

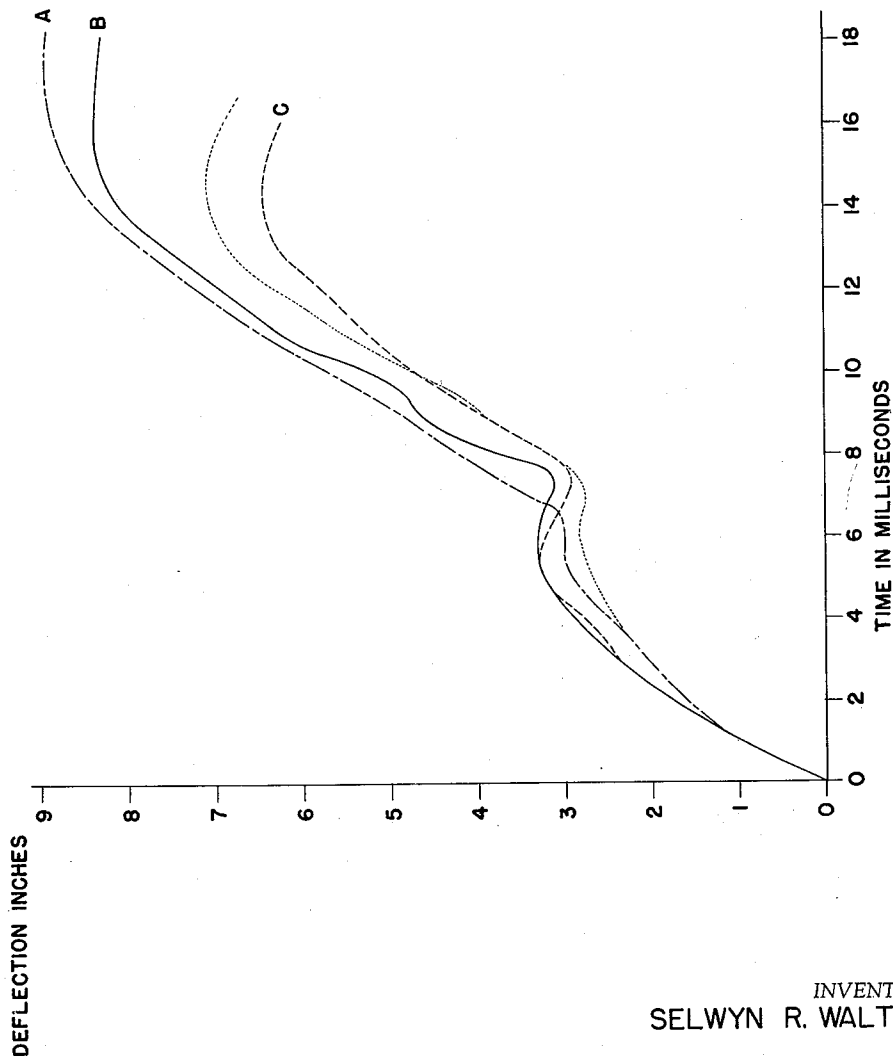
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HIGH EXPLOSIVE FILLER FOR NAVAL UNDERWATER MUNITIONS

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1

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HIGH EXPLOSIVE FILLER FOR NAVAL UNDERWATER MUNITIONS

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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 to an improved underwater explosive and more particularly to an underwater explosive mixture of a type comprising as the active explosive ingredients thereof, a mixture of cyclotrimethylenetrinitramine hereinafter referred to as RDX and trinitrotoluene similarly designated as TNT, and a more effective afterflow agent in a castable admixture therewith.

The instant invention employs a high relative percentage of aluminum dispersed therein which functions in a capacity to greatly increase the underwater bubble pulse energy effect accompanying the shock wave action of the explosive, and which effect occurs subsequent thereto to greatly increase the overall effectiveness of the explosive cycle in an underwater environment.

Aluminum as previously added to various explosive mixtures has been utilized in relatively small percentages and directed to the purpose of cooperation in the initial discharge impact to increase the dynamic energy of the shock wave phase thereof. The optimum results in this respect as determined by shock wave effect testing were believed to be obtained with proportionate quantities of approximately 10% to 20% aluminum depending on the type and prospective use of the particular explosive. With a mixture of RDX and TNT the amount of aluminum added was approximately 18% and with mixtures of pentaerythritoltetranitrate hereinafter designated PETN and TNT the additive quantity of aluminum was approximately 20%. The amount of aluminum added to TNT when used alone was approximately 20%. However, these values as derived with the intent of increasing the initial explosive effect were predicated on test information indicative of the maximum shock wave energy created by the explosive. This was usually measured by recordings of the shock wave caused by the explosion in water or other data obtained by such means as measurement of the deformation or dishing of a diaphragm located in the vicinity thereof or by other criteria, such as deformation of test cylinders and other targets, indicative of the apparent effectiveness of the explosive. However, it has been determined by these methods that the underwater effectiveness of an explosive involves consideration of the several phases of the entire destructive cycle of an underwater explosion.

For a better consideration of the several phases of the destructive cycle, it is well to have an appreciation of the phenomena that occur during the underwater explosion. When a high explosive is detonated under water, the water is initially disturbed by a pressure wave in the reacting explosive and the disturbance is propagated outwardly at very high velocity as a compressive wave which is referred to as a shock wave. The pressure rise is so rapid that it is for all practical purposes discontin-

2

ous and then decays roughly exponentially. This phase is hereinafter designated as the primary or shock wave phase and the energy transmitted during this phase is hereinafter called shock wave energy. When the detonation is complete, there is a very dense mass of gases resulting from the explosion which constitutes a gas sphere or bubble that begins to expand and move the water radially outwardly at great speed. This phase immediately follows the shock wave phase and is hereinafter designated as the secondary or afterflow phase and the energy transmitted during this phase is called afterflow energy. There is a rapid increase in the diameter of the gas sphere or bubble over a relatively long time with the internal gas pressure diminishing gradually. However, the movement of the water continues due to inertia and later as the gas pressure falls below the equilibrium hydrostatic pressure of the water, the outward movement of the water ceases and the bubble begins to contract at an increasing rate. This contraction proceeds until the compressibility of the gas acts to reverse the motion abruptly. Thus, the inertia of the water along with the elastic characteristics of the gas and water produce the necessary conditions for an oscillating system; the bubble in fact undergoing cycles of expansion and contraction which diminish in magnitude with the passage of time. This phase is hereinafter designated as the final or bubble pulse phase and the energy transmitted during this phase is referred to as bubble pulse energy.

It is thus seen that the initial destructive portion of the cycle occurs immediately after detonation and is designated the primary or shock wave phase, which is immediately thereafter followed by a secondary destructive effect hereinafter designated as the secondary or afterflow phase. Additional impact is imparted through the water during the remaining portion or final phase of the cycle, also known as the gas globe or bubble pulse phase, which follows the afterflow phase. The final phase of the complete cycle comprises a series of bubble pulses of destructive energy which occur in an appreciable time delay relationship with respect to the primary and secondary phases. The time delay between the shock wave and the afterflow being in the order of a few milliseconds, and the bubble pulses of the final phase or gas globe phase being of an order extending to hundreds of milliseconds. The bubble pulses of destructive energy are emitted in timed delayed relationship with respect to the preceding pulses and the intensity of each pulse is in inverse proportion with respect to time whereby the frequency thereof provides an indication as to the degree of the destructive effect. The time delay between the afterflow and the first bubble pulse also provides a measurable indication of the proportions of the damaging effect thereof.

Both afterflow energy and bubble energy have the same source, namely the residual energy of the gas globe which contains the reaction products of the explosive after emission of the shock wave.

The method of determining the destructive effect of the energy of the bubble pulse or gas globe differs from the method of taking measurements of the shock wave, in that a measurement of the bubble pulse energy of an underwater explosion generally is not obtained or derived from pressure recordings as is the case for shock wave energy; but rather from either the determination of the comparative maximum sizes of the gas globes, or from measurements of the delay period between the shock wave and accompanying afterflow and the first gas globe or bubble pulsation therefollowing. It has been determined by test procedures that the afterflow energy as well as the bubble energy is of considerable effect in producing damage to the hull of a ship like

structure. The afterflow energy has been shown to be effective in underwater explosions particularly when directed against structures of a relatively thin wall type, in which the wall member is subject to deflection accompanying the explosion, such for example, as a relatively thin air backed plate or as hereinabove stated the hull of a ship. A complete explanation of the explosive phenomenon is not herein set forth since the theoretical and practical aspects thereof are quite involved and therefore do not lend to a simple explanation. It will suffice for purposes of background understanding to state that the explosive effect sequence appears to present a deformation condition of the hull with the initial shock wave which produces cavitation of the air backed plate or the hull as the case may be adjacent to the surface thereof. When this cavitated space is closed by the surrounding water which is also under shock wave-transmitted energy effects and at approximately the same time as the deformed area of the hull or the plate comes to rest under the impact, the afterflow energy produces further deflection of a much higher degree. The afterflow has little effect on the heavy or rigid plate, however, if the plate is relatively thin and is subject to yielding action under shock wave influences, the afterflow builds up pressure and assumes greater importance, the ultimate result of which has not heretofore been obvious.

A reloading action takes place in the cycle and follows immediately after the initial shock wave. Apparently, it is due to the closing of the cavitated space formed adjacent to the plate by the shock wave. A secondary pressure pulse is thus built up in a manner to contribute considerably to the overall damage. The energy of this pulse is mainly afterflow energy.

In accordance with the hereinbefore outlined theory of the underwater explosive cycle, the complete damage process with respect to air backed plates can be summarized as follows:

With the initial explosion there occurs a very intense force or push due to the shock wave impact. The plate is accelerated to a high velocity and as it comes to rest thereafter the energy of the cavitated water in particle or spray form is transmitted as afterflow energy to the plate.

At the momentary condition when the plate comes to rest, the cavitated space is substantially simultaneously closed to provide a second push which occurs in cyclic relationship thereto and which again accelerates the plate in a manner to further increase the deflection thereof to a considerable extent. The energy of this second push is almost exclusively afterflow energy.

The amount of deflection caused by the second push with explosives of the instant invention is of the same order of magnitude as that caused by the shock wave. This evidences the fact that the afterflow energy is an important factor for consideration in comparing explosives.

Another decisive factor in the damage mechanism to ships or submarines is the migration of the bubble which contains the reaction products of the explosive. The hull of a ship or a submarine attracts this bubble in such a way that the bubble pulses are produced close to the target. This makes the bubble pulses very effective in doing damage. At or within a critical distance which depends upon the size of the explosive charge and the depth at which it is detonated submarine hulls seem to be broken or split by the bubble pulse energy. The migration is further transmitted by gravitational forces as the explosion takes place beneath the target. All these migratory effects are considerably enhanced if the bubble pulses are increased.

In accordance with the present invention aluminum is added to the herein recited explosives in percentages well over the 18 or 20% proportions which were previously considered to be the optimum, and preferably

wherein a quantitative proportion within the range of 25 to 40% of aluminum is added.

The addition of these extremely high percentages of aluminum would appear under cursory determinations to decrease the effectiveness of the explosive, and such observation would be borne out by the usual tests enumerated above. It has been found, however, that the additional aluminum, while it does not function to increase the shock wave energy, does function to greatly increase the afterflow phase and the resultant destructive overall effect of the explosive as well as the bubble energy level, the singular effect of which causes most of the damage in underwater explosion. The addition of aluminum in amounts substantially above 40% reduces the overall destructive effect of the explosive and is undesirable.

One object of the present invention is to provide an explosive having increased underwater effectiveness against submerged targets.

It is a further object of the present invention to provide an underwater explosive having increased bubble pulse or afterflow energy.

It is another object of the present invention to provide an underwater explosive having a high percentage of aluminum which substantially increases the afterflow energy.

Another object of the present invention is to provide an underwater explosive comprising a high percentage of aluminum and which is castable for filling cavities in underwater ordnance devices.

Other objects and advantages of this invention will appear or be obvious from the hereinafter set forth description of the invention as will be better understood by reference to the following complete description and accompanying drawing.

The drawing illustrates the plate deflection curves for four different explosives.

Referring now to the drawing the curves illustrated are based on tests performed on a relatively thin air-backed plate submerged under water with explosions produced by equal weights of explosive located at a fixed distance from the plate. The deflection in inches is plotted against the time in milliseconds and indicates the relative effectiveness of three different types of explosives compared to TNT as a standard or control. Curve A is a plotting of the overall effectiveness of an RDX, TNT, Al mixture in the proportions of 50, 10, 40 with the several phase effects represented in chronological order. Curve B is similarly derived, and characterizes an RDX, TNT, Al mixture in the proportions 42, 40, 18, while curve C is for a PETN, TNT mixture proportioned 50, 50. Curve TNT is the comparison or standard curve.

The deflection caused by the shock wave energy of the initial phase is indicated in the first part of the curve from 0 to about 5 milliseconds at which time the deflection levels off to a substantially constant value indicating that the plate has come to rest. Subsequently the afterflow energy becomes effective and causes up to three times the deflection caused by the shock wave energy from about 7 milliseconds to 18 milliseconds.

It will be obvious in comparing these three explosives that explosives B and C have substantially the same shock wave energy but explosive C which contains no aluminum has substantially less afterflow energy whereas explosive B containing 18% aluminum has about twice the afterflow energy shown for explosive C. Explosive A which contains 40% aluminum and is illustrative of one specific embodiment of the present invention shows a marked decrease in the shock wave energy but a substantial increase in afterflow energy over that indicated for explosive B with a smaller percentage of aluminum which would indicate, according to previous standards, that explosive A was a less effective explosive but actually explosive A causes almost twice the damage to an under-

water target, particularly when considered on an equal volume basis since the curves shown are on an equal weight basis, and explosive A has a higher density or weight per cubic foot than either explosive B or explosive C. Adding aluminum to an explosive usually increases the explosion energy, but the aluminum can only react partially in the detonation front. This makes it understandable that a maximum shock wave energy exists for a certain percentage of aluminum, if a series of explosions with increasing aluminum content is considered. An increase in the aluminum amount in excess of the one for the maximum shock wave will decrease the shock wave energy, as shown by the graph in the drawing, but the afterflow energy still increases because it is emitted at a later time and its maximum is reached at a considerably higher aluminum content.

The following charts, which are based on an equivalent charge of TNT having a factor of one and on an equal weight basis with explosives A, B, C, indicate the relative energies and damage effects of the shock wave and afterflow phases of the explosives when compared to TNT, which is used as a standard or control. An inspection of the Damage chart will disclose that while the effect upon test devices by the shock wave energy of explosive A, which contains an unusually high percentage (40%) of aluminum is somewhat less than that by the shock wave energy of explosive B, which contains the usual percentage (18%) of aluminum, the effect due to the afterflow energy of explosive A is considerably greater than that due to the afterflow energy of explosive B. In the drawing, curves A and B illustrate these relations graphically, it being noted that initially curve A is below curve B but later the reverse is true. The charts also indicate that in the case of explosive A the ratio of the afterflow energy to the shock wave energy is almost two to one whereas in the case of explosive B the ratio is practically unity. The foregoing would indicate the novel and unexpected advantages of using percentages of aluminum in underwater explosives well beyond those ordinarily employed.

	TNT	C	B	A
Shock wave--(Peak pressure.....)	1.00	1.24	1.26	0.99
(Energy.....)	1.00	1.30	1.48	0.98
After flow energy.....	1.00	1.06	1.44	1.89
Damage.....(Shock wave phase.....)	1.00	1.30	1.46	1.15
(Afterflow phase.....)	1.00	0.80	1.45	1.81

A comparison of these explosives on an equal volume basis would indicate even more clearly the novel and unexpected advantages of adding aluminum beyond the percentages indicated by the criteria previously used in evaluating explosives.

The above charts indicate that the afterflow energy constitutes a major portion of the mechanical energy of the water and that most of this energy contributes to the damage phenomena. Until recently the influence of the afterflow has been neglected principally because no pressure is connected with the afterflow. Even in the case of an explosion near an infinitely heavy and infinitely rigid plate, the afterflow contributes nothing to the pressure which is built up on the surface of this plate.

The preferred form of the present invention consists of mixture of RDX in the form of rounded or globular particles of varying sizes which are distributed throughout the mixture, TNT, and aluminum in the form of discrete rounded particles of a small size uniformly dis-

tributed throughout the mixture. The preferred percentages of these essential ingredients are from about 33% to about 40% RDX, from about 25% to 32% TNT and from about 25% to about 40% aluminum.

It is frequently desirable to add a desensitizer to the essential ingredients of the explosive composition and with this particular explosive it is also desirable to add a small percentage of calcium chloride to reduce gas developed on long storage. The desensitizer preferably consists of a mixture approximately 84% wax, such as a high melting point paraffin, 14% nitrocellulose and 2% lecithin. However, other suitable desensitizers may also be used. When a desensitizer is added the preferred percentages are from about 31% to about 38% RDX, from about 22% to about 29% TNT, from about 25% to about 40% aluminum, about 5% of a suitable desensitizer and an additional amount of about 0.5% of calcium chloride.

As noted above, the RDX and the aluminum, both in the form of rounded particles, may be simply mixed together with the TNT so that the components of the mixture are uniformly dispersed and poured into a mine or like. By virtue of the shape of the particles the mixture is readily pourable.

Alternatively, if desired the RDX and TNT may be mixed and melted, the aluminum particles uniformly dispersed therein and the molten composition poured into any desired container. The high percentage of aluminum tends to reduce fluidity and increase viscosity; however, using rounded particles of aluminum and RDX offsets the reduction in fluidity and thus reduces the viscosity of the molten mixture so that it may be cast with ease.

What is claimed as new and desired to be secured by Letters Patent is:

1. A low viscosity castable underwater explosive consisting essentially of from about 33% to about 40% RDX, from about 25% to about 32% TNT, and from about 25% to about 40% aluminum.

2. A low viscosity castable underwater explosive consisting essentially of from about 31% to about 38% RDX, from about 22% to about 29% TNT, from about 25% to about 40% aluminum, about 5% of a desensitizer, said amount of desensitizer consisting essentially of about 84% paraffin wax, about 14% nitrocellulose and about 2% lecithin, and an additional amount of about 0.5% of calcium chloride.

3. An underwater explosive mixture consisting of about 50% RDX, about 10% TNT and about 40% aluminum.

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