DENSE CORE IMPLOSION CHARGES

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UNITED STATES PATENTS
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ABSTRACT

An underwater implosion system having an outer shell of high explosive and an inner core of high explosive. The detonation velocity of the inner core of high explosive is less than the detonation velocity of the outer shell of high explosive, and the speed of sound in the detonation products of the core is less than the speed of sound in the detonation products of the shell. A plurality of detonators uniformly spaced on the surface of the outer shell initiate the implosion.

7 Claims, 5 Drawing Figures
EXPLOSIVE SURFACE

DETONATION STARTS HERE

DETONATION WAVE

FIG. 1

DETONATION WAVE

DETONATION STARTS ON SURFACE

FIG. 2

DETONATION WAVES AT DIFFERENT TIMES

FIG. 3

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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates generally to underwater explosives, and more particularly to an improved configuration in explosives which produces an increase in the efficiency of underwater detonations by a radical alteration of the hydrodynamic flow resulting in increases in peak pressure and shock wave energy thereby inflicting greater damage to underwater targets.

In the prior art, underwater high explosive ordnance operated on the explosion principle: high explosive charges are initiated at an end or an interior point. The resulting detonation produces a shock wave with a very high initial pressure in the water adjacent the charge. This results in a large percentage of the explosive energy being dissipated due to irreversible shock heating of the water.

With a view of increasing the total energy content of a given volume of explosive mixture, fine metal powders, normally aluminum, have been added to the explosive. Due to its relatively slow rate of reacting chemically during the detonation process, the energy released by oxidation of the metal, is delayed and, to a great extent, shows up as bubble-pulse energy at the expense of the shock-wave energy. For example, in some detonation-velocity experiments with TNMTB (trinitrotoluene: C_6H_4(NO_2)_3) containing finely-divided boron, aluminum, and zirconium, analysis of the results indicated that these powders were behaving as inert fillers, at least within the time scale of the detonation reaction zone duration.

Since the damage-producing ability of an underwater detonation is controlled more by the energy in the first shock-wave, as compared with the bubble-pulse energy, it was desirable to increase the proportion of the detonation energy going into the shock-wave, as compared to that going into the bubble-pulse. As disclosed in U.S. patent application, Ser. No. 327,152 filed Nov. 29, 1963, entitled "Method For Improving The Performance Of Underwater Explosive Warhead", and assigned to the assignee of the present application, Bernard E. Drimmer accomplished this by initiating detonation of a high explosive charge simultaneously at a plurality of points on its surface. This produces an implosion of the charge resulting in a detonation front that moves inward and is reflected at the center of the explosive as a shock. This shock overtakes and reinforces the initial shock in the water, producing a relatively high pressure in the water at between 2.5 and 3.0 charge radii from the center.

While Drimmer’s implosion method has resulted in significant improvements in the effectiveness of underwater detonations, it is necessary for practical application in torpedoes to increase the relative shock-wave energy at ten charge radii from the charge center. To understand the reason for this, consider the structure of a submarine which may be assumed to be the potential underwater target. Submarines have two hulls: an outer hull and a pressure hull. To achieve a kill, the pressure hull must be ruptured. The closest that a torpedo can approach the pressure hull is the distance between the outer hull and the pressure hull. This distance is usually on the order of ten charge radii.
perature within the reaction zone by only a few hundred degrees would increase the reaction rate by several orders of magnitude. Such an increase in reaction rate would obviously make available for possible use many energetic, though slow-reacting, chemical reactions not feasible under normal detonation conditions. Drimmer (application, Ser. No. 327,152) accomplished an increase in the temperature of the detonation reaction zone by using an implosion system generally illustrated in FIG. 2. In this system a plurality of detonators uniformly spaced over the surface of the explosive are simultaneously initiated. This produces a plurality of divergent detonation waves which propagate inwardly, reacting with the one another to produce a resultant convergent detonation wave within the charge. During this implosion phase, an initial shock-wave is driven into the surrounding water medium due to the expansion of product gases from the outer layers of the explosive. The amplitude, however, of the initial shock-wave is lower than that of the corresponding shock-wave caused by a centrally initiated explosion. When the converging detonation wave reaches the center of the explosive, shock reflection occurs producing a secondary shock-wave which radiates from that point. Passing through the explosive products, the secondary shock-wave picks up energy from any metal-products reaction that occurred since the passage of the detonation wave. The secondary shock-wave thereafter enters into the surrounding water medium and overtakes and reinforces the primary shock-wave. Thereafter, only a single shock-wave propagates through the water medium, the peak pressure at any given point being greater than that due to the normal explosion of an identical charge. Thus, the implosion, with its higher reaction-zone temperatures and pressures, supplies the proper conditions to initiate reactions whose activation energies are not exceeded by the conditions prevailing in the reaction zone of a normal detonation.

The implosion of a homogeneous explosive produces a relatively high pressure in the water at 2.5 to 3.0 charge radii from the center. As was explained previously, it is desirable to further improve the shock wave energy at 10 charge radii from the charge center. This is accomplished by the present invention, a preferred embodiment of which is shown in FIG. 3. The embodiment of FIG. 3 comprises a dense, spherical core 11 of high explosive surrounded by an outer, spherical shell 12 of high explosive of normal density. The core material is made by intimately mixing fine, heavy metal powders, such as tungsten or lead, with conventional high explosives to thereby raise the density of the explosive mixture to between 3.0 and 10.0 grams per cubic centimeter. The radius of the core 11 is between 0.3 and 0.8 times the radius of the composite charge. A plurality of detonators 13 are uniformly distributed over the surface of the composite charge. When initiated simultaneously, the detonators 13 produce a plurality of inwardly directed divergent detonation waves which interact to produce a resultant convergent detonation wave. The detonation waves propagating inwardly of the charge at different times are represented by the dotted lines in FIG. 3.

The main purpose of increasing the density of the explosive core is to decrease both the detonation velocity of the explosive and the speed of sound in the gaseous explosion products. This results in a longer time being required for secondary shock-wave reflected at the center to overtake and reinforce the initial water shock. In this way the benefit from the implosion is realized at a greater distance from the charge center than is possible with a homogeneous implosion charge. FIG. 4 graphically illustrates this improvement. Note that in this space-time flow diagram the secondary reflected shock-wave overtakes and reinforces the initial water shock-wave after 6 microseconds at about 2.5 charge radii in the case of a homogeneous implosion charge. The dense core implosion charge according to this invention, however, produces a secondary reflected shock-wave which overtakes and reinforces the initial water shock-wave after 18 microseconds at about 5 charge radii. The point of reinforcement can be varied over considerable limits by varying the core density and relative diameter.

FIG. 5 displays graphically the merit of the dense core implosion system as compared with a conventional explosion system and a homogeneous implosion system with regard to the increase in peak pressure in the water. In FIG. 5 it is seen that between one and two charge radii the pressure in the water due to the explosion is greater than that due to the implosion of a homogeneous charge and between one and three charge radii the pressure in the water due to the explosion is greater than that for implosion of a dense core charge. Beyond two and three charge radii, respectively, the reverse is true. At about 5 charge radii, peak pressure due to implosion of a dense core charge begins to exceed that due to implosion of a homogeneous charge. The percent increase in the pressure due to implosion of homogeneous and dense core charges as a function of charge radii is shown in the lower graph of FIG. 5.

It should be understood, of course, that the foregoing disclosure relates to only a preferred embodiment of the invention and that numerous modifications are contemplated and may be obviously resorted to by those skilled in the art. For example, hafnium or uranium powders could be used in the core to provide added energy to the system in addition to increasing core density. Other geometrical shapes of charge may be used with equal effect so long as the requirement for an implosion of a resultant converging detonation wave is met. It is therefore to be understood, that within the scope of the appended claims, the invention may be practiced otherwise than as specifically disclosed.

What is claimed is:
1. An improved implosion system which produces an increase in shock-wave energy at a substantial distance from the center of the charge, said system comprising: a solid explosive charge having a spherical geometry and symmetry, said explosive charge including a core of high explosive and an outer shell of high explosive, said core of high explosive having a detonation velocity less than the detonation velocity of said shell of high explosive and the speed of sound in the detonation products of said core being less than the speed of sound in the detonation products of said shell, means including a plurality of detonators uniformly spaced on the surface of said charge for directing a plurality of simultaneously initiated divergent shock-waves inwardly of said charge and for producing a resultant convergent uninterrupted shock-wave front converges within said charge which completely encloses a progressively smaller volume.
of said charge as said shock-wave front to a point at the center of said charge.

2. An improved implosion system as recited in claim wherein the radius of said core of high explosive is between 0.3 and 0.8 times the radius of the entire charge.

3. An improved implosion system as recited in claim wherein said core of high explosive is composed of a conventional high explosive intimately mixed with a fine, heavy metal powder.

4. An improved implosion system as recited in claim wherein the heavy metal powder it tungsten.

5. An improved implosion system as recited in claim wherein the heavy metal powder is lead.

6. An improved implosion system as recited in claim wherein the heavy metal is hafnium.

7. An improved implosion system as recited in claim wherein the heavy metal powder is uranium.

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