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(54) Title: SHAPED CHARGE UTILIZING POLYMER COATED PETN

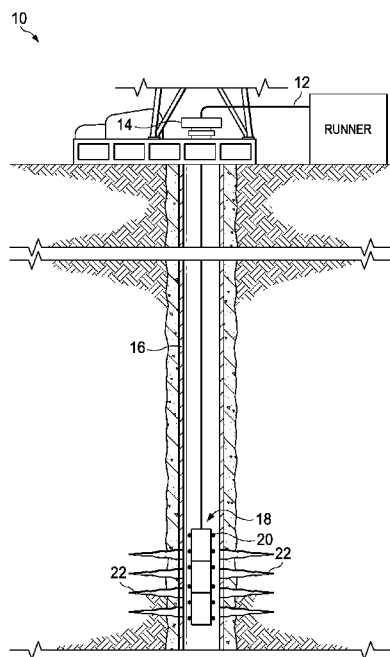


FIG. 1

(57) Abstract: A shaped charge for perforating a formation surrounding a wellbore. The shaped charge including a casing having a section with polymer-coated explosives and a liner encapsulating the section with the polymer coated explosives. The polymer-coated explosives includes a booster explosive and a main load explosive. The booster explosive and the main load explosive are PETN. The polymer is a low-density polyethylene.



SHAPED CHARGE UTILIZING POLYMER COATED PETN

TECHNICAL FIELD OF THE DISCLOSURE

5 [0001] The present disclosure relates, in general, to shape charges and, in particular, to shape charges configured for perforating formations in wellbores.

BACKGROUND

[0002] Shaped charges, sometimes called oilwell perforators, are typically used in oil and gas operations for perforating formations surrounding wellbores in order to access hydrocarbon
10 reservoirs. These types of shaped charges typically are loaded with a main load explosive and a booster explosive. The main load explosive is typically a secondary high explosive such as PETN, RDX, HMX, or HNS that has been desensitized by the application of a wax or polymer coating to the explosive crystals. The booster explosive is typically the same
15 secondary high explosive, except that the explosive has been rendered more sensitive by utilizing the material in its pure form (*i.e.*, uncoated crystals). Oilwell perforators utilizing these combinations of explosives are quite effective at perforating formations but due to the sensitive nature of the booster explosive handling of such charges requires extreme care. This is particularly true for the explosive PETN, since molecularly it is inherently more sensitive than RDX, HMX, and HNS, and even more so when it is uncoated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] For a more complete understanding of the features and advantages of the present disclosure, reference is now made to the detailed description along with the accompanying figures in which corresponding numerals in the different figures refer to corresponding parts and in which:

[0004] FIG. 1 is an illustration of a well operations site where perforations are created in formations surrounding a wellbore, in accordance with certain example embodiments;

10 [0005] FIG. 2 illustrated is a shaped charge for formation perforation in a wellbore, in accordance with certain example embodiments; and

[0006] FIG. 3 illustrated is another shaped charge for formation perforation in a wellbore, in accordance with certain example embodiments.

DETAILED DESCRIPTION

[0007] While the making and using of various embodiments of the present disclosure are discussed in detail below, it should be appreciated that the present disclosure provides many applicable inventive concepts, which can be embodied in a wide variety of specific contexts.

5 The specific embodiments discussed herein are merely illustrative and do not delimit the scope of the present disclosure. In the interest of clarity, not all features of an actual implementation may be described in the present disclosure. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developer's specific goals, such as compliance with system-related and
10 business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming but would be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0008] The disclosure describes a shaped charge utilizing polymer-coated PETN
15 (Pentaerythritol tetranitrate) both as a main load explosive and as a booster explosive. In an embodiment, the shaped charge includes a shaped section filled with the booster explosive and the main load explosive. In this embodiment, the shaped section may have, but not be limited to, conical, hemispherical, or parabolic geometry. In some embodiments, the shaped charge includes a metal or metal alloy liner, or even one fabricated using powder metallurgy. In an
20 embodiment, the polymer coating for the PETN is a low-density polyethylene. The use of the polymer-coated PETN eliminates the need to use separate explosive charges for the main load and booster that are typically required in oilwell perforators. The polymer-coated PETN has sufficient inherent sensitivity to be used as a booster explosive without being overly sensitive to

the impact, friction, and electrostatic discharge hazards normally associated with pure, uncoated booster explosives. In addition, the same polymer-coated PETN is sufficiently insensitive such that it can be used as the main load explosive fill for shaped charges utilized in oil and gas applications. The advantage of using the polymer-coated PETN in such way is that the shaped charge can be loaded with one common explosive; there is no need to have separate explosives for the booster and main load.

[0009] Referring to FIG. 1, illustrated is a well operations site during the perforation of a formation to access a reservoir deposit using a shaped charge utilizing polymer coated PETN, in accordance with certain example embodiments, denoted generally as 10. The site 10 includes a winch for running a cable 12, such as an electric wireline, through a well head 14 and down a well casing 16 in a wellbore to position a perforation gun 18 near the reservoir deposit. The perforation gun 18 is loaded with multiple shaped charges 20 that utilize a polymer coated PETN. Once in position, the perforation gun 18 can be triggered remotely using wireless or wired activation. Once triggered, the shaped charges are detonated and perforations 22 are created through the casing 16 and formation that allows access to the reservoir deposit.

[0010] Referring now to Fig. 2, illustrated is a shaped charge for formation perforation in the wellbore, denoted generally as 40. The shaped charge 40 includes a casing 42 with a hollowed out section, such as a conical section. The conical section can include a booster explosive section 44 in ballistic communication with a detonating cord located inside the perforation gun 18. The booster explosive section 44 is filled with a first portion of polymer-coated PETN, and likewise the main load section 46 is filled with a second portion of polymer-coated PETN. The polymer for the PETN is based on low-density polyethylene. Alternatively, polyethylene coated RDX (Royal Demolition eXplosive) can be used as booster and main load

explosive. The shaped charge does not have to be loaded during manufacture in two distinct steps, *i.e.*, in two geometrical sections using two explosive loadings that are in fact the same material. In production, this charge can be loaded in one step using one total amount of explosive (booster and main load added together). The entire explosive filling consolidates into the charge
5 during a single pressing step.

[0011] The shaped charge 40 also includes a conical liner 48 surrounding and encapsulating the explosives. The casing 42 can be made of at least one of steel, zinc, aluminum, copper, brass, ceramics and glass. The conical liner 48 can be made of a mixture of metals such as copper and lead. Other metals may be included or substituted such as brass, bismuth, tin, zinc, silver,
10 antimony, cobalt, nickel, tungsten, uranium or other malleable, ductile metals in proportions and formulations known to the art. Other materials can also be included in the mixture, such as certain plastics, polymers, and graphite. Fabrication methodologies for the liner include wrought, machined, and powdered-metal techniques. The conical liner 48 of a typical shaped charge is internally open. When the explosives are detonated, the liner 48 collapses into the
15 internal space and forms a jet emanating from the casing 42 as a very high velocity stream of metal.

[0012] Referring to Fig. 3, illustrated is another shaped charge for formation perforation in a wellbore, denoted generally as 60. The shaped charge 60 includes similar features to that of Fig. 2, the exception being the hollowed out section. The shaped charge 60 includes a casing 62
20 with a hollowed out section and, in this particular embodiment, the hollowed out section is generally parabolic or even hemispherical in shape. The parabolic or hemisphere section can include a booster explosive section 64 in ballistic communication with a detonating cord located inside the perforation gun 18. The booster explosive section 64 is filled with a first portion of

polymer-coated PETN, and likewise the main load section 66 is filled with a second portion of polymer coated PETN. The polymer for the PETN is based on low-density polyethylene. The shaped charge 60 also includes a generally parabolic or hemispherical liner 68 surrounding and encapsulating the explosives. The casing 62 can be made of at least one of steel, zinc, aluminum, copper, brass, ceramics and glass. The generally parabolic or hemispherical liner 68 can be made of a mixture of metals such as copper and lead. Other metals may be included or substituted such as brass, bismuth, tin, zinc, silver, antimony, cobalt, nickel, tungsten, uranium or other malleable, ductile metals in proportions and formulations known to the art. Other materials can also be included in the mixture, such as certain plastics, polymers, and graphite. Fabrication methodologies for the liner include wrought, machined, and powdered-metal techniques. The generally parabolic or hemispherical liner 68 of a typical shaped charge is internally open. When the explosives are detonated, the liner 68 collapses into the internal space and causes it to be ejected from the casing 62. Depending on the shape of the generally parabolic or hemispherical liner, the ejected material may be a high velocity stream of metal or explosively-formed projectile.

[0013] The above-disclosed embodiments have been presented for purposes of illustration and to enable one of ordinary skill in the art to practice the disclosure, but the disclosure is not intended to be exhaustive or limited to the forms disclosed. Many insubstantial modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the disclosure. The scope of the claims is intended to broadly cover the disclosed embodiments and any such modification. Further, the following clauses represent additional embodiments of the disclosure and should be considered within the scope of the disclosure:

[0014] Clause 1, a shaped charge for perforating a formation surrounding a wellbore, the shaped charge device comprising: a casing having a section loaded with polymer-coated explosives; and a liner encapsulating the section with the polymer coated explosives;

[0015] Clause 2, the shaped charge of clause 1, wherein the casing is made of at least one
5 of steel, zinc, copper, brass, aluminum, ceramics, and glass;

[0016] Clause 3, the shaped charge of clause 1, wherein the liner is made of at least one of copper, lead, brass, bismuth, tin, zinc, silver, antimony, cobalt, nickel, tungsten, uranium and other malleable, ductile metals;

[0017] Clause 4, the shaped charge of clause 1, wherein the liner is one of conical, parabolic,
10 and hemispherical shape;

[0018] Clause 5, the shaped charge of clause 1, wherein the explosives are a booster explosive and a main load explosive;

[0019] Clause 6, the shaped charge of clause 5, wherein the booster explosive and the main load explosive are PETN;

[0020] Clause 7, the shaped charge of clause 1, wherein the polymer is a low-density
15 polyethylene;

[0021] Clause 8, the shaped charge of clause 1, wherein the section filled with the polymer coated explosive includes a first section with a first polymer-coated explosive and a second section with a second polymer-coated explosive.

[0022] Clause 9, the shaped charge of clause 8, wherein the first section and the second
20 section are common, and include a first and second polymer-coated explosive that are common.

[0023] Clause 10, a method of using shaped charges for perforating a formation surrounding a wellbore, the method comprising: placing shaped charge devices on a well casing; setting the well casing in the wellbore using a downhole running tool; and detonating the shaped charge devices; wherein the shaped charge devices comprise: a casing having a section with polymer-coated explosives; and a liner encapsulating the section with the polymer coated explosives;

[0024] Clause 11, the method of clause 10, wherein the casing is made of at least one of steel, zinc, copper, brass, aluminum, ceramics, and glass;

[0025] Clause 12, the method of clause 10, wherein the liner is made of at least one of copper, lead, brass, bismuth, tin, zinc, silver, antimony, cobalt, nickel, tungsten, uranium and other malleable, ductile metals;

[0026] Clause 13, the method of clause 10, wherein the liner is one of conical, parabolic, and hemispherical shape;

[0027] Clause 14, the method of clause 10, wherein the explosives are a booster explosive and a main load explosive;

[0028] Clause 15, the method of clause 14, wherein the booster explosive and the main load explosive are PETN;

[0029] Clause 16, the method of clause 10, wherein the polymer is a low-density polyethylene;

[0030] Clause 17, the method of clause 10, wherein the section filled with the polymer coated explosive includes a first section having a first polymer-coated explosive and a second section having a second polymer-coated explosive;

[0031] Clause 18, the method of clause 17, wherein the first section and the second section are common, and include a first and second polymer-coated explosive that are common;

[0032] Clause 19, a shaped charge for perforating a formation surrounding a wellbore, the shaped charge device comprising: a casing enclosing a polymer-coated booster explosive and a
5 polymer-coated main load explosive and a liner encapsulating the polymer-coated explosives;

[0033] Clause 20, the shaped charge of clause 19, wherein the explosive is PETN.

[0034] The foregoing description of embodiments of the disclosure has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure to the precise form disclosed, and modifications and variations are possible in light
10 of the above teachings or may be acquired from practice of the disclosure. The embodiments were chosen and described in order to explain the principals of the disclosure and its practical application to enable one skilled in the art to utilize the disclosure in various embodiments and with various modifications as are suited to the particular use contemplated. Other substitutions, modifications, changes and omissions may be made in the design, operating conditions and
15 arrangement of the embodiments without departing from the scope of the present disclosure. Such modifications and combinations of the illustrative embodiments as well as other embodiments will be apparent to persons skilled in the art upon reference to the description. It is, therefore, intended that the appended claims encompass any such modifications or embodiments.

What is claimed is:

1. A shaped charge for perforating a formation surrounding a wellbore, the shaped charge device comprising:
 - a casing having a section loaded with polymer-coated explosives; and
 - 5 a liner encapsulating the section with the polymer coated explosives.
2. The shaped charge of claim 1 wherein the casing is made of at least one of steel, copper, brass, zinc, aluminum, ceramics, and glass.
- 10 3. The shaped charge of claim 1 wherein the liner is made of at least one of copper, lead, brass, bismuth, tin, zinc, silver, antimony, cobalt, nickel, tungsten, uranium and other malleable, ductile metals.
4. The shaped charge of claim 1 wherein the liner is one of conical, parabolic, and
15 hemispherical shape.
5. The shaped charge of claim 1 wherein the explosives are a booster explosive and a main load explosive.
- 20 6. The shaped charge of claim 5 wherein the booster explosive and the main load explosive are PETN.

7. The shape charge of claim 1 wherein the polymer is a low-density polyethylene.

8. The shaped charge of claim 1 wherein the section filled with the polymer coated explosive includes a first section with a first polymer-coated explosive and a second section with a second polymer-coated explosive.

9. The shape charge of claim 8 wherein the first section and the second section define a single shared space, and include a first and second polymer-coated explosive that are the same.

10. A method of using shaped charges for perforating a formation surrounding a wellbore, the method comprising:

placing shaped charge devices on a well casing;
15 setting the well casing in the wellbore using a downhole running tool; and
detonating the shaped charge devices;
wherein the shaped charge devices comprise:
a casing having a section loaded with polymer-coated explosives; and
a liner encapsulating the section with the polymer coated explosives.

20

11. The method of using shaped charges of claim 10 wherein the casing is made of at least one of steel, zinc, copper, brass, aluminum, ceramics, and glass.

12. The method of using shaped charges of claim 10 wherein the liner is made of at least one of copper, lead, brass, bismuth, tin, zinc, silver, antimony, cobalt, nickel, tungsten, uranium and other malleable, ductile metals.

5 13. The method of using shaped charges of claim 10 wherein the liner is one of conical, parabolic, and hemispherical shape.

14. The method of using shaped charges of claim 10 wherein the explosives are a booster explosive and a main load explosive.

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15. The method of using shaped charges of claim 14 wherein the booster explosive and the main load explosive are PETN.

16. The method of using shaped charges of claim 10 wherein the polymer is a low-
15 density polyethylene.

17. The method of using shaped charges of claim 10 wherein the section filled with the polymer coated explosive includes a first section having a first polymer-coated explosive and a second section having a second polymer-coated explosive.

20

18. The method of using shaped charges of claim 17 wherein the first section and the second section are common, and include a first and second polymer-coated explosive that are common.

19. A shaped charges for perforating a formation surrounding a wellbore, the shaped charge device comprising:

a casing enclosing a polymer-coated booster explosive and a polymer-coated main load
5 explosive and a liner encapsulating the polymer-coated explosives.

20. The shaped charges of claim 19 wherein the explosive is PETN.

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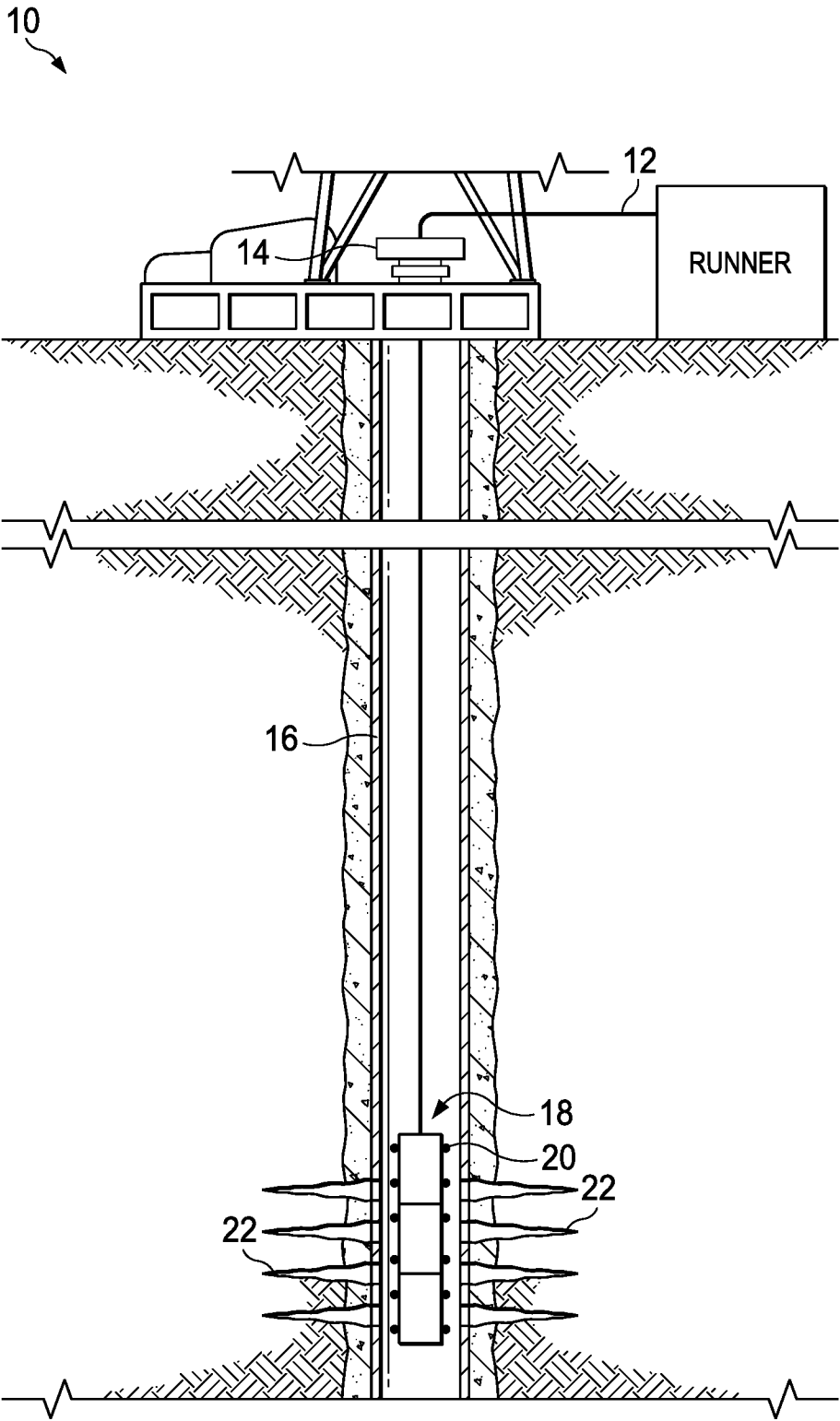


FIG. 1

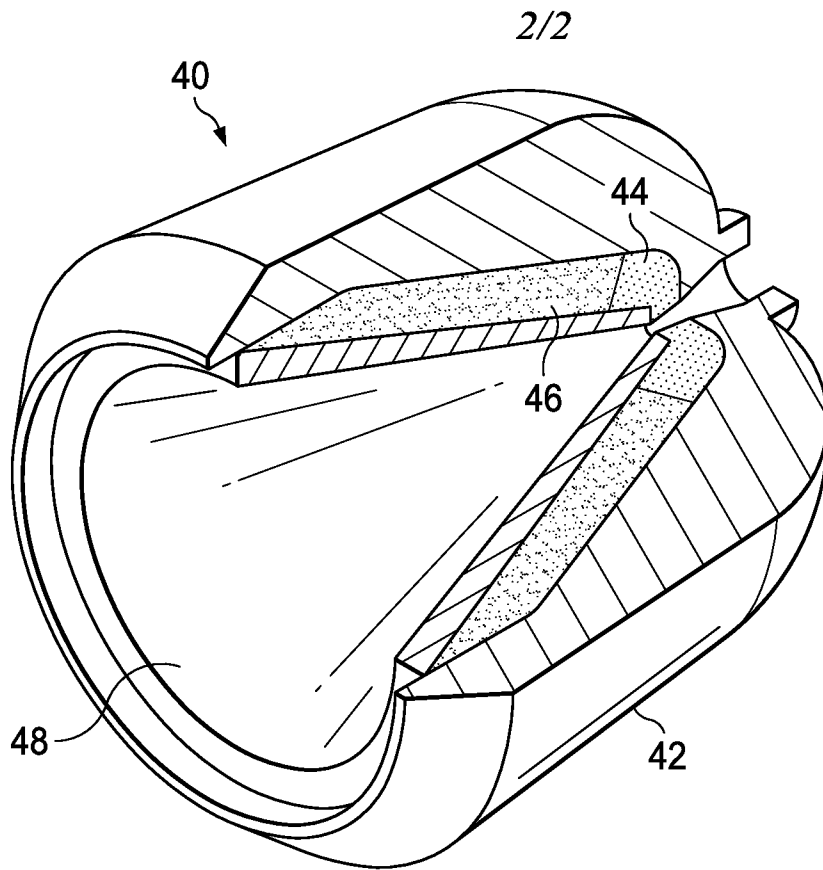


FIG. 2

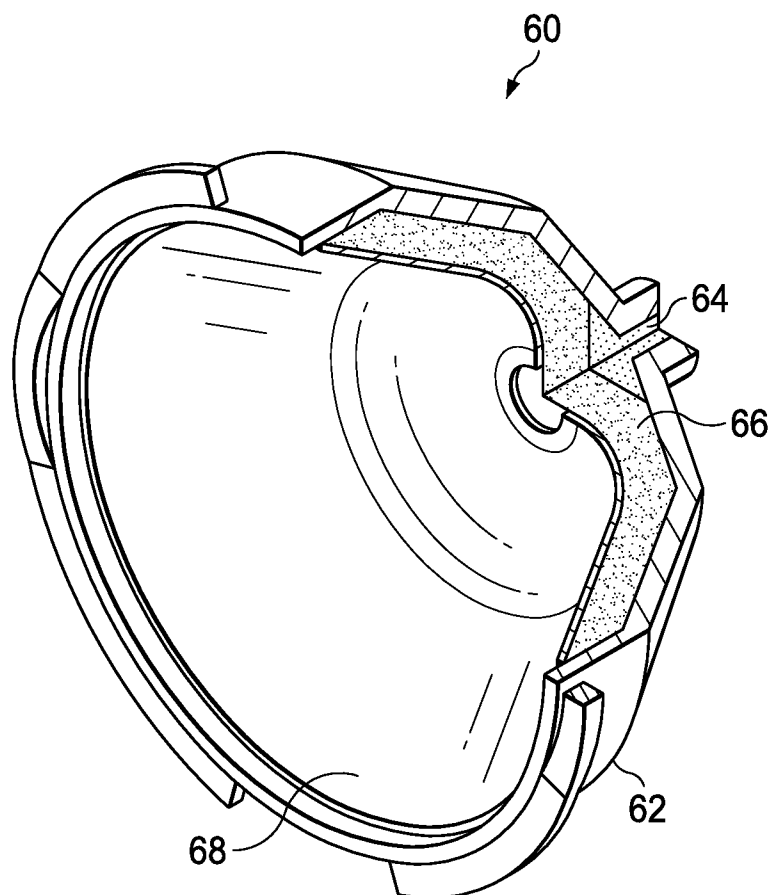


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/013839**A. CLASSIFICATION OF SUBJECT MATTER****E21B 43/117(2006.01)i, F42B 1/028(2006.01)i, F42B 1/032(2006.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
E21B 43/117; E21B 43/114; F42B 10/00; F42B 12/00; F42B 3/08; F42B 1/028; F42B 1/032Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: perforating, shaped charge, explosive, booster, coating, polymer, sensitive**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013-0061771 A1 (BETANCOURT et al.) 14 May 2013 See paragraphs [0005], [0018] and figures 1, 2.	1-20
Y	US 2015-0376992 A1 (HALLIBURTON ENERGY SERVICES, INC.) 31 December 2015 See paragraphs [0029]-[0033] and figure 2.	1-20
A	US 2016-0153267 A1 (WALKER et al.) 02 June 2016 See paragraphs [0031]-[0035] and figure 2.	1-20
A	US 2005-0115448 A1 (PRATT et al.) 02 June 2005 See paragraphs [0021]-[0023] and figures 1, 2.	1-20
A	US 2007-0056462 A1 (BATES et al.) 15 March 2007 See paragraph [0052] and figure 1.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2019/013839

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