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SMOKE TRACER COMPOSITION

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

Our invention relates to compositions for smoke tracing projectile trajectory.

In the patent to Stevenson et al., No. 2,115,047, dated April 26, 1938, it was taught, in respect of the use of arms on the ground, that tracing of initial trajectory was a disadvantage to gunnery. The invention of that patent presented a solution in the form of igniter compositions whose combustion left no trace. According to the quantity and rate of burning of the Stevenson igniter compositon which effected ignition of an underlying flame tracer composition, a delay was obtained whereby no visible trace was produced until a selected distance had been covered.

From the extensive aerial gunnery experiences of World War II, stemming from air combat operations therefore unparalleled in scope, it developed that the accuracy of pilot-gunners was greatly enhanced when projectiles emanating from the guns of their aircraft, particularly wing-mounted guns, produced a smoke trace or trail which in its visual effect was "connected" to the aircraft. Air combat personnel had resorted to various field expedients, such as a coating of ammunition with oils and waxes of various types, to cause the ammunition, when fired, to leave a more or less satisfactory smoke trace from the very muzzle of the weapon.

The effect of conventional, flame tracers stems from what is actually a pointlike source of light that is ineffectual until a projectile so traced is far enough forward of an aircraft to render the base or tracer end of the projectile visible to the gunner. Thereafter a line trace effect results but it is "disconnected" from the aircraft and fails to yield the accuracy of aim attainable with a trace whose origin is at the muzzle of the aircraft's gun. Also, in night firing, conventional flame tracer composition adversely affects the dark adaptation of the human eye and reveals or emphasizes position to the enemy.

Accordingly, the principal object of our invention is the provision of improved projectile trajectory smoke tracer compositions that are susceptible of direct ignition by propellant and, in such small quantity as can be accommodated in the space provided in projectiles for tracer, operative to produce smoke trail originating at gun muzzle and extending in adequate density over at least 1000 yards of trajectory, without emission of light or with emission of a controlled intensity.

A further object of our invention is to provide improved formulations of the kind described for the production of smoke trail in various colors.

At the time of undertaking of the developments leading to our invention, we were aware that many types of smoke producing compositions had been taught for various other purposes. In an effort to adapt such prior art compositions to our objects, many were tested with unsuccessful results. Our survey of the prior art reflected that smoke

compositions were comprised of sublimable dyestuffs and other sublimable and readily vaporizable materials together with oxidizing agents such as: chlorates, perchlorates, dichromates, dioxides, nitrates, black powder, nitroguanidine, nitrosoguanidine; pyrophoric metals; and such fuels as sucrose, lactose, pitch, sawdust, carbon, hexachloroethane and other carbonaceous materials. Additionally, waxes, minerals, clays, earths, powdered glass, varnishes and inorganic compounds were found to be utilized in compositions as binders, cooling agents, abrasives and burning rate regulators.

It is pertinent to the advantages inherent in the compositions of our invention, as will be detailed later, to observe that the prior art compositions are packaged and utilized in pots, canisters, fuze trains and ignited by separate igniter compositions that are initiated mechanically as by removal of a cover or actuation of a draw string or by impact. The prior art compositions also are packed under relatively low pressure and their usual application is to the production of voluminous smoke, or smoke and flame signals for longer periods, running into hours, involving quantities of the order of one to four pounds of composition per canister.

As will be shown, prior art smoke compositions have been governed by considerations notably different from those that rule in the case of smoke tracer compositions for projectiles.

The requirement that the smoke trail originate at the muzzle of the gun makes necessary a composition ignitible directly by the projectile propellant within an element of time less than projectile time in the gun barrel. This is of the order of less than one hundredth of a second and hence precludes an intermediary igniting means. In this regard, chlorate, perchlorate, dichromate, nitrate, black powder, nitroguanidine and other conventional types of smoke compositions were tested and found unreliable in function or to leave corrosive residue in the gun barrel. Space limitations in projectiles ordinarily impose a total composition quantity within a range of 5–80 grains in the face of a requirement that smoke trail must be of visible density over a distance of at least 1000 yards. This is in contrast with prior art smoke compositions that are used in comparatively large quantities as previously observed. Projectile smoke tracer compositions also must be susceptible of undergoing high compression of the order of 110,000 p. s. i. during loading without igniting. Such composition after being compressed under 110,000 p. s. i. shows a density of 2 grams per cubic centimeter. Loading pressures of that order are required to prevent dislodgement of the composition by forces at play during projectile launching. By comparison, prior art smoke compositions are not subject to high accelerational forces while "open-end packaged" as is the case with our compositions and hence need not be consolidated at such high pressures. Stability in storage in exposure to the acidic products of decomposition of propellant to which our smoke tracer composition necessarily must be exposed directly also is a requirement peculiar, distinguishing from the prior art compositions. Still another requirement is that the smoke tracer composition shall not leave a corrosive residue in the gun barrel as results when oxidizers such as chlorates and perchlorates are used.

In searching for a formulation that would perform reliably and satisfactorily under conditions imposed in projectile trajectory smoke tracing, we discovered that a composition comprising as basic ingredients an alkaline earth peroxide, a combustible resin and sublimable material would yield the required performance. More specifically, our formulation comprises an alkaline earth peroxide such as strontium or barium peroxide as an oxidizer in a proportion ranging from 50% to 85%, a

combustible resin such as calcium resinate, polyvinyl chloride, or other polymers as a fuel in a proportion ranging from 5% to 20%, and a sublimable material such as an anthraquinone, anthracene, or ortho dihydroxy benzene known in the trade as pyrocatechol, or a combination of such sublimable materials, in a proportion ranging from 5% to 25%. As an example, a formulation of strontium peroxide, calcium resinate and ortho dihydroxy benzene known in the trade as pyrocatechol yielded satisfactory qualities of ignition, rate of burning and stability upon having been conventionally loaded into projectile ammunition. In test firing, a heavy, white smoke trail behind the bullet for approximately 1000 yards resulted. The same results were attained with a formulation wherein anthracene was substituted for ortho dihydroxy benzene known in the trade as pyrocatechol, with the exception that the smoke trail or trace was then black. In relying upon the ranges of proportion of ingredients forming a part of our discovery, excellent results are attained in formulation with a variety from among the classes of materials recited as basic ingredients. For example, our research and firing tests have demonstrated that barium, calcium, lithium and lead peroxides may be utilized in lieu of strontium peroxide. Also a commercial grade of rosin or Amberlite resin may be used in place of calcium resinate. And we have determined that in accordance with our formulation the sublimable material may be selected freely according to the color that it is desired to impart to the smoke trace. We prepared and tested many compositions containing various sublimable compounds as the sublimable material ingredient, singly and in combinations. These included many dyes of different color, subliming temperature and vaporizing characteristics. Our tests included loading and firing in various projectiles representative in design and caliber of the gamut of arms. We obtained smoke trails of various color, density and length and the information upon which our proportion of ingredients is based. As a sublimable material, dyes of the anthraquinone series are preferred for the reason that they participate to give the most consistently satisfactory compositions with regard to the several requirements governing projectile trajectory smoke tracer.

We discovered that our formulations could be modified by including a fourth ingredient in quantity operative to produce dual purpose tracer compositions that in the daytime yield only a smoke trail without discernible light but emit glow that is readily resolved in the dark with the unaided eye to a distance in excess of one thousand yards. We have accomplished this result by addition of an experimentally established quantity of a pyrophoric metal in the usual powdered form.

Notable advantages deriving from our improved projectile trajectory tracer compositions are: direct ignitibility; trail of marked persistence enabling a gunner to observe his fire as an extension of his aircraft into space; stability in storage; noncorrosive residue in gun barrel; color trails for code purposes and for range estimation by loading appropriate quantities of composition yielding different colors at successive stages of a trajectory; unimpaired night time visual acuity or at least materially less affected than by conventional flame tracer.

Examples of our preferred compositions are as follows:

Ingredient:	Percent by weight
Strontium peroxide	70
Calcium resinate	15
1-methylaminoanthraquinone	15

This formulation yields a red smoke trace visible by daylight to one thousand yards with no effect visible in the dark.

Ingredient:	Percent by weight
Strontium peroxide	70
Calcium resinate	10
1-methylaminoanthraquinone	15
Powdered magnesium	5

This formulation yields a red smoke trace visible by daylight to one thousand yards with a glow resolvable in the dark to one thousand yards.

Ingredient:	Percent by weight
Strontium peroxide	70
Calcium resinate	10
1-methylaminoanthraquinone	10
Ortho dihydroxy benzene known in the trade as pyrocatechol	10

This formulation yields a red smoke trace visible by daylight to one thousand yards with no effect visible in the dark and is an example of combined sublimable materials.

Ingredient:	Percent by weight
Strontium peroxide	80
Calcium resinate	10
Bis (p-dimethylaminophenyl)-methylenimine hydrochloride known as auramine dye	10

This formulation produces a yellow smoke trace visible by daylight to one thousand yards with no effect visible in the dark.

Ingredient:	Percent by weight
Strontium peroxide	70
Calcium resinate	10
Anthracene	15
Powdered magnesium	5

This formulation operates to produce a black smoke trace visible to one thousand yards by daylight with a glow resolvable in the dark to one thousand yards.

We claim:

1. A smoke tracer chlorate-free composition which will be readily ignitable within one-hundredth of a second by a propellant used to drive any standard projectile forward and which will withstand compression when placed inside of a projectile by a force greater than that developed by the thrust of the propellant and which has been compressed under about 110,000 p. s. i. during loading without undergoing ignition to a point where the composition has a density of 2 grms./cc., this high compression serving to prevent dislodgement of the composition when the projectile is fired, whereby 5 to 80 grains of this composition will cause a rearward trail of colored smoke which is sufficiently voluminous to be visible to a gunner firing said projectile over an entire range of at least 1,000 yards when the projectile is in flight from the muzzle of a gun to the target, the composition having the further property of rapid ignition without rapid burning, the combination therewith of a composition consisting of 50% to 80% of a peroxide of an alkaline earth metal selected from the group consisting of barium, strontium and calcium, 5% to 20% of calcium resinate, and 5% to 25% of at least one sublimable dye material selected from the group consisting of 1-methylamino-anthraquinone, 1,4-dimethylaminoanthraquinone, ortho dihydroxy benzene known in the trade as pyrocatechol; bis (p-dimethylaminophenyl)-methylenimine hydrochloride known in the trade as auramine dye.

2. A smoke tracer composition according to claim 1 which consists of 70% strontium peroxide, 15% calcium resinate and 15% of 1-methylaminoanthraquinone.

3. A smoke tracer composition according to claim 1 which consists of 70% strontium peroxide, 10% calcium resinate, 10% 1-methylaminoanthraquinone, 10% of ortho

dihydroxy benzene to obtain a reddish glow by a mixture of the two sublimable materials.

4. A chlorate free smoke tracer composition according to claim 1 but which in addition has 5% of a pyrophoric powdered metal contained therein so that a controlled amount of light will be emitted which is visible at night but not during the day.

5. A composition according to claim 4 which consists of 70% strontium peroxide, 10% calcium resinate, 15% 1-methylaminoanthraquinone, 5% powdered magnesium.

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