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SHAPED CHARGE EXPLOSIVE UNIT AND LINER THEREFOR

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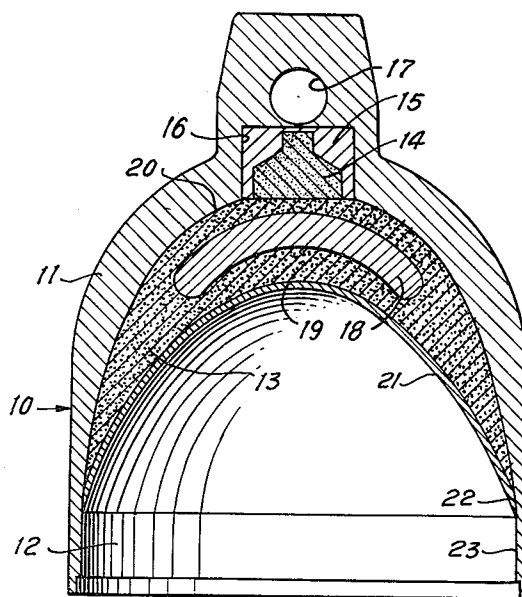


Fig. 1

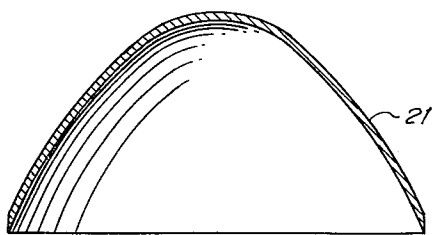


Fig. 2

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SHAPED CHARGE EXPLOSIVE UNIT AND LINER THEREFOR

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3 Claims. (Cl. 102-24)

This invention relates to shaped charge explosive devices and to metal liners for the cavities in shaped charge explosives.

Shaped charge explosive perforating units have been used for a number of years to perforate oil and gas wells. One of the features of most of the shaped charge explosive units previously used for this service is the formation of a "slug" or "carrot" from a portion of the metal liner for the charge cavity. This carrot is formed near the rear of the jet particle stream generated when a shaped charge explosive unit having a metal cavity liner is detonated. The carrot or slug has a lower velocity than the forward portion of the jet particle stream and frequently has a smaller diameter than the perforation produced in the well casing so that it often follows the jet particle stream into the earth formation and lodges in the perforation. This is undesirable as it blocks off a portion of the perforation and reduces the flow of formation fluids into the well bore. Even more objectionable is the situation where the diameter of the slug is great enough to cause it to lodge in the hole in the well casing, completely blocking any flow from the earth formation into the casing.

Therefore, it is an object of this invention to provide a shaped charge explosive unit for perforating a well which is free from formation of a slug capable of plugging the perforation produced upon detonation of the unit.

It is another object of this invention to provide a metal liner for the face of the cavity of a shaped charge explosive unit that does not form a slug capable of plugging the perforation produced upon detonation of the unit.

The lined, shaped explosive charge of the present invention includes a body of explosive material providing a cavity in a face thereof and a metal liner covering the face of the cavity. The metal liner comprises a composition consisting essentially of from 75 percent to 99.5 percent copper and from 25 percent to 0.5 percent lead. This composition has a metallographic structure consisting of copper dendrites with the spaces between the dendrites filled with lead. The liner is adapted to break up substantially completely into small particles when the explosive material is fired.

The invention will be more fully described in the following detailed description of an embodiment thereof illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is an axial, sectional view of a shaped charge explosive device in accordance with the present invention; and

FIG. 2 is a detailed, axial, sectional view of the liner of the shaped charge explosive device of FIG. 1.

Referring now to FIG. 1, a shaped charge unit, designated 10 generally, is shown. The shaped charge unit has a case 11 made of any suitable material such as metal or plastic. The case has an open forward end 12 and is closed at the rear thereof. Inside the case is contained a suitable quantity of compressed detonating explosive material 13. A charge of booster explosive 14 is compressed in a booster cup 15 seated in a recess 16 in the rear of the charge case 11. An opening 17 is provided in the rear of the charge case through which may be threaded a length of detonating fuse (not shown) to fire the perfor-

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rating device. A curved, disk-shaped barrier 18, of a suitable dense metal such as steel, is embedded in the explosive material about midway between the front surface 19 and the rear surface 20 of the explosive and is symmetrical with the longitudinal axis of the shaped charge device. A metal liner 21 covers the front concave surface 19 of the explosive material and contacts at its periphery 22 the inner wall 23 of the charge case 11 near the front of the case.

Referring now to FIG. 2, the metal liner 21 is shown in section and is substantially uniform in thickness over its entire area.

The metal liner 21 is made from a composition or alloy of copper and lead. It is known that lead is almost entirely insoluble in solid copper and only partly soluble in liquid copper. Molten mixtures of copper containing from about 0.5 percent to about 25 percent lead upon cooling will produce alloys in which the structure consists of copper dendrites with the spaces between the dendrites filled with lead. Such metals tend to be hot short and cold short so that they are workable only with care. These metals are not true alloys in the strict sense of the word. This can be readily determined by subjecting the copper-lead metal to microscopic examination. In the molten state, the lead goes into solution in the copper and as the metal solidifies the lead separates out and distributes itself along the boundaries of the copper grains. The fact that copper-lead metal does not form a true alloy is responsible for the liner breaking up into many fine pieces instead of forming a slug or carrot. The low tensile strength lead along the grain boundaries weakens the cohesive tensile and shear strength between the copper grains or dendrites, thus causing the liner to break up into grain size particles and, at the same time, reducing the force necessary to extrude the metal from the form of the liner into a jet particle stream. Therefore, it is to be understood that all references herein to "copper-lead alloy" or "alloy" are to be construed in the light of the foregoing explanation.

Liners, in accordance with the invention, for shaped charge explosive devices may be made from alloys of copper containing lead from about 0.5 percent up to about 25 percent. The preferred copper-lead liners are produced from copper alloys containing from 0.5 percent up to 6 percent maximum lead. A typical composition has a lead content of 3.2 percent with the balance being copper.

The liners of the invention are fabricated by casting and machining the alloy. Alternatively, and preferably, the alloy may be rolled into sheets and formed to final shape by die-pressing blanks cut from the sheets.

A specific example of the invention is made by constructing a shaped charge device in strict accordance with the design shown in FIG. 1 of the drawings. The case 11 is die cast from a high zinc-base alloy and has an inside diameter of 1.698 inches at the front of the case with an overall length of 2.187 inches. The recess 16 for the booster cup 15 is 0.415 inch in diameter and 0.290 inch deep. The booster cup 15 containing 0.45 gram of compressed cyclonite is inserted in the recess 16. Four grams of cyclonite coated with about 3 to 5 percent microcrystalline wax is loaded into the case on top of the booster. A steel barrier 18 one inch in diameter is positioned centrally in the case on top of the four gram charge of waxed cyclonite. A further charge of 15 grams of waxed cyclonite is added to the case on top of the barrier. A liner 21 of 0.030 inch thickness is fabricated from a copper-lead alloy containing 3.2 percent lead. This liner is placed on top of the cyclonite and pressed with a conforming punch powered by a total ram force of 32,000 pounds. The case 11 is supported by a close fitting, steel die during the compression step.

A shaped charge device, constructed in accordance with

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the before-mentioned instructions, was fired into a cement target. The target face was covered with a mild steel face plate $\frac{3}{8}$ inch thick. The charge was fired at a clearance of $\frac{1}{2}$ inch from the face plate and a total penetration of 10% inches was obtained. The entrance hole in the mild steel face plate measured $\frac{1}{2}$ by $\frac{5}{8}$ inch in lateral dimensions. The target was cut open for examination and no carrot or slug was found therein.

Other shaped charge units like that described in the foregoing specific example when shot into a soap foam tank leave in the tank all of the particles from the jets formed from the copper-lead alloy liners. The liner residue recovered from the tank shows that the liner is practically entirely disintegrated into small particles of about the size of common table salt. A few fragments of somewhat larger size are also recovered.

The depths of the perforations obtained in a number of target shots using leaded-copper liners were comparable to those obtained in shots using a substantially pure copper liner in the same size shaped charge units.

From the foregoing, it is evident that a new and improved shaped charge explosive unit and liner therefor has been developed. While the liner shown and described is generally paraboloidal in shape, the use of leaded copper metal for liners of any shape is contemplated. Further, the present invention is not to be limited to the specific form of shaped charge unit herein described and depicted.

It is not necessary that the shaped charge explosive unit utilize a barrier within the explosive material as shown in FIG. 1 of the drawings. The barrier is optional and may be omitted if desired. Barrier charges are well known in the art and such units, per se, form no part of the present invention. An improved barrier type shaped charge device similar to that shown in FIG. 1 is disclosed and claimed in the copending U.S. patent application of Thomas C. Poulter, Serial No. 786,888, filed January 14, 1959, now U.S. Patent No. 3,100,445, issued August 13, 1963, for "Shaped Charge and Method for Firing the Same," which is a continuation-in-part of the application of Thomas C. Poulter, Serial No. 439,564, filed June 28, 1954, now abandoned, for "Shaped Charge." The copending application Serial No. 786,888, now U.S. Patent No. 3,100,445, is assigned jointly to two corporations owning all the capital stock of the assignee of the present application.

I claim:

1. A lined, shaped explosive charge comprising:
 - (a) a body of explosive material providing a cavity in a face thereof; and

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(b) a metal liner covering the face of said cavity, said metal liner comprising a composition consisting essentially of from 75 percent to 99.5 percent copper and from 25 percent to 0.5 percent lead, said composition having a metallographic structure consisting of copper dendrites with the spaces between said dendrites filled with lead, said liner being adapted to break up substantially completely into small particles when said explosive material is fired.

2. A lined, shaped explosive charge comprising:

(a) a body of explosive material providing a cavity in a face thereof; and

(b) a metal liner covering the face of said cavity, said metal liner comprising a composition consisting essentially of from 94 percent to 99.5 percent copper and from 6 percent to 0.5 percent lead, said composition having a metallographic structure consisting of copper dendrites with the spaces between said dendrites filled with lead, said liner being adapted to break up substantially completely into small particles when said explosive material is fired.

3. A lined, shaped explosive charge comprising:

(a) a body of explosive material providing a cavity in a face thereof; and

(b) a metal liner covering the face of said cavity, said metal liner comprising a composition consisting essentially of 96.8 percent copper and 3.2 percent lead, said composition having a metallographic structure consisting of copper dendrites with the spaces between said dendrites filled with lead, said liner being adapted to break up substantially completely into small particles when said explosive material is fired.

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