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SHAPED CHARGE DEVICE

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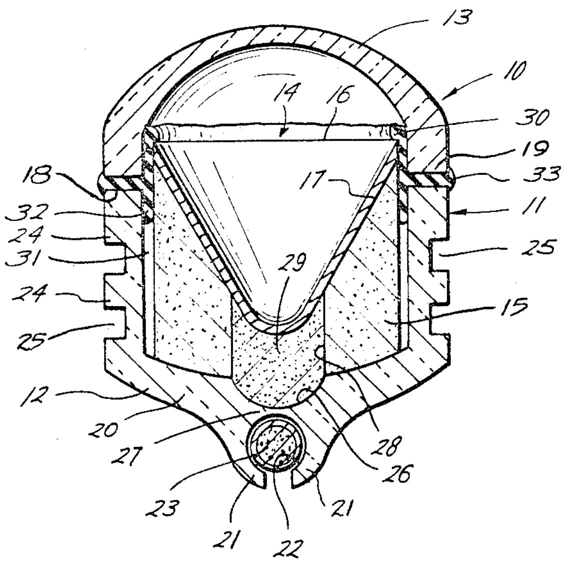

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SHAPED CHARGE DEVICE

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This invention relates to shaped charges for use in perforating earth formations traversed by a well bore; and, more particularly, to a new and improved, compactly arranged capsule shaped charge device having a case of high strength that has desirable debris characteristics.

Capsule shaped charges include an explosive sealed within a frangible case which should be capable of withstanding (1) high external pressures and temperatures encountered in a well, (2) the corrosive fluids often found in wells, (3) normal impact and shock, (4) abrasion with the casing while being positioned within a well, as well as (5) being substantially disintegrated by the explosive so as to leave only small, uniform particles of debris in the well. It is obvious, of course, that capsule shaped charges must be fluid tight and reliably detonatable by an external detonating cord under all well bore conditions.

Heretofore, cases for capsule shaped charges have been constructed of such disintegrable materials as aluminum, or, as described in U.S. Patents Nos. 2,629,325, 2,733,657, 2,819,673 and 2,947,251 of glass or porcelain.

Although aluminum cases satisfy some of the five above-described requirements with a fair amount of success, they have been unsatisfactory in other respects. For example, although typical aluminum cases are strong, disintegration of the cases is not always predictable and can result in large, non-uniformly sized debris fragments. The aluminum cases are also subject to abrasive action with the well casing. Furthermore, some corrosive fluids encountered in well bores readily attack aluminum and, with sufficient time, can leak into the cases to render the shaped charges inoperative or otherwise affect their performance.

Properly designed shaped charge cases of glass or porcelain typically will disintegrate into uniform, small-sized debris particles as well as successfully resist the effects of highly corrosive fluids. These cases, however, have such a low mechanical strength that they are easily damaged by scraping against a metal casing or by striking a hard object.

Accordingly, it is an object of the present invention to provide a new and improved, compactly arranged, encapsulated shaped charge unit which meets each of the five above-mentioned requirements thereby overcoming the above-mentioned difficulties experienced heretofore with shaped charge units employing either the aluminum or glass cases of the prior art.

This and other objects of the present invention are accomplished by providing a generally cylindrical two-part case sized and adapted to receive a shaped explosive charge, which case is made of an improved high-strength ceramic material composed of at least 86 percent aluminum oxide by weight. Suitable means are provided to secure a conventional detonating cord against the outside of the rearward end wall of the case. A booster explosive charge is confined within an axial bore within the explosive pellet and extended to a place on the rearward end wall of the case which is particularly formed so as to leave no more than a particular thickness of ceramic material separating the booster explosive from a detonating cord.

The novel feautres of the present invention are set forth with particularity in the appended claims. The pres-

ent invention, both as to its organization and manner of operation together with further objects and advantages thereof, may best be understood by way of illustration and example of a typical embodiment when taken into conjunction with the accompanying drawing, in which:

The figure is a view partially in cross-section, showing a representative shaped charge device arranged in accordance with the present invention.

The aforementioned disadvantages of the shaped charge cases of the prior art are overcome by forming the charge cases of the present invention from a compressed, powdered ceramic material composed of more than about 86 percent aluminum oxide by weight. It has been found that the aluminum oxide content must be greater than about 86 percent to ensure that the cases have sufficient tensile strength to withstand breakage; whereas, if the aluminum oxide content exceeds about 99 percent, it is difficult to economically manufacture the cases to a desired shape. Preferably, the aluminum oxide content of the ceramic material should be about 94 to 96 percent.

Cases of such material not only possess the desirable debris and corrosion-resistance characteristics of glass cases, but also retain the strength and trouble-free nature of aluminum cases. Cases formed from this material have a tensile strength in the order of 25,000 p.s.i. as compared with a tensile strength of only about 1,500 p.s.i. for the glass cases of the prior art. Such ceramic cases, nevertheless, disintegrate into uniformly small particles upon detonation of the charge as readily as conventional glass cases.

Moreover, as an added feautre, the ceramic cases of the present invention provide a degree of confinement not attainable in either a glass or aluminum case. By momentarily confining the laterally directed explosive forces, the effectiveness of the jet is improved and distortion of the casing on either side of the perforation is minimized.

Capsule shaped charges typically include a booster explosive within the case and arranged to be detonated whenever a detonating cord against the outside of the case is detonated. Although the exposive energy released upon detonation of the detonating cord is somewhat reduced as it is transmitted through the case to the booster exposive, there is no particular problem in detonating shaped charges contained in cases of either aluminum or glass. It has been found, however, that the transmission factor "Q" of the above-described high-strength ceramic materials is so low that a conventional detonating cord apparently cannot reliably induce a high-order detonation through a case of such material. Thus, although it is generally recognized that ceramic materials have such superior properties, these materials have not been successfully employed for shaped charge cases heretofore because of the apparent inability to reliably induce a high-order detonation through a ceramic material of this nature.

Accordingly, it has been found that to ensure reliable high-order detonation of a shaped charge in a case of such high-strength ceramic material, it is necessary to employ an "induction distance mechanism." The term "induction distance" as used herein is the axial distance that an explosive shock wave commencing at one end of a column of a first explosive material must travel along the column before attaining sufficient velocity to induce a high-order detonation in a second explosive material disposed in intimate contact therewith. The particular factors generally governing the induction distance for a particular explosive detonated by a given level of explosive energy are its grain size, its degree of compaction and confinement, and, to some extent, the approximate lateral dimensions of the column.

To illustrate the induction distance mechanism, assume that a first detonating explosive is disposed against one side of a solid wall and that a column of a second explosive is extended away from the opposite side of the wall to a third explosive which is to be detonated. It will be appreciated, of course, that for the detonation of the first explosive to induce a detonation of the second explosive, at least a particular minimum level of explosive energy must be transferred through the wall. Similarly, before the third explosive will detonate, the second explosive must develop sufficient explosive energy to detonate that third explosive. Thus, should either the explosive energy transferred through the wall or that generated by the second explosive be insufficient, the third explosive will either fail to detonate at all, or, at best, detonate only at low-order.

Inasmuch as explosive energy diminishes exponentially as its distance from the source increases, the booster explosive may be detonated slightly below high-order even where a conventional case is used and the wall is very thin. In such instances, however, only a small amount of booster explosive is needed to bring the shock wave up to high-order detonating velocity; and no particular attention need be given to the arrangement of the booster in a conventional case.

It will be appreciated, therefore, that should the rear wall of the charge case of the present invention be too thick, substantially all of the explosive energy will be dissipated or attenuated within the wall itself. Thus, since the high-strength ceramic material used in the present invention greatly attenuates explosive energy, the thickness thereof becomes critical as well as making it essential that there be sufficient induction distance for the booster explosive to ensure high-order detonation of the shaped charge.

In the typical embodiment of the invention shown in FIG. 1, a shaped charge device 10 is comprised of a two-part case 11 having a generally cylindrical container portion 12 and a dished cover portion 13 with a generally cylindrically shaped explosive charge 14 being enclosed within the case.

The shaped charge 14 is a pre-formed pellet 15 of a suitable high-explosive material, such as RDX, having an axially symmetrical conical cavity diverging outwardly toward the forward end 16. A hollowed, complementary shaped, frusto-conical liner 17 of a suitable metal is disposed in the conical cavity with the base of the conical liner terminating at the forward peripheral edge 16 of the shaped charge 14.

The mating abutting surfaces, 18, 19, respectively, of the container 12 and cover 13 portions are suitably prepared to enable a fluid-tight seal to be made whenever these portions are joined. On the exterior of the rear wall 20 of the container portion 12, two spaced-apart, axially projecting lugs 21 are provided which form a transverse groove 22 sized and adapted to snugly receive and retain a suitable detonating cord 23 such as, for example, "Primacord." In addition, spaced-apart lateral projections 24 are centrally located on opposite sides of the container portion 12 to form opposed peripheral grooves 25 sized and adapted for mounting of the shaped-charge unit 10 to an expendable carrier (not shown).

An axially directed recess 26 formed in the interior of the rear wall 20 extends toward the transverse groove 22 and is terminated so as to leave only a thin, integral web 27 immediately adjacent to the bottom of the groove 22.

An axial bore 28 extends through the pre-formed pellet 15 and is suitably arranged to coincide with the axial recess 26 when the pellet is disposed within the container portion 12. A suitable high-explosive material 29, such as RDX, is disposed within the aligned bore 28 and recess 26 to act as a booster charge.

In preparing the shaped charge device 10, the shaped charge pellet 15 is pre-formed to a slightly greater density than ordinarily used. By way of example, pellets are customarily compacted to a density of approximately 1.4-grams/cm.^{3} where the explosive is wax-impregnated RDX. In preparing the pre-formed pellet 15, however, it is initially compacted to a density of approximately 1.6-grams/cm.^{3}. The pre-formed pellet 15 is disposed into the container portion 12 and a sufficient quantity of explosive 29 is poured into the aligned recess 26 and axial bore 28 to fill them. The booster charge 29 is then tap-compacted and the liner 17 placed into the frusto-conical cavity of the shaped charge pellet 15.

When the liner 17 is pressed inwardly in the typical manner, the increased density of shaped charge pellets 15 prevents the walls of the axial bore 28 from collapsing which otherwise would tend to further compact the booster charge 29. It has been found that this arrangement and loading procedure ensures that the booster charge 29 will be readily detonated by conventional detonating cords 23.

In one method for securing the shaped charge 14 within its case 11, the container-engaging surface 19 and adjacent interior surface portion of the cover 13 are coated with an appropriate hardenable or firming adhesive material such as, for example, the epoxy resin known as Epoxylite No. 810 manufactured by the Epoxylite Corporation of South El Monte, California.

As the cover portion 13 is brought into engagement with the container portion 12, the interior portion of the adhesive flows over the forward edge 16 of the shaped charge 14 and forms an annular bead 30. Then, as the two case portions 12, 13 are pressed tightly together, a second portion of the adhesive material extrudes inwardly into the annular space 31 to form a ring 32 between the charge 14 and the container 12, and the remainder of the adhesive spreads over the abutting surfaces 18, 19 with a portion thereof being extruded radially outwardly to form a peripheral bead 33 at the junction of the abutting surfaces.

Thus, upon hardening or firming of the adhesive material, the two case portions 12, 13 are sealingly secured together by the adhesive between the surfaces 18, and 19. At the same time, the annular bead 30 provides a forward abutment to retain the shaped charge 14 in a longitudinally-fixed position within the case 11 and the ring 32 supports the shaped charge in a laterally-fixed position. Accordingly, it will be appreciated that the shaped charge 14 is securely retained within the case 11 without requiring an integral shoulder in the cover portion 12 and without requiring any close dimensional tolerances of either the container 12 and cover 13 portions of the case 11 or the charge 14. It was found, however, that the approximate maximum thickness for the web 27 is 0.050 to 0.055-inch for standard detonating cord. Reliable high-order detonation by conventional detonating cords could not be achieved at greater web thicknesses. Although the design pressure will be a factor, it is preferred to hold the thickness of the web 27 to about 0.020 to 0.030-inch. This is suitable for even very high well pressures and does not complicate manufacture of the cases. It was also found that reliable operation is had by extending the axial bore 28 substantially to the apex of the liner 17 which assures a sufficient induction distance for the booster charge 29. Since the loading procedure is greatly simplified by having the axial bore 28 open at the apex of the shaped cavity, it is preferred to extend the axial bore completely through the pellet 15 as described.

Accordingly, it will be appreciated that the shaped charge device of the present invention has a case that withstands high-external well pressures and temperatures; is not affected by corrosive well fluids; is strong enough to resist shocks from handling and impact; will not be abraded by steel well casings; disintegrates into small particles; and, by virtue of the induction distance mechanism employed, will be reliably detonated at high-order by conventional detonating cords.

While a particular embodiment of the present invention has been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim of the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. A shaped charge device including: a case comprised of ceramic material containing at least 86 percent aluminum oxide and adapted to receive explosive charge means, said case having an end wall with an outer surface portion thereof adapted for securing detonating means thereon and an inner surface portion adjacent thereto, wherein the thickness of said end wall between said surface portions is no greater than about 0.050-inch; shaped explosive charge means having a frusto-conical metal liner secured in its forward end and having a bore formed therein and extending to the rearward end of said shaped explosive charge means, said shaped explosive charge means being sufficiently compacted to maintain the integrity of said bore, said shaped explosive charge means being disposed in said case with the rearward end of said bore being coincidental with said inner surface portion; booster explosive powder loosely received in said bore and having an end thereof disposed against said inner surface portion; and sealing means encapsulating said charge means within said case.

2. A shaped charge device including: a case comprised of ceramic material containing at least 86 percent aluminum oxide and having a generally cylindrical hollowed container portion adapted to receive explosive charge means and a cover portion adapted to be disposed over the explosive charge means and joined along abutting surfaces to said container portion, said container portion having a rear end wall with a central portion thereof having an outer surface adapted for securing detonating means thereon, wherein the thickness of the said end wall central portion along the longitudinal axis of said container portion is no greater than about 0.050-inch; shaped explosive charge means having a frusto-conical metal liner secured in its forward end and having an axial bore formed therein and extending to the rearward end of said shaped explosive charge means, said shaped explosive charge means being sufficiently compacted to maintain the integrity of said axial bore, said shaped explosive charge means being disposed in said container portion with the rearward end of said axial bore being coincidental with the inner surface of said central portion; booster explosive powder loosely received in said axial bore with its rearward end disposed against said inner surface; and sealing means joining said abutting surfaces of said case portions for encapsulating said charge means within said case.

3. A shaped charge device including: a case comprised of ceramic material containing at least 86 percent aluminum oxide and having a generally cylindrical hollowed container portion adapted to receive explosive charge means and a domed cover portion adapted to be disposed over the forward end of the explosive charge means and joined along abutting circumferential surfaces to said container portion, said container portion having a rear end wall with a central portion thereof having an outer surface adapted for securing detonating means thereon and having an axial recess therein terminating at an inner surface adjacent to said outer surface, wherein the thickness of said end wall central portion between said outer and inner surfaces is no greater than about 0.050-inch; shaped explosive charge means having a frusto-conical metal liner secured in its forward end and having an axial bore formed therein and extending to the rearward end of said shaped explosive charge means, said shaped explosive charge means being sufficiently compacted to maintain the integrity of said axial bore, said shaped explosive charge means being disposed in said container portion with the rearward end of said axial bore being coincidental with said axial recess; booster explosive powder loosely received in said axial bore and axial recess; and sealing means joining said case portions and encapsulating said charge means within said case.

4. A shaped charge device including: a case comprised of ceramic material containing at least 86 percent aluminum oxide and having a generally cylindrical hollowed container portion adapted to receive explosive charge means and a domed cover portion adapted to be disposed over the forward end of the explosive charge means and joined along abutting circumferential surfaces to said container portion, said container portion having a rear end wall with a central portion thereof having an outer surface adapted for securing detonating means thereon and having an axial recess therein terminating at an inner surface adjacent to said outer surface, wherein the thickness of said end wall central portion between said outer and inner surfaces is no greater than about 0.050-inch; shaped explosive charge means having a frusto-conical metal liner secured in its forward end and having an axial bore formed therein and extending from said liner to the rearward end of said shaped explosive charge means, said shaped explosive charge means being sufficiently compacted to maintain the integrity of said axial bore, said shaped explosive charge means being disposed in said container portion with the rearward end of said axial bore being coincidental with said axial recess; and booster explosive powder loosely received in said axial bore and axial recess; and sealing means joining said case portions and encapsulating said charge means within said case.

References Cited by the Examiner

UNITED STATES PATENTS

2,629,325	2/1953	Sweetman	102—20
2,708,408	5/1955	Sweetman	102—20
2,947,642	8/1960	Glowacki	106—65 X
2,982,664	5/1961	Luks et al.	106—65 X

FOREIGN PATENTS

578,995	7/1946	Great Britain.

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