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[54] PROJECTILE CONTAINING PYROTECHNIC COMPOSITION FOR REDUCING BASE DRAG THEREOF

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[58] **Field of Search** 149/43, 44, 61; 102/49.3

[56] **References Cited**
UNITED STATES PATENTS

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[57] **ABSTRACT**

Cartridge employing projectile which carries an improved pyrotechnic composition in a posterior cavity thereof, the pyrotechnic composition emitting gaseous reaction products upon ignition thereof to fill the void or low pressure area rearward the moving projectile to thus reduce drag on the projectile in flight, said pyrotechnic composition comprising by weight about 20-35 percent magnesium, about 47-58 percent strontium nitrate, about 6-12 percent calcium resinate, and about 1-12 percent gelatin.

7 Claims, No Drawings

PROJECTILE CONTAINING PYROTECHNIC COMPOSITION FOR REDUCING BASE DRAG THEREOF

The invention described herein may be manufactured, used and licensed by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to projectiles and more particularly to improved pyrotechnic compositions for reducing projectile drag.

A conventional bullet in flight forms a partial vacuum immediately therebehind. This partial vacuum or low pressure area creates a force which acts on the projectile in a direction opposite its motion thereby lessening the flight velocity of the projectile. This force is commonly referred to as "base drag". Drag may be defined as that force acting on the projectile in a direction opposite its motion. Base drag is that drag acting on the projectile at its base, and this invention concerns itself primarily with base drag and the reduction thereof.

Until the present time, no satisfactory means has been found for counteracting base drag. Conventional tracer bullets have reduced total drag by about 9.3 percent and base drag about 18.6 percent over comparable inert rounds, with attendant increases of velocity of about 4 percent, due to the rearward pressures exerted by the reaction gases formed during combustion of the tracer compositions. It would be desirable, however, if base drag could be further reduced or substantially eliminated, thus providing our fighting forces with more effective weapons having greater striking power.

It is thus a principal object of this invention to provide improved pyrotechnic compositions for reducing projectile drag.

It is a further object of this invention to provide projectiles with greater velocities and striking energies.

These and further objects will be apparent from the following discussion.

Briefly, I have discovered that if pyrotechnic compositions to be described hereafter are placed in a rearward cavity of a projectile, combustion of this pyrotechnic composition during the flight of the projectile will cause a high pressure gas to be emitted into the otherwise low pressure area behind the projectile and thereby reduce the base drag of the projectile. Pressures of approximately 12 pounds per square inch are produced in the low pressure region rearward the projectile during combustion of my pyrotechnic compositions as compared to pressures of only 9.0 pounds per square inch when a standard, unignitable, inert filled round is used. Pressures have been measured using a wind tunnel, Pitot tubes, and pressure transducers. The production of ambient pressure in the otherwise low pressure area will give optimal drag reducing results, while pressures exceeding ambient will cause dispersion of the bullet or projectile. The projectiles containing these improved pyrotechnic compositions may be referred to as "fumers". The pyrotechnic mixtures thereof should preferably burn to yield temperatures of at least 2,700°C to insure the production of sufficient pressure. It is well known that the pressure of a confined gas increases as its temperature is raised. It is the filling of the void rearward the projectile with these gases, not exceeding ambient pressure, that reduces projectile drag and makes my inventive compositions so effective. In contrast therewith, conventional tracer compositions, among other things, generally burn to yield temperatures of only about 2,200°C and thus produce considerably less gas pressure. Further, the burning time of my pyrotechnic compositions used in my fumers is of sufficient duration so as to emit products of combustion over the effective range of the projectile. Tracer bullet compositions, on the other hand, possess generally shorter burning times since initial visibility of the projectile is their primary concern. Accordingly, a fumer will utilize typically about 20 percent by weight more pyrotechnic material than will a tracer for projectile of comparable dimensions. To insure the proper burning time, factors must be considered such as the burning rate and column length of the pyrotechnic composition. For 7.62 mm projectiles, composition burning rates of about 0.080–0.250 inches per second will be employed in the practice of this invention, the preferred burning rate being about 0.128 inches per second, at which pressures of approximately 12 psi are produced in the low pressure region rearward the projectile. My compositions worked admirably well in 20 and 30 mm projectiles, as well as in 7.62 mm projectiles, although burning rates were not identical thereto. Another factor influencing burning time is the column length required for the pyrotechnic composition, which is readily calculable by merely multiplying the burning rate by the length of time of flight of the effective range of the projectile. For smaller caliber ammunition, the column length will generally be shorter but the burning rate will remain approximately the same. Similarly, for larger caliber ammunition, the column length will be longer, the burning rate again remaining approximately the same. The diameter of the generally cylindrical column of pyrotechnic composition is such that it will be approximately 75–85 percent the diameter of the projectile, but preferably 80 percent. With dimensions such as described above, gas pressure effectively reducing drag will be produced for projectiles of varying configuration and sizes. Additionally, and of significant import, the products of combustion of my improved compositions used in my fumers have a low molecular weight, the average being 30 grams per mole or lower. A gas of low molecular weight exerts as much pressure per mole as a gas of considerably higher molecular weight at the same temperature and volume. With few exceptions, however, those pyrotechnic formulations producing low molecular gaseous products are capable of being packed into a lesser volume. Typically, the combustion products emitted into the low pressure area by conventional tracers have average molecular weights as high as 45 to 50 grams per mole. Finally, the composition of my pyrotechnic composition is such that the ingredients thereof are present in approximately stoichiometric proportions to thus provide the highest combustion temperatures per unit weight of formulation and thereby maximize the pressure of the emitted gas.

Standard tracer projectile manufacturing techniques will be used in making the projectiles of my invention, my compositions being placed in the posterior cavities thereof. Illustrative of the relative weights of my pyrotechnic composition to various projectile weights, a 7.62 mm caliber projectile weighing 8.6 grams will require about 0.55 grams of pyrotechnic composition. Similarly, a 20 mm projectile weighing 120 grams will require about 5.0 grams. Standard and diverse means well known in the art, for propelling the projectile may be employed in the practice of the invention.

The combustion products of my pyrotechnic composition are primarily gaseous although some liquid and solid particles are also emitted into the void behind the projectile during the burning process. My compositions may be used advantageously with projectiles of various standard sizes. Thus 20 and 30 mm caliber projectiles and larger shells, as well as 7.62 mm, may be used advantageously with my invention. By use of such pyrotechnic compositions, base drag of projectiles has been reduced about 44 percent in 7.62 mm projectiles when tested over a 1000 meter range. Velocity of these projectiles have been increased about 16 percent when tested over the same 1000 meter range. Velocities for the above calculations may be determined by standard means.

In Table I below, the effective ranges and preferred amounts, by weight, of the ingredients of my pyrotechnic compositions are indicated:

TABLE I

Material	PYROTECHNIC COMPOSITIONS Effective Range %	Preferred %
Magnesium	25–35	29.9
Strontium Nitrate	44–58	51.9
Calcium Resinate	6–12	8.2
Gelatin	1–12	10.0

will absorb heat from the reaction to lower the temperature thereof.

When less than the lower limit of strontium nitrate is used, insufficient oxidizer is present to react stoichiometrically, and therefore a lower heat of reaction results. On the other hand, when greater than about 58 percent strontium nitrate is present, all the nitrate will not be consumed thus leading to a lowering of the resultant flame temperature since the nitrates decompose endothermically.

The percentage ranges of the metal and oxidizer (magnesium and strontium nitrate) are in contrast to those employed in conventional pyrotechnic tracer or illuminating mixtures, wherein the metal (magnesium) is usually somewhat in excess of the stoichiometric quantity. A tendency for the pyrotechnic mixture to flow out of the cavity into which it has been consolidated results when the binder is present in insufficient proportions. When excess calcium resinate is present, however, the resultant flame temperature will be lowered. When no gelatin is present, the composition yields combustion products of higher molecular weight, although producing a higher flame temperature. Excess gelatin absorbs heat and hence lowers the flame temperature.

In Table II below, percentage weights of ingredients used in four different pyrotechnic compositions are cited along with other pertinent physical values.

TABLE II

	PYROTECHNIC COMPOSITIONS EX. I	EX. II	EX.III	EX. IV
Magnesium	33.2	25.4	7.3	29.9
Strontium Nitrate	57.7	49.3	—	51.9
Calcium Resinate	9.1	—	8.2	8.2
Gelatin	—	10.0	10.0	10.0
Polyvinylchloride	—	15.3	—	—
Strontium Peroxide	—	—	70.9	—
Carbon	—	—	3.6	—
Burning rate, in./sec	0.126	0.080	0.200	0.128
Burning temperature, °C, *	3300–3500	2300–2800	3000–3500	3000–3300
Pressure produced in void, p.s.i. *	12	11	11	12
Average molecular weight of gases of combustion, g/mole *	30–35	45–50	30–40	25–30
Column length, in.	0.3	0.3	0.3	0.3

* Approximate values

In the above, magnesium serves as the fuel, strontium nitrate functions as an oxidizer for the fuel, while calcium resinate effectively binds the pyrotechnic composition. Gelatin provides low molecular weight products upon ignition. Any organic source of gelatin has been found suitable in the practice of the invention. A color intensifier, such as polyvinylchloride may be used in combination with my drag reducing composition to provide a combination fumer and tracer. However, in general, color intensifiers tend to lower the burning temperature of the mixture and are to be avoided in the practice of my invention.

When less than about 25 percent magnesium is used, a lack of sufficient fuel to obtain maximum temperatures results. When more than about 35 percent magnesium is present in the composition, some magnesium

All values above were obtained on 7.62 mm caliber projectiles tested over a 1000 meter range.

For my compositions containing magnesium, strontium nitrate, calcium resinate, and gelatin, burning rates will range from 0.080 to 0.135 inches per second, preferably 0.128 inches per second. Of the four compositions tabulated above, the composition of Example IV produced increases in velocity of 16 percent over that of a standard unignitable inert filled round and attendant increases of striking energy of 34.4 percent. Striking energy may be defined as the kinetic energy of the projectile when it strikes any object.

The composition of Example I produced increases in velocity of about 15 percent over that of a standard unignitable inert filled round and increases in striking energy of 32.5 percent. As is apparent from Table II, the composition of Example I includes slightly more magnesium and strontium nitrate than that of Example IV, and thus produces a slightly higher combustion temperature, but its absence of gelatin results in combustion products of higher molecular weight. Example IV may thus be considered a slightly better composition for the purposes of my invention. Of the four compositions, the composition of Example II served least well, the increase in velocity over a standard unignitable inert filled round being only 7 percent with a 14.4 percent increase in striking energy. Example II is illustrative of the deleterious effect of a color intensifier, polyvinylchloride, in the composition, its presence resulting in lower combustion temperatures and higher molecular weight combustion products. The composition of Example III effected increases in velocity over that of a standard unignitable inert filled round of 9 percent and increases in striking energy of 19.8 percent. The peroxide used in Example III has less overall oxygen than does the nitrate, thus providing less heat and lower temperatures of combustion than the compositions of either Example IV or I.

I claim:

1. Pyrotechnic composition for reducing drag of a projectile, said projectile having a posterior cavity, said composition disposed in said posterior cavity of said projectile, said composition reducing drag by emitting gases into void rearward said projectile, said void caused by flight of said projectile, said gases substantially filling said void, said pyrotechnic composition comprising by weight 25 to 35 percent magnesium, 47 to 58 percent strontium nitrate, 6 to 12 percent calcium resinate, 1 to 12 percent gelatin.

2. Pyrotechnic composition according to claim 1 wherein said gases substantially filling said void effect a total pressure of approximately 12 pounds per square inch in the area rearward said projectile.

3. Pyrotechnic composition according to claim 1 wherein said composition comprises by weight 29.9 percent magnesium, 51.9 percent strontium nitrate, 8.2 percent calcium resinate, 10 percent gelatin.

4. Pyrotechnic composition according to claim 1 wherein said composition comprises by weight 33.2 percent magnesium, 57.7 percent strontium nitrate, 9.1 percent calcium resinate.

5. Pyrotechnic composition according to claim 4 wherein said gases substantially filling said void effect a total pressure of approximately 12 pounds per square inch in the area rearward said projectile.

6. Pyrotechnic composition for reducing drag of a projectile, said projectile having a posterior cavity, said composition disposed in said posterior cavity of said projectile, said composition reducing drag by emitting gases into void rearward said projectile, said void caused by flight of said projectile, said gases substantially filling said void, said pyrotechnic composition comprising by weight 7.3 percent magnesium, 8.2 percent calcium resinate, 10 percent gelatin, 70.9 percent strontium peroxide, 3.6 percent carbon.

7. Pyrotechnic composition according to claim 6 wherein said gases substantially filling said void effect a total pressure of approximately 11 pounds per square inch in the area rearward said projectile.

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