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HIGH BLAST METAL-OXYGEN REACTION EXPLOSIVE

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This invention relates to explosives and, more particularly, to a high blast explosive having a large effective range.

It is a main object of this invention to provide an explosive particularly adapted for use in ammunition for aircraft destruction, though its high blast and high temperature properties render it effective for other purposes where these properties are importantly involved.

Explosives of this invention rely, for their effective blast, upon a metal-oxygen reaction and are, hence, so compounded as to include as large a proportion of metal as is consistent with the inclusion of only so many other ingredients as to insure efficient metal-oxygen reaction in the form of a nearly instantaneous explosion.

That kind of reaction is dependent upon the presence at the instant of final blast of sufficient oxygen in such active form and so distributed throughout the reaction zone as to react practically instantaneously with the metal present at the prevailing temperature and pressure.

Requisite ingredients in addition to the metal are, hence, (2) a source of oxygen of such nature and so distributed as to release the necessary amount of oxygen in the proper active form and properly distributed, at the prevailing temperature, and (3) a source of heat in the form of an explosive, both for liberating the oxygen from its source, usually by decomposition of an oxidant, and for raising the temperature in the reaction zone within a fraction of a second to a temperature conducive to the production of a metal-oxygen reaction.

This invention coordinates the assemblage and intimate association of the ingredients (2) and (3) with the metal in such manner that the metal is usually the predominant, and preferably the major, constituent of the mixture by weight. However, in the case of the lighter metals weighing less than about 20 grams per mole, the metal may be less than the predominant constituent by weight, provided it remains the predominant constituent on a molar basis. As a consequence, there occurs, upon detonation, a metal-oxygen reaction (explosion) of substantially greater vigor than has heretofore been achieved.

A principal feature of the invention thus resides in the utilization of a minimum quantity of oxygen source and heat source, and preferably of both. Optimum results are obtained by the inclusion of no oxidant in excess of that required for efficient consumption of the metal and by the inclusion of only that amount of explosive which is necessary both to liberate the oxygen from its source and to produce conditions of pressure and temperature for initiating the metal-oxygen reaction.

Experience with high proportion metal compositions of this invention indicates that there appears first a relatively weak slow broad detonation which traverses the charge, consuming little, if any, of the metal present, but rather creating (usually in a period not exceeding one milli-second) a homogeneous vapor or gas cloud containing very reactive particles of the non-metallic ingredients and vaporized metal particles, under great pressure. The source of heat, in the form of an explosive ingredient, is thus chosen for its ability to provide in the amount used the thermo-dynamic heat requirements for accomplishing such gasification. After a period of expansion of this gas cloud and constituting a probable second phase, a second reaction takes place in a third phase

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with incredible rapidity (of the order of 10 to 50 microseconds) releasing the major portion of the potential energy.

In the case of a 20 mm. H.E. projectile loaded with approximately 12 grams of an explosive in accordance with this invention plus 2 grams of an H.E. booster, the fragment size is wholly determined by the nature of the first two phases while the third phase occurs after fragmentation. The shock wave generated by this third phase has an intensity which appears to be independent of the oxygen content of the surroundings, but is propagated in a manner determined by the physical and physico-chemical nature of the surroundings. This characteristic is of importance in high altitude detonation. The effectiveness of explosives of this invention appears to be less affected at high altitude than most explosives.

In order to attain such performance, it can be seen that the oxidant is so chosen that its oxygen, though liberated during the first phase, does not absorb so much of the booster energy provided by the explosive as to detract detrimentally from the heat available for satisfying the thermo-dynamic gasification requirements of the particular metal or metals present.

Similarly, it is desirable that the non-metallic residue remaining after oxygen liberation do not compete unfavorably with the gasified metal for the released oxygen. Expressed physically, this means that the number of effective atomic collisions between metal and oxygen in a single unit of time be maintained above a critical minimum value. Expressed chemically, conditions are preferably such that there is a preferential combination of metal and oxygen over other oxide formation.

Typical formulations in accordance with this invention are as follows:

Example.....	I	II	III	IV	V
Metal:					
Atomized aluminum.....		27			
Atomized magnesium.....		27	7		
Dichromated atomized aluminum.....	54		27	36	42
Nickel powder.....			20		
Nickel-clad zirconium.....				18	
Oxidant:					
Ammonium perchlorate.....	36	36	36	28	
Potassium nitrate.....					28
Explosive:					
TNT (trinitrotoluene).....	4			8	
97/3 RDX (cyclotrimethylenetri- nitramine).....	6				
Tetryl (2,4,6-trinitrophenolmethyl- nitramine).....		10	10	10	30
Binders and Lubricants (Optional):					
Calcium Stearate.....	2	2	2	2	2
Graphite.....	1	1	1	1	1

The formulation of Example I may be compounded as follows: Granulated ammonium perchlorate is dried in an open vessel for 24-48 hours at approximately 120-130° F. to insure freedom from moisture. The TNT is placed in a steam-jacketed kettle with an agitator and melted, a temperature of around 90-95° C. being suitable. The dry ammonium perchlorate is then added gradually to the molten TNT with agitation. Agitation is continued for 30 minutes to render the mass homogeneous. The mixture, while still hot, is then put through a granulator and allowed to cool. This method of preparation provides a fine free-flowing powder. This material is then fed into a twin-shell blender with dichromated atomized aluminum powder of 200 mesh particle size. The remaining explosive and the binder and lubricant, if used, are also added to this blend.

This method of preparation, and particularly the coating of the oxidant with the TNT, has the advantage of producing better handling qualities since there is less dusting, better flowability and increased density, the latter also contributing to better performance. The coat-

ing operation, however, is not essential and other methods of preparation may be utilized.

Such an explosive in chamber and target tests (as specified at the end of this application) of loaded 20 millimeter RM-97 projectiles provides a chamber pressure in excess of 16.0 p.s.i. and a 20-inch target rating in excess of 8, with contrast with normal explosive chamber pressures of approximately 2-13 p.s.i. and 20-inch target ratings sometimes as high as 4 but more often 1 or 2.

Moreover, explosives of this invention do not exhibit a significant case-charge effect.

These results evidence the efficient consumption during the critical phase of the reaction of at least a substantial portion of the metal present.

In Example IV, the ratio of ammonium perchlorate to TNT used in the coating operation was 78.3 to 21.7, instead of the 90 to 10 ratio of Example I, the total coated perchlorate remaining 36% as in Example I.

As will be seen from the formulae, the substitution in Example V of potassium nitrate for ammonium perchlorate necessitates an increase in the amount of explosive, whereas, in Example IV, the use of a less active metal also required an increase in explosive at the cost of the oxidant content.

While the above formulations are compounded with the metals aluminum, magnesium and nickel-clad zirconium, other metals or metal alloys may be substituted in whole or in part including magnesium-aluminum alloy 50/50, magnesium boride, titanium, titanium-nickel alloy, titanium hydride, vanadium, zirconium, zirconium-nickel alloy 70/30, silicon, zinc, nickel and antimony.

In addition to ammonium perchlorate, other inorganic perchlorates, chlorates, nitrates or oxidants used in conventional explosives, and other inorganic nitrates besides potassium nitrate may be utilized provided the metal-oxidant-explosive ratio is suitably adjusted.

By and large, the metal oxidant weight ratio should be approximately 3:2 for optimum results in the case of ammonium perchlorate and with the explosive constituting not substantially more than 10% of the total weight of the metal, oxidant and explosive. As heretofore indicated, the metal should comprise the predominant constituent on a molar basis of the three essential ingredients of the explosive. Suitable ranges are:

	Percent
Metal	20-70
Oxidant	10-65
Explosive	5-50

CHAMBER TEST

The chamber is cubic in shape, internal dimensions 3 feet by 3 feet and made of ½ inch steel plate. The cover of a flanged manhole (sealed with an O ring) is provided with a drilled, threaded 1½ inch solid plug for ease of loading and an exit for the detonating cap lead wires. The gauge used is a 12 inch Bourdon-type Foxboro pressure recording instrument, range 0 to 50 pounds per square inch.

In testing, the round, fuzed for static firing with an M75 fuze, and No. 6 electric detonating cap, is lowered to the approximate vertical center of the chamber, the lead wires fed through the drilled plug, twisted to suspend the round in the chamber, and connected to a firing line sufficiently long to reach outside the chamber house. Firing of the round is accomplished by using a ten-shot electric generator; the pressure is automatically recorded on the gauge chart.

TARGET TEST

The targets consist of a cubic (20 inches to a side) welded angle iron box, the six sides of which are covered with separate panels of sheet aluminum. The panels are held in place by retaining bars, or frames, secured to the angle iron frame by bolts and wing nuts.

The angle iron and retaining bars are made from 1½ x ¾ stock.

The sheet aluminum of which the box panels were constructed is .032 inch thick—24ST-3 AN-A-12.

The target is supported by an open angle iron stand.

For testing, the top panel of the aluminum box is drilled to accommodate the test round. This, fuzed and provided with a No. 6 electric detonating cap, is suspended by the detonating cap lead wires at the center of the box.

Target damage is evaluated primarily with two factors in mind:

- (1) Removal, peeling-back, or rupturing of panels.
- (2) Production of bulge in intact panels.

The following evaluation code is used:

Assessment of target damage code

Description of Damage	Numerical Rating
Bulge in intact panel—0 inches.....	0
Bulge in intact panel—0 to 1 inches.....	1
Bulge in intact panel—1 to 2 inches.....	2
Bulge in intact panel—2 to 3 inches.....	3
Bulge in intact panel—3 to 4 inches.....	4
One panel blown off, peeled or ruptured.....	5
Two panels blown off, peeled or ruptured.....	6
Three panels blown off, peeled or ruptured.....	7
Four panels blown off, peeled or ruptured.....	8
Five panels blown off, peeled or ruptured.....	9
Six (all) blown off, peeled or ruptured.....	10

I claim:

1. An explosive composition for use in a high blast projectile consisting essentially of a finely divided mixture of from about 20% to about 70% by weight of a finely divided material selected from the group consisting of aluminum, dichromated atomized aluminum, magnesium, nickel clad zirconium, 50/50 magnesium-aluminum alloy, magnesium boride, titanium, titanium-nickel alloy, titanium hydride, vanadium, zirconium, 70/30 zirconium-nickel alloy, silicon, zinc, nickel, antimony, and mixtures of the foregoing materials, from about 10% to about 65% by weight of a finely divided oxidant selected from the group consisting of ammonium perchlorate and potassium nitrate, and from about 5% to about 50% by weight of a finely divided explosive selected from the group consisting of TNT, 97/3 RDX/wax and tetryl, and mixtures thereof, said composition being substantially oxygen balanced with respect to the metal therein.

2. The explosive composition consisting essentially of about 54% by weight of dichromated atomized aluminum, about 36% by weight of ammonium perchlorate, about 4% by weight of TNT and about 6% by weight of 97/3 RDX/wax.

3. The explosive composition consisting essentially of about 27% by weight of atomized aluminum, about 27% by weight of atomized magnesium, about 36% by weight of ammonium perchlorate and about 10% by weight of tetryl.

4. The explosive composition consisting essentially of about 7% by weight of atomized magnesium, about 27% by weight of dichromated atomized aluminum, about 20% by weight of nickel, about 36% by weight of ammonium perchlorate and about 10% by weight of tetryl.

References Cited in the file of this patent

UNITED STATES PATENTS

1,301,646	Burrows et al.	Apr. 22, 1919
1,705,874	Olsen	Mar. 19, 1929
2,473,405	Zebree	June 14, 1949
2,669,182	Weiss	Feb. 16, 1954

FOREIGN PATENTS

18,551	Great Britain	1909
408,260	Great Britain	Mar. 26, 1934
402,862	Italy	Mar. 27, 1943