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PRESSURE RESPONSIVE BOOSTERS

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FIG. 1

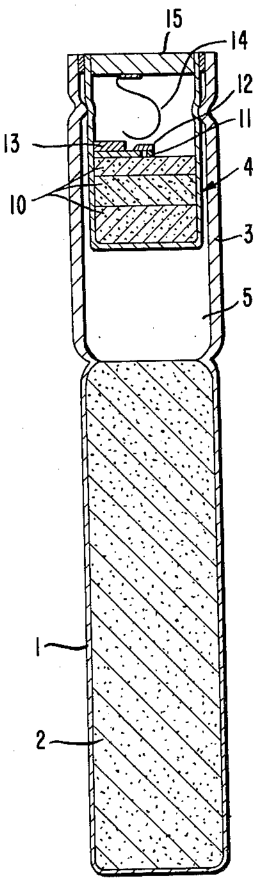

FIG. 2

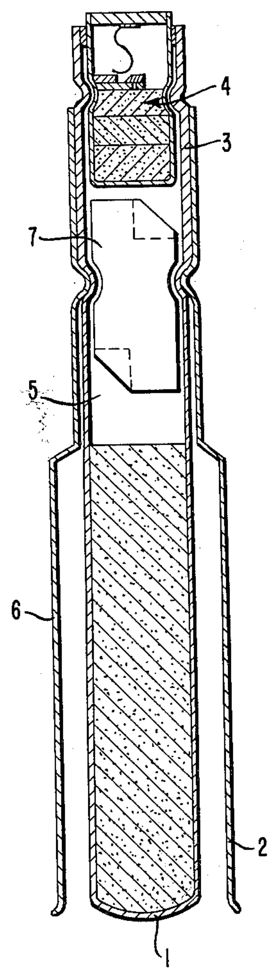

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FIG. 3

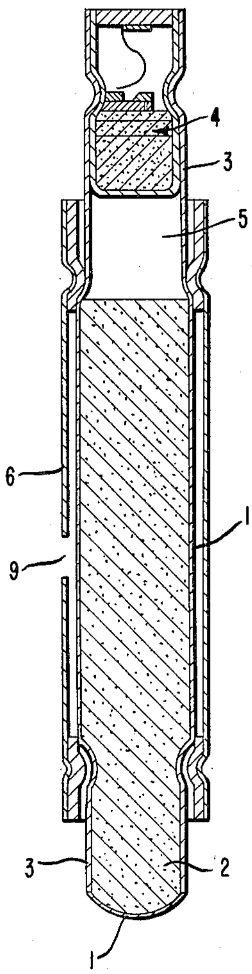
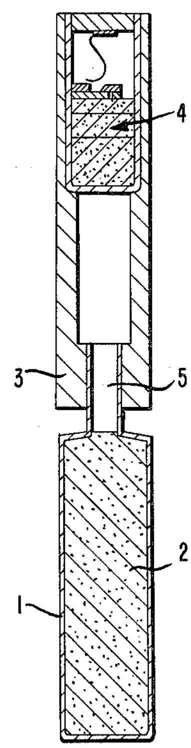


FIG. 4



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PRESSURE RESPONSIVE BOOSTERS

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The present invention relates to explosive boosters which are armed by means responsive to hydrostatic pressure.

For activities wherein the detonation of explosive charges below the surface of water is desired, such as in seismic exploration, underwater signalling, echo-ranging for detection purposes, and destruction of undersea craft, a need exists for a reliable, accurate, and non-hazardous booster which can be armed, i.e., made capable of propagating an initiation impulse, in response to the hydrostatic pressure of the water at a predetermined depth.

In accordance with this invention, a booster assembly for underwater use comprises a tubular container having a section thereof readily deformable and another section rigid and resistant to deformation, the readily deformable section being closed at the end most remote from the said rigid section, an extrudable cap-sensitive detonating explosive filling at least part of the readily deformable section, and an initiator disposed within the said rigid section and spaced from the deformable section by a distance sufficient that the initiation impulse upon actuation of the initiator will not initiate the explosive contained in the readily deformable section.

When the described assembly is subjected to sufficient hydrostatic pressure, deformation of the deformable section will force the walls of that section inwardly to cause extrusion of the explosive composition into the rigid section and into sufficient proximity to the initiator so that initiation of the explosive will be assured upon actuation of the initiator.

The sections of the tubular container may be made of the same material using different wall thicknesses, or of different materials. In a preferred embodiment of this invention, baffling means are provided between the extrudable detonating explosive in the readily deformable section and the initiator to act as a safeguard against premature initiation of the extrudable explosive if accidental actuation of the initiator should occur by obstructing the path of any particles of the initiator toward the detonating explosive and further to hinder free flow of the detonating explosive. In another preferred embodiment, a shield of a rigid material, which may be an extension of the rigid section of the tubular container, is positioned about the readily deformable section to inhibit premature accidental arming of the booster, for example, above the surface of the water, without inhibiting flow of the water about the deformable section when the unit is submerged.

In order to describe this invention in greater detail, reference is made to the accompanying drawings in which:

FIGURE 1 represents a cross-sectional elevation of a device of this invention,

FIGURE 2 is a sectional elevation of an embodiment of this invention which has a safe-guarding baffle in the space between the extrudable explosive in the deformable section and which is in a shield of a rigid material,

FIGURE 3 is a sectional elevation of an embodiment of the device of this invention enclosed in shield of a rigid material,

FIGURE 4 is a sectional elevation of an embodiment of the device of this invention modified for ease of assembly.

In all figures, identical parts are indicated by the same symbols.

Referring now to the figures in greater detail, in FIGURE 1, symbol 1 represents the readily deformable section of the container, 2 is a charge of an extrudable cap-sensitive detonating explosive composition filling this readily deformable section, and 3 is the rigid section of the tubular container. A pressure-actuated initiator 4 is positioned in the rigid section and is separated from the deformable section 1 by a space 5 sufficient that the initiation impulse produced upon actuation of the initiator will not initiate the explosive in the deformable section. In the initiator, 10 represents the initiator charges, 11 is an anvil, and positioned on top of the anvil 11 is an igniting charge 12 of a percussion-sensitive explosive. Integrally formed at one edge of anvil 11 is a striker-arm arrester 13 for striker arm 14 attached to piston 15 located at the open end of the initiator shell.

In FIGURE 2, the components are as in FIGURE 1, except that a shield 6 surrounds the readily deformable section and safe-guarding staggered baffles 7 are provided to prevent a direct missile path between the initiator and the leading mass of the extrudable, cap-sensitive explosive composition when the initiator is actuated.

In FIGURE 3, the components are as in FIGURE 1 except that the readily deformable section 1 is formed by an insert of a deformable material replacing a portion of the rigid material, and shield 6 is provided with an aperture 9 to allow the water to contact the insert.

In FIGURE 4, the deformable section 1 is connected to the rigid section 3 through an elongated portion of the deformable section which mates with the rigid section 3.

In actual operation, the booster of this invention may be positioned adjacent to a secondary explosive charge which cannot be initiated reliably by a conventional initiator, or it may be inserted into an aperture therein. Although the unit is secured to the secondary explosive, e.g., by tape, provisions are made for water to contact the outer walls of the booster. When the assembly is submerged, increasing hydrostatic pressure encountered at increasing depth effects deformation, i.e., collapse, of the walls of the readily deformable section 1 of the tubular container forcing them inwardly against extrudable cap-sensitive detonating explosive 2 filling this section. As inward movement continues, the extrudable explosive flows into space 5 in the rigid section of the container so that it is within propagating relationship of the pressure-actuated initiator 4, i.e., the leading mass of the extruding explosive is separated from the base of initiator 4 by a distance less than the "gap sensitivity" of the extrudable cap-sensitive explosive. When the extrudable explosive is in this proximity to the initiator, actuation of an initiator 4 such as described in copending U.S. patent application Serial No. 64,087, filed October 21, 1960, or in copending U.S. patent application Serial No. 105,494, filed April 25, 1961, is effected by the inward movement of piston 15 under the hydrostatic pressure such that the striker arm 14 is bent to a degree that the free end slips off arrester 13 and snaps onto the igniting charge 12. The impulse produced upon actuation of the initiator effects initiation of the extrudable cap-sensitive explosive which detonates and thereby delivers a detonation wave to the main secondary explosive charge. When the initiator is not of the pressure-responsive type, actuation of the initiator may be accomplished by electrical means adapted to fire the initiator at the predetermined depth.

The invention is described further by this example.

EXAMPLE 1

Fifteen units similar to that shown in FIGURE 4 were prepared. The deformable section of the container was of a 95/5 alloy of lead and tin and was formed from a tube 1.75 inches long, had an outer diameter of 0.375 inch and an inner diameter of 0.365 inch. One end of the tube had a formed external threaded end and an inner orifice 1/16 inch in diameter. The tube was filled with 5.5 grams of an extrudable cap-sensitive explosive composition consisting of, by weight, 67% of very fine PETN and 33% of triethylene glycol dinitrate, and the end of the tube was integrally sealed. The threaded extension of the orifice was inserted into a tapered threaded extension of a 1.500 inch long cylinder of aluminum having an outer diameter of 0.375 inch and an inner diameter of 0.188 inch at its widest portion and of 0.125 inch at its tapered, threaded portion. An epoxy resin containing aluminum powder was used to secure the orifice of the deformable section to the rigid section. A hydrostatic pressure-actuated initiator, outer diameter, 0.320 inch, as described in U.S. application Serial No. 64,087, was inserted into the open end of tubular sleeve and secured in place by the epoxy resin.

Five of the units were initiated in air at atmospheric pressure at 34° F. and initiation of the detonating explosive did not occur even though the initiator functioned properly in all five cases. When ten of the units were fired in water at 34° F. under a pressure of 150 p.s.i.ga., the initiators functioned properly and the extrudable explosive composition detonated in all ten cases.

The pressure at which the device will be armed, i.e., where the extrudable detonating explosive is positioned in propagating proximity to the initiator, is dependent upon such factors as the viscosity, thixotropy and related flow properties of the extrudable detonating explosive, the sensitivity of the explosive, the deformation resistance of the section of the container filled with the extrudable detonating explosive, the space between the initiator and the readily deformable section, and the like. By proper selection of the appropriate factors, a booster can be produced to be armed at any predetermined pressure, i.e., depth.

The readily deformable section should be constructed of a material which will collapse without rupture upon the exertion of a predetermined pressure and which is chemically inert to the explosive. The wall thickness naturally will depend upon the physical properties, e.g., structural strength, deformability, etc. of the material used. If desired, walls may be formed so that the resistance to deformation of the walls near the rigid section is greater than their resistance at the closed portion of the container to insure against collapse in the proximity of the rigid section. Wall collapse in this area might prevent flow of the extrudable cap-sensitive explosive composition into the rigid section. Exemplary materials for use in the walls of this section include ductile metals, such as aluminum, tin, lead, zinc, and alloys of such metals, natural and synthetic rubbers, and relatively long-chain polymers, e.g., polyethylene, polypropylene, neoprene, polyvinylidene chloride and the like.

The walls of the rigid section and of the protective shield which is present in two embodiments of the device of this invention are of a material which will not be deformed, i.e., collapse, at the hydrostatic pressure at which the booster is adapted to function. This section may be constructed of the same material as the deformable section but with a greater wall thickness, or with smaller diameter, or with an entirely different material of less deformability or of a combination of materials to provide increased rigidity. Suitable materials include metals such as aluminum, bronze, copper, brass, steel, and the like, natural and synthetic rubbers, resins, waterproofed cardboard, and similar water resistant materials having the structural strength to withstand the hydrostatic pressure at the predetermined firing depth. The material of construction also should be chemically inert to the extrudable cap-sensitive explosive composition.

The extrudable cap-sensitive explosive composition is preferably thixotropic and of a viscosity which will prevent premature flow. A suitable extrudable explosive may contain a normally crystalline cap-sensitive detonating explosive, e.g., pentaerythritol tetranitrate (PETN), cyclotetramethylenetetranitramine (HMX), tetryl, cyclotrimethylenetrinitramine (RDX), TNT, ammonium nitrate, etc. or a noncrystalline explosive such as nitroglycerine dispersed in a gel-like matrix so that the composition possesses the flow properties requisite for proper functioning of the booster at the predetermined hydrostatic pressure. The matrix may be of an explosive nature or of a composition inert to and compatible with the explosive. Exemplary matrices include triethylene glycol dinitrate, acetyl butyl citrate, and low-molecular weight rubbers such as polyisobutylene. Effective ratios in the composition may be varied to give a composition of the requisite flow properties for use at a predetermined pressure.

As stated, the distance between the base of the initiator and the upper surface of the extrudable detonating explosive in the readily deformable section must be such that the initiation impulse produced upon actuation of the initiator will not initiate the explosive composition when the booster is under less than the predetermined pressure. The space required depends to a large extent upon the "gap sensitivity" of the extrudable cap-sensitive detonating explosive. The "gap sensitivity" is defined as the minimum distance (or air-gap) over which the explosive composition will be initiated by the stimulus of a conventional initiator. The following table gives gap sensitivity values for representative compositions with respect to a conventional No. 6 electric blasting cap.

Table 1

Extrudable explosive:	Gap sensitivity (inches)
PETN/triethylene glycol dinitrate	1/4
PETN/nitrocotton/acetyl tributyl citrate	1/8
PETN/isobutylene	1/8
Nitroglycerine/gelling agent	1/8

Primarily, those compositions having a gap sensitivity within the range of 1/8 to 3/8 inch will be most suitable for use in this invention. Compositions having a gap sensitivity of greater than 1 inch will in general be too sensitive to insure non-initiation at low pressures. On the other hand, compositions having an air-gap sensitivity of less than 1/16 would not be suitable since the composition would be, in general, too insensitive for reliable operation.

A variety of initiator assemblies may be used to actuate the booster of this invention. A pressure-actuated initiator is particularly suitable since both the initiator and booster can be constructed so that reliable initiation and detonation of the booster will occur only at the predetermined depth, i.e., pressure. However, if desired, the booster may be actuated at the desired depth by means of a conventional electric initiator or electric delay initiator fired by a bridgewire in a loose ignition composition, a bridgewire and bead arrangement, an "exploding" bridgewire or an arc-firing system, in which cases the lead wires extend to a source of electric current at the surface of the water and the sink rate of the device is known, to a water-actuated battery, or to a pressure-sensitive switch which will fire the assembly at the predetermined depth.

Baffling between the deformable section and the initiator present in preferred embodiments of this invention may be provided simply by decreasing the diameter of the tubular container at the desired point, e.g., by forming a deep, circumferential crimp, or by inserting an obstructing element, such as, for example, a rectangular plate having diagonally opposed corners folded in opposite directions into the open space within the rigid section during assembly of the unit.

The foregoing description has been given for clearness of understanding only and no undue limitations are to be construed therefrom. The invention is not limited to the precise details shown and exemplified since various modifications which do not materially alter the basic character of the invention or depart from the spirit and scope of the invention will occur to those skilled in the art. It is intended, therefore, to be limited only by the following claims.

What is claimed is:

1. An explosive booster assembly for underwater use comprising a tubular container, one section thereof being readily deformable and another section thereof being rigid and resistant to deformation, the readily deformable section being closed at the end most remote from the said rigid section, an extrudable cap-sensitive detonating explosive filling the deformable section, and an initiator disposed within the said rigid section and separated from the deformable section by a distance sufficient that the initiation impulse upon actuation of said initiator will not initiate said explosive contained in said deformable section, the walls of said deformable section being adapted to collapse under pressure to force said extrudable explosive into propagating relationship with said initiator.

2. A booster as in claim 1 wherein a baffling means is contained within the space between the said extrudable cap-sensitive detonating explosive and the said initiator.

3. A booster as in claim 1 wherein the readily deformable section of the said container is surrounded by a tubular shield adapted to prevent accidental deformation of said deformable section resulting in premature arming.

4. A booster as in claim 1 wherein said extrudable cap-sensitive explosive composition is selected from the group consisting of a mixture of pentaerythritol tetranitrate and triethylene glycol dinitrate; a mixture of pentaerythritol tetranitrate, nitrocotton, and acetyl tributyl citrate; and a mixture of pentaerythritol tetranitrate and a low molecular weigh rubber.

5. A booster as in claim 1 wherein said extrudable cap-sensitive explosive composition is selected from the group consisting of a mixture of cyclotrimethylenetrinitramine and triethylene glycol dinitrate; a mixture of cyclotrimethylenetrinitramine, nitrocotton and acetyl tributyl citrate; and a mixture of cyclotrimethylenetrinitramine and a low molecular weight rubber.

6. A booster as in claim 1 wherein said extrudable cap-sensitive explosive composition is selected from the group consisting of a mixture of cyclotetramethylenetetramine and triethylene glycol dinitrate; a mixture of cyclotetramethylenetetranitramine, nitrocotton and acetyl tributyl citrate; and a mixture of cyclotetramethylenetetranitramine and a low molecular weight rubber.

7. An explosive booster assembly for underwater use comprising a bissectional tubular container, one section thereof being readily deformable and the other section thereof being rigid and resistant to deformation, said readily deformable section being closed at the end most remote from said rigid section, an extrudable cap-sensitive detonating explosive filling the deformable section, and a pressure-responsive initiator disposed within said rigid section and separated from the deformable section by a distance sufficient that the initiation impulse upon actuation of said initiator will not initiate said explosive contained in said deformable section, the walls of said deformable section being adapted to collapse under pressure to force said extrudable explosive into propagating relationship with said initiator.

8. The booster of claim 1 wherein said extrudable cap-sensitive explosive composition is a mixture of nitroglycerine and a plasticizer.

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