. The spacer 126 may generally assist with maintaining the individual detonating cords 118 in a separated condition from one another. The spacer 126 also confines the cord at the end of the charge and avoids gaps between the cord and the backside of the shaped charge.

[0021] Countless variations are contemplated by the present disclosure. For example, the shaped charge holder may be configured to hold any number of charges desired, for example, 5, 6, 7, 8, or 9 charges. It is also contemplated that multiple shaped charge holders according to the present disclosure may be used in conjunction with one another.

[0022] Alternate detonator cord configurations and/or boosters may be included if desired. For example, instead of individual detonating cords 118 from the upper cord holder 122, a single detonating cord may be formed in a circle and connect to each shaped charge C along the periphery of the circle. FIG. 7 shows a configuration with two boosters 120, each attached to a detonating cord 118. Each of the two detonating cords 118 have a semi-circular section 128 that attaches at its periphery to multiple charges C. When the main detonating cord 124 detonates the two boosters 120, each booster 120 detonates the attached detonating cord 118. Each detonating cord 118 then detonates the shaped charges C to which it is attached, with a very slight delay between each detonation proceeding around the semi-circular section 128 of each detonating cord 118. Alternatively, each of the two detonating cords 118 need not be attached to neighboring shaped charges C. Rather, by way of example, the cords 118 may be attached to charges C displaced from one another by about 180° and then proceed in the same direction around the circle. Such an arrangement would prevent any single charge C from needing to withstand the simultaneous explosion of two immediately neighboring charges. In the same way,

the circle can be divided into 3 or more sections, with each being accorded its own detonating cord 118 and booster 120.

[0023] FIG. 8 shows a configuration with a single booster 120 and detonating cord 118. The semi-circular section 128 of detonating cord 118 attaches to each of the nine charges C shown; the semi-circular section 128 in this configuration very nearly completes a complete circle. When the main detonating cord 124 detonates the booster 120, it detonates the attached detonating cord 118. The detonating cord 118 then detonates all of the shaped charges C, with a very slight delay between each detonation proceeding around the semi-circular section 128 of the detonating cord 118.

[0024] FIG. 5 shows perforating gun 130 with sub 134 screwed into the base of the perforating gun 130. As seen in FIG. 4, shaped charge holder 100 is disposed on top of sub 134 and attached thereto. Perforating gun 130 may include scallops 132 opposite each shaped charge C. FIG. 6 illustrates a shaped charge holder 100 according to the present disclosure attached to sub 134 which is screwed into and becomes part of perforating gun 130. In this embodiment, one booster initiates the shaped charges C. The booster is connected to a detonating cord, and includes a detonator at its end.

[0025] The present disclosure, in various embodiments, configurations and aspects, includes components, methods, processes, systems and/or apparatus substantially developed as depicted and described herein, including various embodiments, sub-combinations, and subsets thereof. Those of skill in the art will understand how to make and use the present disclosure after understanding the present disclosure. The present disclosure, in various embodiments, configurations and aspects, includes providing devices and processes in the absence of items not depicted and/or described herein or in various embodiments, configurations, or aspects hereof, including in the absence of such items as may have been used in previous devices or processes, e.g., for improving performance, achieving ease and/or reducing cost of implementation.

[0026] The phrases “at least one”, “one or more”, and “and/or” are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions “at least one of A, B and C”, “at least one of A, B, or C”, “one or more of A, B, and C”, “one or more of A, B, or C” and “A, B, and/or C” means A alone, B alone, C alone, A and B together, A and C together, B and C together, or A, B and C together.

[0027] In this specification and the claims that follow, reference will be made to a number of terms that have the following meanings. The terms “a” (or “an”) and “the” refer to one or more of that entity, thereby including plural referents unless the context clearly dictates otherwise. As such, the terms “a” (or “an”), “one or more” and “at least one” can be used interchangeably herein. Furthermore, references to “one embodiment”, “some embodiments”, “an embodiment” and the like are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Approximating language, as used herein throughout the specification and claims, may be applied to modify any quantitative representation that could permissibly vary without resulting in a change in the basic function to which it is related. Accordingly, a value modified by a term such as “about” is not to be limited to the precise value specified. In some instances, the approximating language may correspond to the precision of an instrument for measuring the value. Terms such as “first,” “second,” “upper,” “lower” etc. are used to identify one element from another, and unless otherwise specified are not meant to refer to a particular order or number of elements.

[0028] As used herein, the terms “may” and “may be” indicate a possibility of an occurrence within a set of circumstances; a possession of a specified property, characteristic or function; and/or qualify another verb by expressing one or more of an ability, capability, or possibility associated with the qualified verb. Accordingly, usage of “may” and “may be” indicates that a modified term is apparently appropriate, capable, or suitable for an indicated capacity, function, or usage, while taking into account that in some circumstances the modified term may sometimes not be appropriate, capable, or suitable. For example, in some circumstances an event or capacity can be expected, while in other circumstances the event or capacity cannot occur - this distinction is captured by the terms “may” and “may be.”

[0029] As used in the claims, the word “comprises” and its grammatical variants logically also subtend and include phrases of varying and differing extent such as for example, but not limited thereto, “consisting essentially of” and “consisting of.” Where necessary, ranges have been supplied, and those ranges are inclusive of all sub-ranges therebetween. It is to be expected that variations in these ranges will suggest themselves to a practitioner having ordinary skill in the art and, where not already dedicated to the public, the appended claims should cover those variations.

[0030] The terms “determine”, “calculate” and “compute,” and variations thereof, as used herein, are used interchangeably and include any type of methodology, process, mathematical operation or technique.

[0031] The foregoing discussion of the present disclosure has been presented for purposes of illustration and description. The foregoing is not intended to limit the present disclosure to the form or forms disclosed herein. In the foregoing Detailed Description for example, various features of the present disclosure are grouped together in one or more embodiments, configurations, or aspects for the purpose of streamlining the disclosure. The features of the embodiments, configurations, or aspects of the present disclosure may be combined in alternate embodiments, configurations, or aspects other than those discussed above. This method of disclosure is not to be interpreted as reflecting an intention that the present disclosure requires more features than are expressly recited in each claim. Rather, as the following claims reflect, the claimed features lie in less than all features of a single foregoing disclosed embodiment, configuration, or aspect. Thus, the following claims are hereby incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment of the present disclosure.

[0032] Advances in science and technology may make equivalents and substitutions possible that are not now contemplated by reason of the imprecision of language; these variations should be covered by the appended claims. This written description uses examples to disclose the method, machine and computer-readable medium, including the best mode, and also to enable any person of ordinary skill in the art to practice these, including making and using any devices or systems and performing any incorporated methods. The patentable scope thereof is defined by the claims, and may include other examples that occur to those of ordinary skill in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

CLAIMS

What Is Claimed Is:

1. A shaped charge holder for a perforating gun, the shaped charge holder comprising:
five or more shaped charges, each shaped charge having a detonation end and a firing end;
one or more charge detonating cords attached to the detonation end of the shaped charges, each charge detonating cord having a booster attached thereto;
the shaped charges arranged in a circular plane having a center with the detonation end and firing end of each shaped charge coaxially aligned, the detonation ends point toward the center of the circular plane and the firing ends point away from the center; and
a single main detonating cord, wherein the main detonating cord is attached to each charge detonating cord with the booster between the main detonating cord and each charge detonating cord.
2. The shaped charge holder of claim 1 wherein the shaped charges are further arranged such that the radial distance between each successive shaped charge holder is constant.
3. The shaped charge holder of claim 1 or 2 wherein the charge detonating cord is arranged in a circle coplanar with the shaped charge circular plane and is attached to the detonation ends of every shaped charge.
4. The shaped charge holder of claim 1 or 2 wherein two or more charge detonating cords each form a semicircle and are attached to two or more shaped charges at a semicircle periphery.
5. A shaped charge holder for a perforating gun, the shaped charge holder comprising:
a first plate and a second plate in an opposed relationship with one another, wherein each plate has an interior face and an exterior face, wherein the interior face of each of the first plate and the second plate includes a plurality of indentations shaped to receive the shaped charges between the first plate and the second plate.
6. A shaped charge holder for a perforating gun, the shaped charge holder comprising:

a pair of annular plates positioned opposite one another, each plate having an interior surface and an exterior surface, wherein the interior face of the annular plates includes a plurality of indentations shaped to receive the shaped charges; and

a plurality of fasteners for connecting the annular plates to one another with the shaped charges positioned therebetween.

7. The shaped charge holder of claim 5 or 6, in combination with a plurality of shaped charges, wherein the shaped charges are positioned in a coplanar configuration within the charge holder.

8. The shaped charge holder of claim 5 or 6, in combination with a plurality of shaped charges, wherein the shaped charges are radially arranged in a coplanar configuration between the plates of the charge holder.

9. A shaped charge holder assembly, comprising:

a plurality of shaped charges;

a pair of annular plates positioned opposite one another, each plate having an interior face and an exterior face, wherein the interior face of each annular plate includes a plurality of indentations, wherein each respective pair of indentations on the annular plates is for receiving one of the shaped charges; and

a plurality of fasteners for securing the annular plates to one another with the shaped charges positioned therebetween.

10. A shaped charge holder assembly, comprising:

a plurality of shaped charges, the shaped charges each having a curved outer surface;

a pair of annular plates positioned opposite one another, each plate having an inner face and an outer face, wherein the inner face of each annular plate includes a plurality of inwardly curved depressions, wherein each inwardly curved depression is shaped to accommodate the curved outer surface of the shaped charges; and

a plurality of fasteners for securing the annular plates to one another with the shaped charges positioned therebetween.

11. A shaped charge holder assembly, comprising:
 - a plurality of shaped charges, the shaped charges each having a curved outer surface;
 - a pair of annular plates positioned opposite one another, each plate having an inner face and an outer face, wherein the inner face of each annular plate includes a plurality of inwardly curved depressions, wherein each inwardly curved depression is shaped to receive one of the shaped charges, such that the plurality of shaped charges are positioned between the pair of the annular plates so that the shaped charges face radially outward from a center of the charge holder in a coplanar configuration; and
 - at least one fastener for joining the annular plates to one another with the shaped charges positioned therebetween.
12. The shaped charge holder assembly of any of claims 9 to 11, further comprising a plurality of individual detonating cords of equal length, each detonating cord being connected to one of the shaped charges.
13. The shaped charge holder assembly of claim 12, further comprising a hub.
14. The shaped charge holder assembly of claim 13, further comprising a primary detonating cord extending from the hub.
15. The shaped charge holder assembly of claim 12, wherein the individual detonating cord comprises a free end, and each free end is connected to a bi-directional booster configured to initiate each shaped charge.
16. The shaped charge holder assembly of claim 15, wherein each bi-directional booster is positioned in the hub.
17. The shaped charge holder assembly of claim 13, further comprising a receiver booster positioned in the hub, wherein the receiver booster is communicably connected to the booster, and the receiver booster is coupled to the primary detonating cord.

18. The shaped charge holder assembly of claim 14, further comprising a detonator coupled to the primary detonating cord.

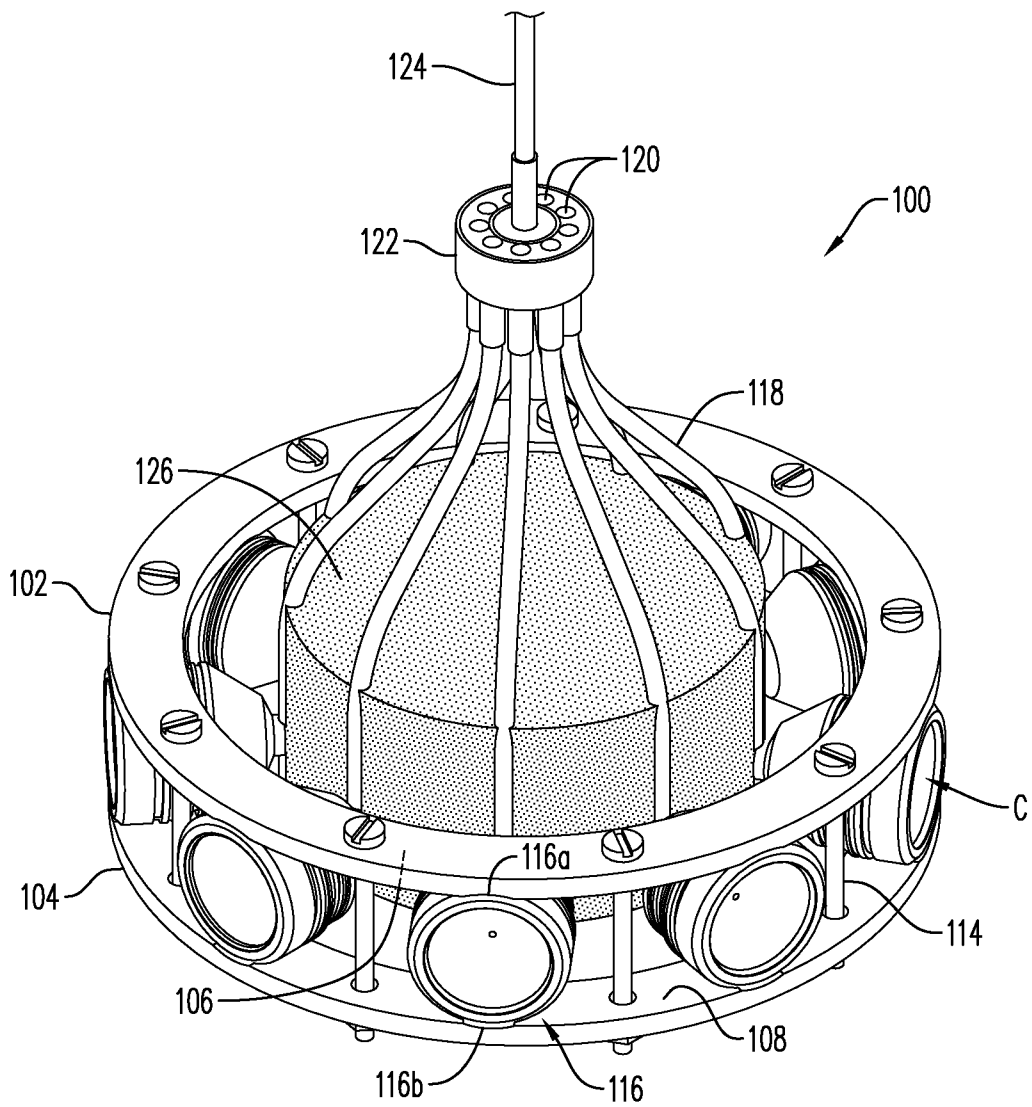


FIG. 1

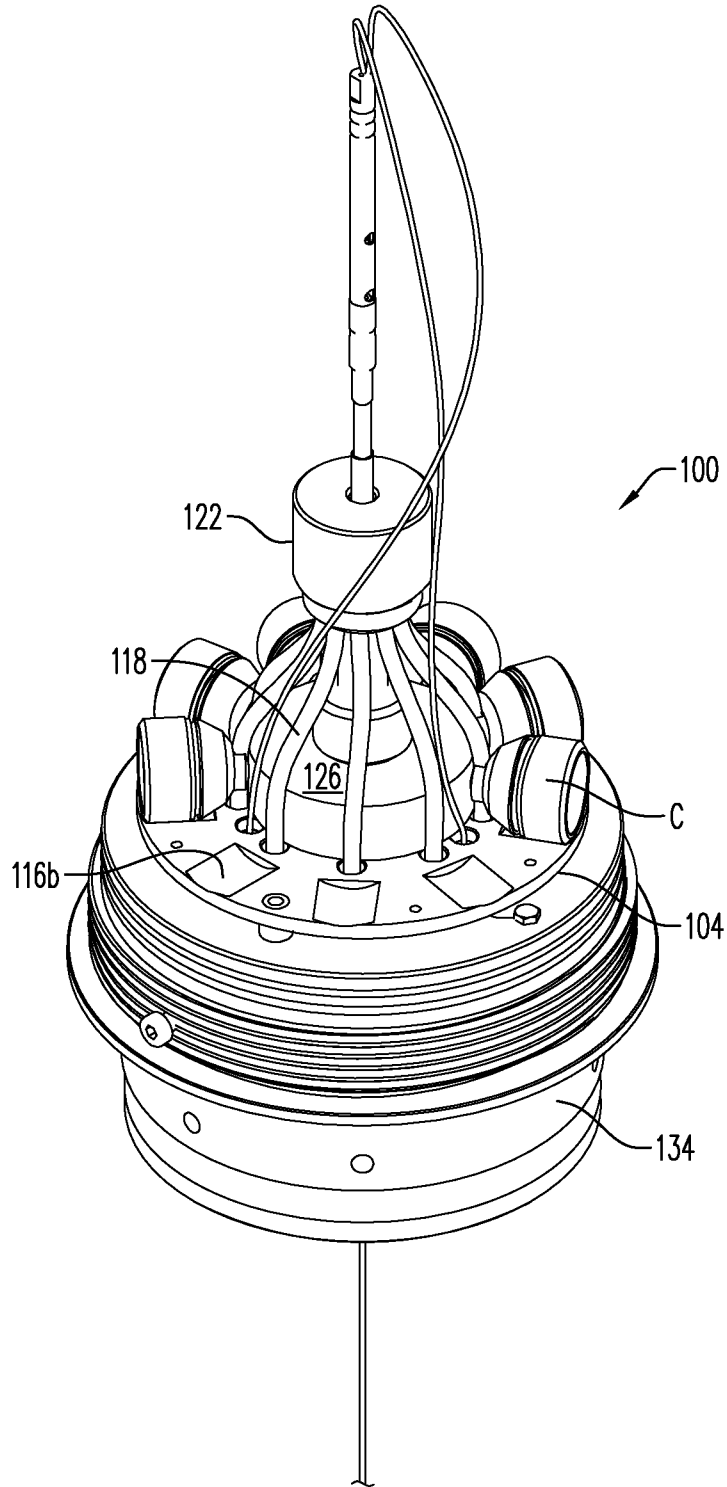


FIG. 4

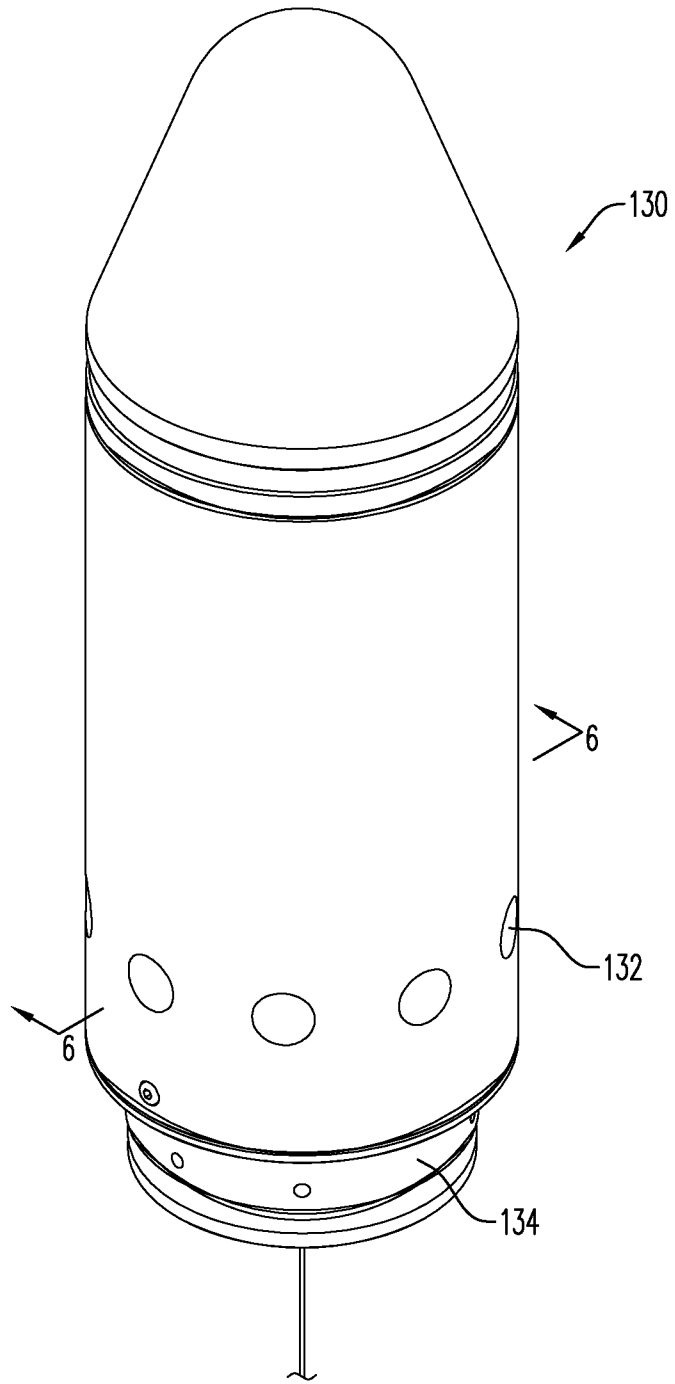


FIG. 5

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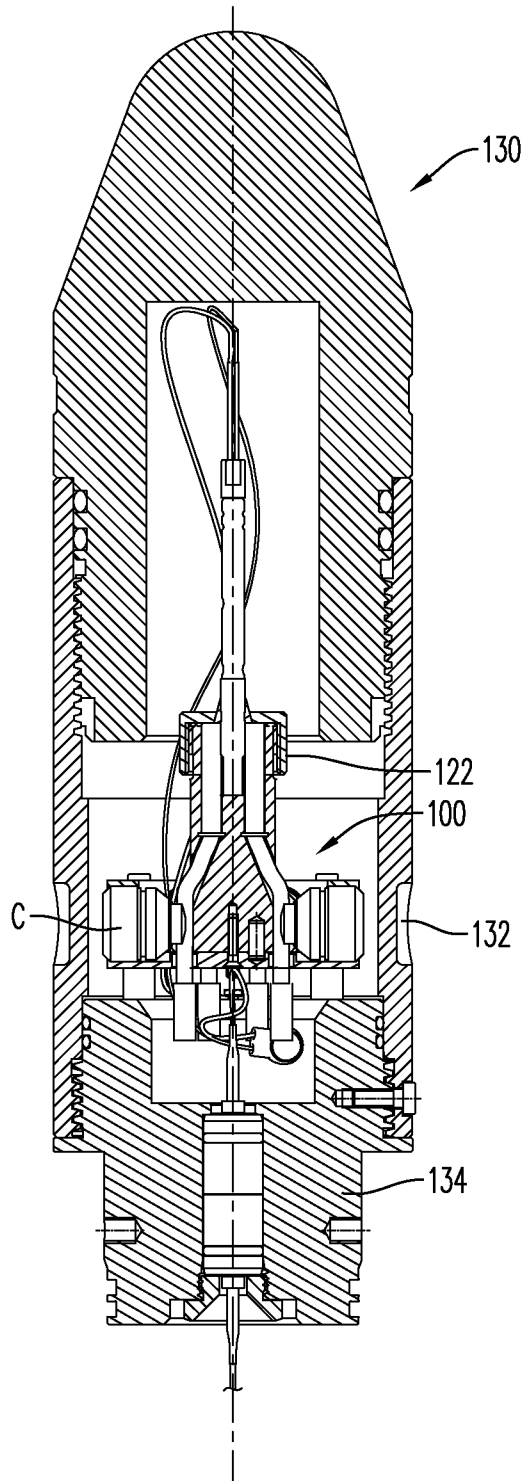


FIG. 6

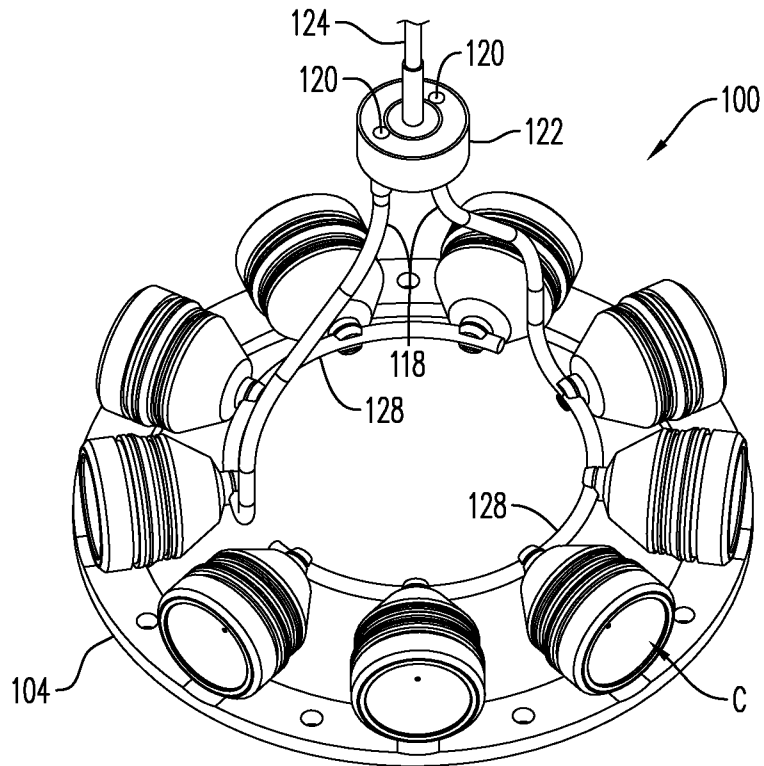


FIG. 7

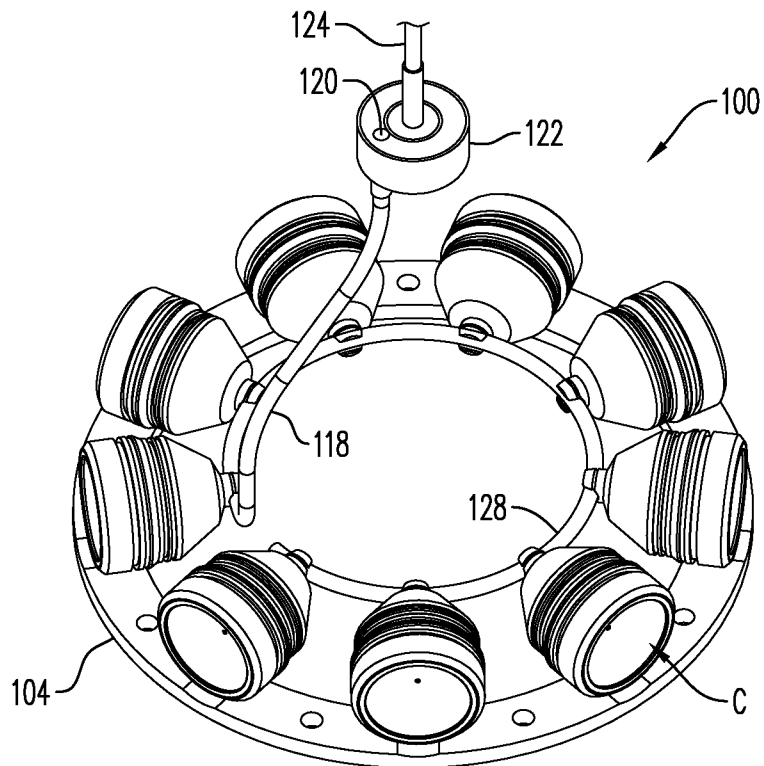


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/080298

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B43/117 E21B43/1185
ADD.
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)
E21B
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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 013 491 A (POULTER THOMAS C) 19 December 1961 (1961-12-19)	1,2
Y	column 1, line 11 - column 5, line 40; figures 1, 2	3,4, 12-18
X	US 4 140 188 A (VANN ROY R) 20 February 1979 (1979-02-20)	5-11
Y	column 1, line 6 - column 3, line 30; figures 1-4	12-18
Y	US 9 038 713 B1 (BELL WILLIAM T [US] ET AL) 26 May 2015 (2015-05-26) the whole document	3,4
A	US 6 505 559 B1 (JOSLIN JOHNNY [US] ET AL) 14 January 2003 (2003-01-14) the whole document	1-18
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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search 30 November 2018	Date of mailing of the international search report 12/12/2018
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/080298

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 354 433 A (OWEN HARROLD D) 19 October 1982 (1982-10-19) the whole document	1-18
A	----- US 2 682 834 A (CHURCH JOSEPH H ET AL) 6 July 1954 (1954-07-06) the whole document -----	1-18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/EP2018/080298

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