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Ridgeway

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[45] **Dec. 24, 1974**

[54] **LINEAR SHAPED CHARGE DEVICE**

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[52] **U.S. Cl.** ..... **102/24 HC**

[51] **Int. Cl.** **F42b 3/08**

[58] **Field of Search** ..... 102/24 HC

[56] **References Cited**

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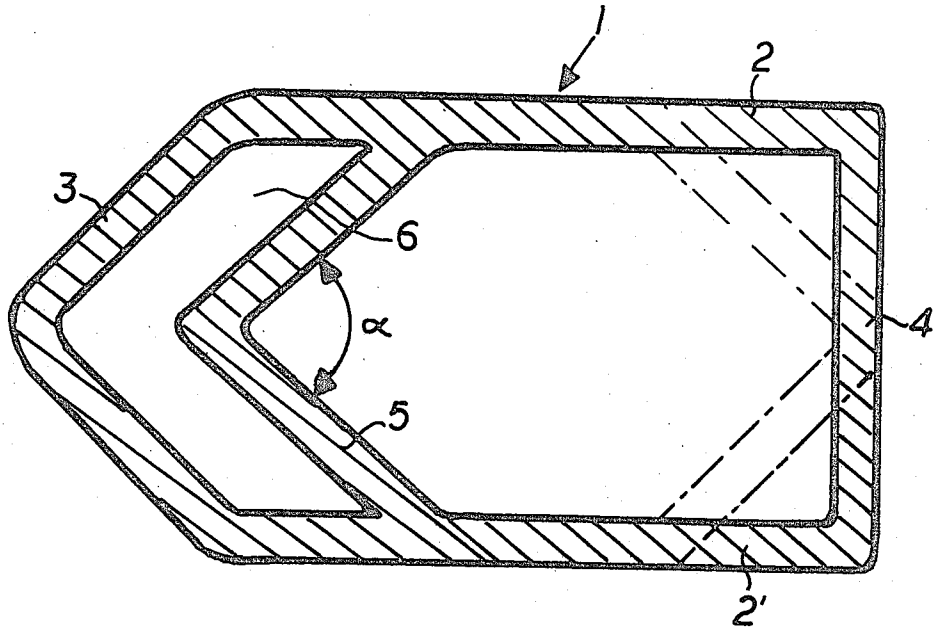
Attorney, Agent, or Firm—Cushman, Darby & Cushman

[57] **ABSTRACT**

An improved linear shaped charge device, particularly for underwater use, wherein there is structurally included an integral air tight standoff to precisely separate the chevron shaped explosive chamber from the work piece and having optimum, critical dimensions for the angle of the chevron, liner thickness and standoff distance. The whole linear shaped charged device is integrally extruded of aluminum and uses a non-detonatable, multi-component explosive for safety. Besides being purely linear, the device has an outer circular cutter configuration (FIG. 2) and an inner circular cutter configuration (FIGS. 3 and 4).

7 Claims, 4 Drawing Figures



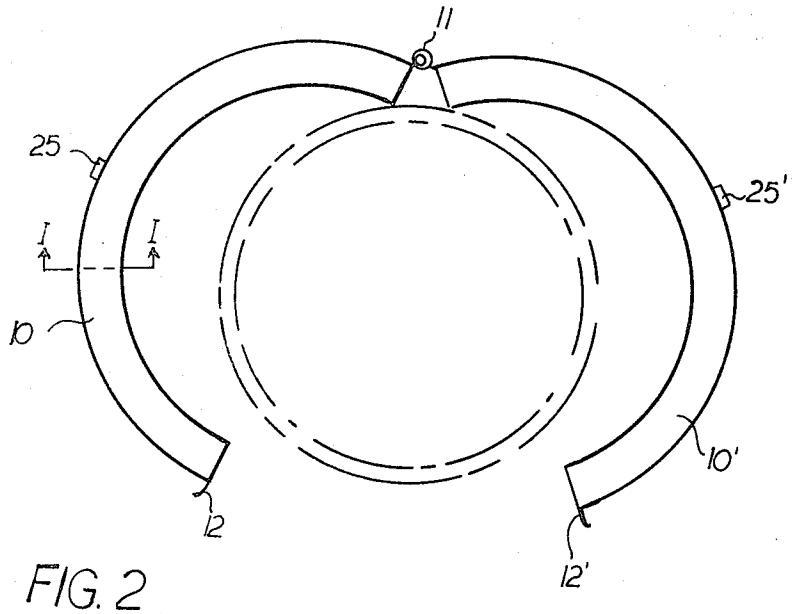


FIG. 2

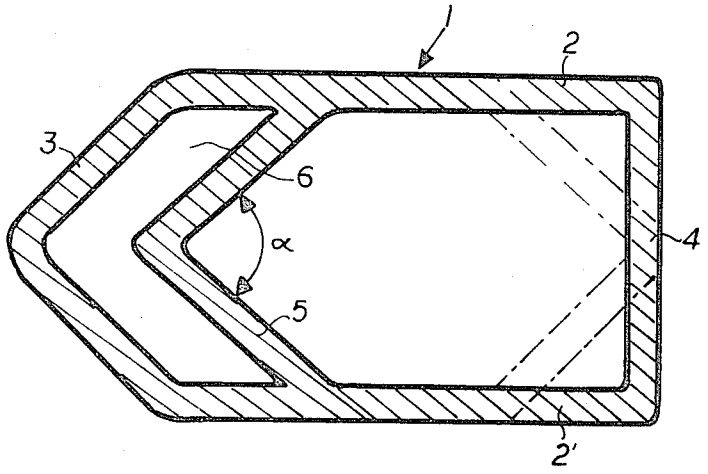


FIG. 1

FIG. 3

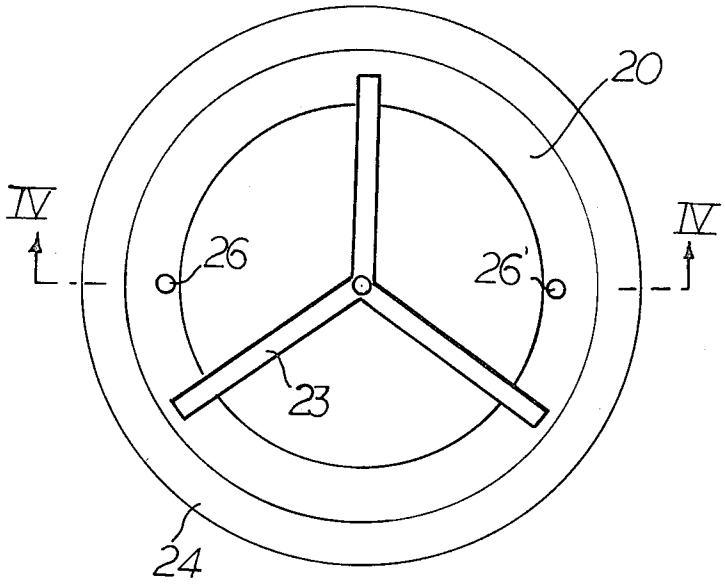
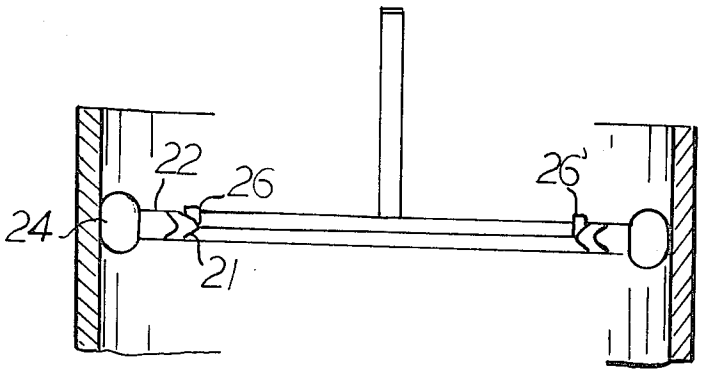


FIG. 4



LINEAR SHAPED CHARGE DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to an improved linear shaped charge device with a built-in integral stand-off and a hollow explosive chamber, both having critical dimensions, the explosive chamber being filled in the field with a nondetonatable multi-component liquid explosive. The purpose of this device is to precisely cut thick metal into sections. The device is particularly well suited for the application of cutting metal and pipe underwater in salvage operations.

Linear shaped charges generally are well known in the prior art and have become generally acceptable for cutting jobs in specialized circumstances. However, the linear shaped charges of the prior art have had various drawbacks and disadvantages, and the present invention has been designed to overcome these prior art problems.

In particular, especially in underwater applications, explosive cutters have been ineffective because of improper spacing and varying transfer medium problems due to the presence of water. In contradistinction to the prior art the present invention includes an air tight standoff chamber integral with the explosive chamber, providing precise minimum spacing between the explosive chamber and the work piece and an initial gas/air medium during the critical time when the explosive shock wave is being formed and initially propagated.

Moreover, the cutting effectiveness of the present invention over the prior art has been maximized by the discovery and adoption of various critical dimensions, particularly as to the liner thickness, the liner angle and the standoff distance.

Additionally a great need has existed for a device which is safer to transport, handle and store and which can be legally air transported to resolve the immediate problems of contractors worldwide. With conventional explosive linear shaped charges, up to eight weeks is often required for surface transport of class A explosive devices abroad and this severely handicaps contractors from performing their work timely and economically.

The present invention provides an improvement to conventional linear shaped charge devices which will safely eliminate the present handicap associated with legally transporting, handling and storing of explosive linear shaped charge devices.

The explosive chamber of the present invention is formed into a chevron or double V and a second adjacent air tight chamber is formed as an integral standoff for this device to function as intended.

When the explosive chamber is filled with a liquid explosive and detonated, the shock wave causes the sides of the interior V to collapse and impinge with a resultant shock wave down the axis of the chevron, bisecting the standoff air chamber and thereby producing a highly magnified shock wave with a gas expansion and high temperature eroding jet sufficient to cut practically any nearby metal.

The liquid explosive is composed of non-detonatable, multi-component chemicals, which if individually packaged, are classified as passenger air-transportable by the International Air Transport Association.

Economy was also an important factor in the development of the present invention.

The cost-optimum material for a multi-component explosive was found to be a one piece extrusion of 6061 aluminum and the critical ideal dimensions of the present invention are a liner thickness of 0.18 inch, liner angle of 85°, minimum standoff of 2.0 inches and a chevron configuration as shown in FIG. **1.**

The major advantages of this design in aluminum, particularly 6061 aluminum, are:

1. Its light weight for ease of handling and reduction in shipping costs.
2. Its resistance to corrosion.
3. Its good compatibility with all multi-component explosives.
4. Its inexpensive fabrication.
5. The reliability of the material; and
6. The safety afforded because of the limited explosive exposure time of property and personnel.

This design is not only unique in its one piece extrusion for a hermetrically sealed underwater linear shaped charge, but in its ability to penetrate steel deeper than existing linear shaped charges using the same grain per foot loading with the same liner material.

The method of initiation for this improved device can be for example by a class C explosive cordeau detonate fuse knotted. The knot acts as a booster sufficient to reliably boost multi-component explosives to high detonation velocity. Also the safety aspects are notably different in that a class A pressure sensitive blasting cap or detonator is never required to go into the water with the diver.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a transverse, cross-sectional view of the improved linear shaped charge device with built-in standoff of the present invention, the cross-section being taken along section lines I—I of FIG. **2.**

FIG. **2** is a plan view of the improved linear shaped charge in the configuration of an outside circular cutter with the work piece shown in phantom lines.

FIG. **3** is a plan view of the improved linear shaped charge as an inside circular cutter.

FIG. **4** is a cross-sectional view, along sections lines IV—IV of FIG. **3,** showing the innertube inflated spacer inside of a pipe to be cut.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The basic transverse, side configuration of the linear shape charge **1** of the present invention is shown in FIG. **1.** The one piece device, which can be extruded from aluminum, includes a hollow chevron-shaped explosive chamber **6** formed between two parallel V-shaped walls —a top exterior wall **3** and an interior liner wall **5.** The liner angle is indicated in FIG. **1** by the symbol "alpha". Integrally formed with the explosive chamber **6** is an adjacent air tight standoff chamber formed between the two flat, parallel side walls **2, 2'**, the bottom exterior wall **4** and the liner wall **5.** Both the explosive chamber **6** and the stand-off chamber are leaktight to keep all exterior water out. As an alternate embodiment the bottom exterior wall **4,** rather than flat as illustrated, could likewise be V-shaped (as indicated in phantom lines) similar but opposite to exterior wall **3.**

For maximum effectiveness of the cutter **1** of the present invention, certain dimensions of the device are

critical. It has been found that in the present invention the optimum liner thickness is 0.18 inch ± 10 percent and the liner angle "alpha" is 85° ± 3°. Also particularly important is the minimum set-off distance provided by the stand-off chamber which should be a minimum of 2 inches, as measured from the center peak of the liner wall **5** to the central portion of the bottom wall **4**, and can be for example 3 and ¾ inches. Such a minimum stand-off distance allows the explosive cutting jet to be fully formed before encountering the exterior water or other ambient.

Besides being a pure linear shaped charge, that is having a straight configuration, the linear shaped charge device of the present invention can be formed by bending into any desired configuration, such as circular to serve as either an outside circular cutter (FIG. **2**) or an inside circular cutter (FIGS. **3** and **4**).

In FIG. **2** hermetically sealed half-sections of an outside circular cutter utilizing the linear shape charge device of the present invention are represented by elements **10** and **10'**. For placement about a workpiece such as a pipe, the two half-sections **10, 10'** rotate about the hinge **11.** Latching hooks **12, 12'** for closing the device about a pipe and fill port and detonation wells **25, 25'** are provided on the cutter half-sections.

In FIG. **3** an hermetically sealed inside circular cutter utilizing the linear shape charge device of the present invention is illustrated. The improved linear shaped charge extrusion of the present invention is represented by element **20,** and includes a spider assembly **23** which acts as a stablizing guide and leveler for the cutter.

FIG. **4** is a transverse, cross-sectional view of the device of FIG. **3.** The linear shape charge device of the present invention is defined by the extrusion walls **21, 22** and includes on its bottom exterior wall an inflated innertube **24** used to displace the water between the linear shaped charge extrusion and the pipe to be cut.

For safety purposes a non-detonatable multi-component explosive is used with the improved linear shape charge device of the present invention and is placed in the hollow explosive chamber **6** by means of suitable fill ports such as elements **25, 25'** and **26, 26'** of FIGS. **2** and **3,** respectively. An example of such an explosive is that marketed under the trade name "Astro-Pak" by the Explosives Corporation of America of Issaquah, Washington. "Astro-Pak" is a two component (binary) liquid explosive system. Each component is separately non-detonatable and classified as a non-explosive by the Department of Transportation prior to mixing. "Astro-Pak" may be transported and stored in conventional vehicles or facilities under lock and key. Magazines, ready boxes, or other special equipment or facilities, are not required for unmixed "Astro-pak." "Astro-Pak" is mixed to form "Astrolite T," a versatile, high performance liquid explosive. The mixed "Astrolite" is a Class A high explosive and must be handled, transported, stored, and used with the care accorded such explosives.

Because many varying and different embodiments may be made within the scope of the inventive concept herein taught, and because many modifications may be made in the embodiments herein detailed in accordance with the descriptive requirements of the law, it is to be understood that the details herein are to be interpreted as illustrative and not in a limiting sense.

I claim:

1. An improved linear shaped charge device comprising a hollow chevron-shaped explosive chamber and integrally formed therewith an air tight, hollow stand-off chamber located adjacent to and below said chevron-shaped explosive chamber, the bottom, interior wall of said explosive chamber being an explosive liner wall, and both hollow chambers being constructed from extrudable metal as a one-piece extrusion.

2. The device of claim **1** wherein said explosive liner wall has a thickness between 0.162 inches and 0.198 inches.

3. The device of claim **2** wherein the entire device is formed of one-piece extruded aluminum.

4. The device of claim **3** wherein said aluminum is type 6061 aluminum.

5. The device of claim **1** wherein the explosive used to power said device is mixed from two or more non-detonatable components which when mixed in said explosive chamber becomes a liquid explosive.

6. The device of claim **1** wherein the distance between the apex of the explosive chamber and the bottom of the stand-off chamber is a minimum of two inches and the central apex angle of the bottom wall of the explosive chamber being between 82° and 88°.

7. The device of claim **1** wherein the bottom wall of the stand-off chamber is V-shaped, the apex being at the bottom of the stand-off chamber.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,855,929 Dated Dec. 24, 1974

Inventor(s) John J. RIDGEWAY

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the front page format, after paragraph "[21]",

insert: --[30] Foreign Application Priority Data
Nov. 25, 1971 France.....7142206--

Signed and Sealed this

thirtieth Day of March 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

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