Patented Aug. 19, 1947 2,425,854

UNITED STATES PATENT OFFICE

2,425,854

PROPELLENT POWDER

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No Drawing. Application July 20, 1943, Serial No. 495,536

18 Claims. (Cl. 52—13)

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This invention relates to an improved propellent powder and more particularly to a progressive-burning propellent powder of high energy content.

In the prior art, there are various known propellent powders, the most important types being single-base or nitrocellulose powders and double-base or nitrocellulose/nitroglycerin powders. These powders, while providing desirable ballistics in most rifles, in certain cases do not provide sufficient propellent force of a rapidly accelerating character to give the projectile being fired from the rifle a desired high velocity. With the modern military and sporting rifle construction, it should be possible to provide a propellent that will impart a high velocity to a bullet when it leaves the gun barrel. In order to impart such velocity, it is necessary to use a propellent charge with a relatively high energy content, but when prior art powders of this type are used, certain inherent disadvantages are encountered, such as, difficulty in causing the initial inertia force of the bullet to be overcome before an extremely high pressure is developed by the burning of the powders.

The single-base powders, uncoated and modified, have given progressive-burning charges which are satisfactory for most uses of low velocity bullets. Upon demand of higher velocities, the potential of the nitrocellulose powder was increased by adding thereto more powerful explosive substances, for example, an explosive nitric ester, such as, nitroglycerin. The nitroglycerin/nitrocellulose double-base powders are satisfactory when they are so deterred by surface coating that their original burning speed is sufficiently slow to overcome the initial inertia force of the bullet, impart velocity to the projectile, and thereafter increase in speed of burning and impart an accelerating effect on the projectile. The double-base nitrocellulose/nitroglycerin powders are limited as to energy content because powder grains which contain more than about 40% nitroglycerin become sticky and are difficult to load. The initial ignition and pressure are difficult to control, and further, such high nitroglycerin content powders upon hot storage tend to desensitize primers. It is also difficult to coat sticky powders with a deterrent.

Other high energy content powders have been

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manufactured but have not met with success because no explosive ingredient of high energy content has been incorporated into nitrocellulose or nitrocellulose/nitroglycerin powders in a manner that would give even burning characteristics. For example, the detonating compositions such as mercury fulminate or lead azide, when included in powders, develop sudden high peak pressures and therefore do not give desirable ballistics. The use of various high energy content explosives such as nitrostarch, PETN, hexogen, and the like, have never met with complete success because when they are incorporated into progressive-burning powders they form local hot spots within the powder that cause dangerous peak pressures and give erratic ballistics. All of the above type added ingredients are capable of increasing or accelerating the rate of combustion of the single- or double-base powders but the increase of acceleration cannot be controlled. Further, it is difficult to modify the powder grains containing such materials so that their initial combustion rate is sufficiently low to overcome inertia force and is also capable of imparting velocity thereafter to the bullet without development of excessive pressure which may cause rupture of breech mechanisms or of the barrel itself.

Research programs have been carried out in an attempt to produce propellent powders which would not develop excessive pressures upon ignition but would immediately thereafter have such an increased and accelerated burning speed that the bullet velocity would be substantially increased. In most development work, the procedure has been an attempt to modify the surface of high energy content powders in order to limit the initial combustion rate without retarding the subsequent acceleration. However, modifying agents have not been found which are satisfactory, because, if sufficient modifying agent is applied to the surface to obtain limited initial combustion desired, ignition is so difficult that either hangfires and misfires result, or the powder fails to completely burn before the bullet is expelled from the barrel.

Now, in accordance with this invention, it has been discovered that a high energy content powder can be made from either single-base nitrocellulose powders or double-base nitrocellulose/nitroglycerin powders, either uncoated or modi-

fied, which will give an acceleration rate after initial ignition that will produce the high velocities desired. To obtain this high energy content powder having this very desirable characteristic, various normal single- and double-base powders have been altered by the uniform incorporation therein of excessively fine discrete particles of solid explosives.

In more detail, the invention provides a progressive-burning smokeless powder which has incorporated in the grain structure a secondary solid explosive which is incompletely soluble and, therefore, not fully dissolved in any ingredient contained in the powder or used during its manufacture. The explosive, in the form of discrete particles, is incorporated in the colloided single- or double-base powder and is uniformly distributed throughout. These discrete particles are of a screen size corresponding to a United States Standard Sieve No. 200, for example, about 74 microns, and the solid explosives which are incorporated in the smokeless powder are capable of reduction to particles having a diameter not in excess of about 100 microns and preferably not in excess of 40 microns. Thus, the material which is incorporated forms discrete particles which will pass a United States Standard Sieve No. 200 and will preferably pass a United States Standard Sieve No. 325.

By the incorporation of such discrete particles, it has been found possible to produce propellent charges for cartridges used in military or sporting rifles which will impart a much higher muzzle velocity to the projectile than known powders will produce under the limitations fixed by the strength of the gun, both barrel and breech, and the space which is provided in the cartridge case for the propellent charge.

In order to illustrate the performance, desirable properties and ballistics of the high energy content powders of this invention, Examples 1 through 6 are presented in tabular form. Table I shows a comparison of ballistics of uncoated double-base powders containing coarse or fine solid explosive materials, where indicated, as an added ingredient. Table I-A shows screen tests on the ingredients used. Table II shows a comparison of ballistics of uncoated single-base powders containing coarse or fine solid explosive materials as an added ingredient. Table II-A shows screen tests on the ingredients used.

The powders of Examples 1 through 4 were prepared by colloiding compositions in accordance with the following formulation and then properly granulating:

	Per cent by weight
Nitrocellulose (13.20–13.24% N)	48.25
Nitroglycerin	20.00
Solid explosive material (where indicated)	30.00
Diphenylamine	0.75
Potassium sulfate	1.00
	100.00

The powders of Examples 5 and 6 were prepared by colloiding compositions in accordance with the following formulation and then properly granulating:

	Per cent by weight
Nitrocellulose (13.20–13.26% N)	67.80
Solid explosive material	30.00
Diphenylamine	1.00
Potassium sulfate	1.00
Graphite	0.20
	100.00

TABLE I

Comparison of ballistics of uncoated double-base powders containing coarse or fine solid explosive materials as an added ingredient

Example No.	Powder	Added Ingredient	Charge Grains	Mean Velocity, ft./sec.	Mean Pressure, lb./sq. in.	Granulation diameter × length in inches
1	A	Fine PETN	43.2	2,777	51,800	.053-.015 × 1/11
	B	Coarse PETN	35.4	2,691	52,400	.053-.015 × 1/11
	C	None	43.8	2,703	51,500	.047-.015 × 1/11
2	D	Fine tetryl	49.3	2,855	52,100	.053-.015 × 1/11
	E	Coarse tetryl	45.0	2,781	52,700	.053-.015 × 1/11
3	F	Fine TNT	56.0	2,439	40,000	.045-.015 × 1/11
	G	Coarse TNT	59.8	2,397	40,100	.045-.015 × 1/11
4	H	Fine PETN	44.8	3,071	51,900	.053-.015 × 1/11
	I	Coarse PETN	40.0	2,996	52,000	.053-.015 × 1/11
	J	None	42.7	2,941	52,000	.047-.015 × 1/11

Bullets Used: .30-06 Springfield—AP M2, Frankford Arsenal Components; Winchester .348—Winchester 200 gr. soft point, Winchester Components; Winchester .270—Winchester pointed soft point, Winchester Components.
Powder A, B, C, D, and E—Tested in .30-06 Springfield.
Powder F and G—Tested in Winchester .348.
Powder H, I, and J—Tested in Winchester .270.
Ten shot tests—Exception Powder I, 8 shots.

TABLE I—A

Screen analysis [1] of added ingredients

A and H—Fine PETN:	Per cent
On 150 mesh screen	0.2
On 200 mesh screen	0.2
Through 200 mesh screen	99.6
B and I—Coarse PETN:	Per cent
On 30 mesh screen	Trace
On 50 mesh screen	30.4
On 100 mesh screen	27.4
On 150 mesh screen	3.4
Through 150 mesh screen	38.8
D—Fine tetryl:	
By microscopic examination—100% through 325 mesh screen.	
E—Coarse tetryl:	Per cent
On 30 mesh screen	4.9
On 50 mesh screen	20.9
On 100 mesh screen	31.1
On 140 mesh screen	9.4
Through 140 mesh screen	33.7

F—Fine TNT:
By microscopic examination—100% through 325 mesh screen.

G—Coarse TNT:	Per cent
On 30 mesh screen	2.0
On 50 mesh screen	5.0
On 100 mesh screen	54.1
On 140 mesh screen	18.9
Through 140 mesh screen	20.0

[1] U. S. Standard Sieve series.

With reference to Table I, Example 1 affords a comparison of powders containing fine PETN, coarse PETN, and a similar uncoated, double-base powder containing no added explosive ingredients. When tested in a .30–06 Springfield at comparative pressures the powder containing the finely divided PETN gave a higher velocity than the powder containing coarse PETN. Also, the powder with the higher energy content (fine PETN added) gave a higher velocity for about the same charge weight than the powder containing no added ingredient. Example 2 shows that, in a .30–06 Springfield, a powder containing fine tetryl has a higher velocity with a comparative pressure than one made with coarse tetryl. Example 3 gives a comparison between powders made with fine and coarse TNT in a .348 cal. Winchester. It will be noted that the powder containing the finely-divided TNT gave better results than the powder containing the coarse TNT. Example 4 is a comparison of the same type powders given in the first example but tested in a .270 cal. Winchester. The powder containing the finely-divided PETN was more progressive burning than the powder containing coarse PETN. For approximately the same charge weights, the powder containing finely-divided PETN gave a higher velocity than the powder containing no added explosive material.

With reference to Table I—A it will be seen that all the finely-divided solid explosive materials have the major portion thereof capable of passing through a United States standard sieve No. 200.

M—Fine tetryl:
By microscopic examination—100% through 325 mesh screen.

N—Coarse tetryl:	Per cent
On 30 mesh screen	4.9
On 50 mesh screen	20.9
On 100 mesh screen	31.1
On 140 mesh screen	9.4
Through 140 mesh screen	33.7

[1] U. S. Standard Sieve series.

With reference to Table II, the powder of Example 5 containing fine PETN gave a higher velocity than did the powder containing coarse PETN. The powders had comparable pressures and approximately the same charge weight. Example 6 clearly demonstrates the effect of using fine and coarse tetryl. The powder made with finely-divided tetryl was very slow burning and the desired pressure of 52000 lbs./ sq. in. could not be reached. However, a velocity of 2411 ft./sec. was obtained. The powder made with coarse tetryl was very fast burning. A charge of 16.9 grains gave a low velocity of 1524 ft./sec. with the desired pressure of 52000 lbs./sq. in. Although the two ballistic tests are not comparable because of the differences in charge weights and pressure levels, the advantages of the present invention are clearly shown, that is, that the powders containing finely-divided material give more progressiveness than powders containing coarse ingredients when prepared under the same conditions.

With reference to Table II—A it will be seen that all the finely-divided solid explosive materials have the major portion thereof capable of passing through a United States Standard Sieve No. 200.

The tables above show the increase in velocity obtainable in accordance with this invention and also show that by the use of very finely-divided solid explosive materials a progressive-burning powder can be produced which will give more favorable pressure/velocity relations than those given by powders containing commercial grain size explosive materials.

The compositions of the powders of the present invention are based upon various known single- and double-base powders now being used and these single- and double-base powders are so altered by the addition thereinto of finely-divided solid explosives having particles of a size less than about 100 microns that there is produced an improved and different powder as shown by pressure and velocity relationships.

The single-base powder compositions altered in accordance with this invention are those now

TABLE II

Comparison of ballistics of uncoated single-base powders containing coarse or fine solid explosive materials as an added ingredient

Example No.	Powder	Added Ingredient	Charge Grains	Mean Velocity, ft./sec.	Mean Pressure, lb./sq. in.	Granulation diameter × length in inches
5	K	Fine PETN	35.0	2,395	51,700	.053–.015 × 1/11
	L	Coarse PETN	33.0	2,356	52,100	.053–.015 × 1/11
6	M	Fine Tetryl	45.0	2,411	39,200	.051–.015 × 1/11
	N	Coarse Tetryl	16.9	1,524	52,100	.051–.015 × 1/11

Bullet—AP M2, Frankford Arsenal Components; Powder K, L, M, and N—Tested in .30–06 Springfield. Ten shot tests.

TABLE II—A

Screen analysis [1] of added ingredients

K—Fine PETN:	Per cent
On 150 mesh screen	0.2
On 200 mesh screen	0.2
Through 200 mesh screen	99.6

L—Coarse PETN:	Per cent
On 30 mesh screen	Trace
On 50 mesh screen	30.4
On 100 mesh screen	27.4
On 150 mesh screen	3.4
Through 150 mesh screen	38.8

used by the art and which normally comprise a preponderance of nitrocellulose of the smokeless type, i. e., containing about 13% nitrogen and preferably about 13.25% nitrogen with approximately 1% of a stabilizer, and if desirable, small amounts of oxidizing salts such as potassium nitrate and barium nitrate. These single-base powders are manufactured by colloiding the admixture with solvents such as a suitable mixture of ether and alcohol or of acetone and alcohol. Usually in single-base poweders, and alcohol/ether admixture is used.

The double-base powder compositions altered in accordance with this invention are those now known to the art and are quite similar to the single-base powders with the exception that between 10 and 40% of the nitrocellulose present therein is replaced by a liquid explosive nitric ester such as nitroglycerin or the nitrated glycols or their equivalents. These powders are manufactured by colloiding solvents such as a suitable mixture of ether and alcohol or of acetone and alcohol and preferably the latter.

Both the single- and double-base powders, after having been colloided, are pressed into strands and cut into the desired grain sizes, thereafter they are dried, glazed, and sieved.

Any of the single- and double-base powders described above may be used as a base for the present invention and the powder of the present invention is produced by the addition during the colloiding operation of the single- or double-base powders of a predetermined amount of very finely-divided explosive material which is difficultly soluble and not fully dissolved in any of the ingredients entering the mixing procedure. The finely-divided explosive material will be present in amount between about 15 and about 65% by weight of the composition and preferably between about 20 and about 40%.

The solid explosive materials which have been found useful in increasing the energy content of the single- and double-base powders are those solid explosives which can be reduced to a particle size of less than about 100 microns in diameter and which are not fully dissolved in the ingredients entering the mixing operation. In particular, the explosive materials may be hexogen, nitrolactose, nitromannite, tetryl, TNT, and PETN, the preferred material being PETN. It is desirable that the solid explosive be non-colloidable, but by regulation of the solvent used, it is possible to use some colloidable solid explosives.

In the preparation of the powders of this invention, it may, of course, be necessary to so regulate their initial combustion by surface modification that the pressure initially developed will not be greater than the maximum allowable. The type coatings or modifications which are satisfactory are numerous and can be either explosive or non-explosive substances such as, for example, dinitrotoluene, the substituted ureas, and the like. Such coatings are well known in the art. It has been found that approximately the same amount of coating is required to obtain the desired initial combustion rate of powders of this invention as is required to obtain the initial combustion rate desired in normal single- and double-base powders.

In accordance with the prior art, there are two methods available whereby the initial burning speed of propellent powders may be retarded. One method is to increase the granulation, and consequently the web of the powder, while the other method is to modify the surface of the powder grains with a deterrent coating. The first of these methods is of limited applicability for as the web is increased, there is a tendency for the powder grains to be expelled from the gun before they are completely burned. Also, when relatively thick web powders are used, an excessive charge is needed to obtain the desired ballistics. The second method has the disadvantage inasmuch as a deterrent coating applied to a powder reduces the average energy content of the composition. By application of the principle disclosed in accordance with this invention, namely, that the burning speed of a smokeless powder may be influenced by the state of division of a crystalline component thereof, there becomes available a third method by which the burning rate of the powder may be desirably regulated. This new method when used in conjunction with proper adjustment of granulation and with also, if desired, employment of a deterrent coating, serves to give improved control of burning characteristics over that which has been previously afforded in accordance with prior art methods. Consequently, novel powders of increased progressiveness of burning may be obtained. This is accomplished by the powders of the present invention as is shown in the foregoing examples in which powders containing finely-divided material gave more progressiveness than powders containing coarse ingredients, when made under corresponding conditions.

The advantages of the powders of this invention are the development of high velocity, greater striking power and penetration, and greater accuracy and range.

What I claim and desire to protect by Letters Patent is:

1. A progressive-burning smokeless powder comprising colloided nitrocellulose, stabilizer and between about 15 and about 65% solid, organic, high explosive material, said solid explosive material being incompletely soluble and non-colloidable in the ingredients and solvents used in preparing the colloided grains, and being uniformly distributed therethrough and sufficiently finely-divided to characterize the powder by an increased burning rate, the major portion of said solid explosive material being in the form of particles capable of passing through a United States Standard Sieve No. 200.

2. A progressive-burning smokeless powder comprising colloided nitrocellulose, liquid explosive nitric ester, stabilizer and between about 15 and about 65% solid, organic, high explosive material, said solid explosive material being incompletely soluble and non-colloidable in the ingredients and solvents used in preparing the colloided grains, and being uniformly distributed therethrough and sufficiently finely-divided to characterize the powder by an increased burning rate, the major portion of said solid explosive material being in the form of particles capable of passing through a United States Standard Sieve No. 200.

3. A progressive-burning smokeless powder comprising colloided nitrocellulose having a nitrogen content of at least 13%, stabilizer, and between about 15 and about 65% of discrete particles of a solid, organic, high explosive material uniformly distributed therethrough, said solid explosive material being incompletely soluble and non-colloidable in the ingredients and solvents used in preparing the colloided grains, said discrete particles being sufficiently finely-divided to characterize the powder by an increased acceler-

ating rate, the said discrete particles having the major portion thereof capable of passing through a United States Standard Sieve No. 200.

4. A progressive-burning smokeless powder comprising colloided nitrocellulose having a nitrogen content of at least 13%, liquid explosive nitric ester, stabilizer and between about 15 and about 65% of discrete particles of a solid, organic, high explosive material uniformly distributed therethrough, said solid explosive material being incompletely soluble and non-colloidable in the ingredients and solvents used in preparing the colloided grains, said discrete particles being sufficiently finely-divided to characterize the powder by an increased accelerating rate, the said discrete particles having the major portion thereof capable of passing through a United States Standard Sieve No. 200.

5. A progressive-burning smokeless powder according to claim 1 wherein said solid, organic, high explosive material is pentaerythritol tetranitrate.

6. A progressive-burning smokeless powder according to claim 1 wherein said solid, organic, high explosive material is hexogen.

7. A progressive-burning smokeless powder according to claim 1 wherein said solid, organic, high explosive material is trinitrotoluene.

8. A progressive-burning smokeless powder according to claim 2 wherein said solid, organic, high explosive material is pentaerythritol tetranitrate.

9. A progressive-burning smokeless powder according to claim 2 wherein said solid, organic, high explosive material is hexogen.

10. A progressive-burning smokeless powder according to claim 2 wherein said solid, organic, high explosive material is trinitrotoluene.

11. A progressive-burning smokeless powder comprising colloided nitrocellulose, nitroglycerin, stabilizer and between about 15 and about 65% solid, organic, high explosive material, said solid explosive material being incompletely soluble and non-colloidable in the ingredients and solvents used in preparing the colloided grains, and being uniformly distributed therethrough and sufficiently finely-divided to characterize the powder by an increased burning rate, the major portion of said solid explosive material being in the form of particles capable of passing through a United States Standard Sieve No. 200.

12. A progressive-burning smokeless powder comprising colloided nitrocellulose, nitroglycerin, stabilizer and between about 15 and about 65% pentaerythritol tetranitrate, said pentaerythritol tetranitrate being incompletely soluble and non-colloidable in the ingredients and solvents used in preparing the colloided grains, and being uniformly distributed therethrough and sufficiently finely-divided to characterize the powder by an increased burning rate, the major portion of said pentaerythritol tetranitrate being in the form of particles capable of passing through a United States Standard Sieve No. 200.

13. A progressive-burning smokeless powder comprising colloided nitrocellulose, nitroglycerin, stabilizer and between about 15 and about 65% hexogen, said hexogen being incompletely soluble and non-colloidable in the ingredients and solvents used in preparing the colloided grains, and being uniformly distributed therethrough and sufficiently finely-divided to characterize the powder by an increased burning rate, the major portion of said hexogen being in the form of particles capable of passing through a United States Standard Sieve No. 200.

14. A progressive-burning smokeless powder comprising colloided nitrocellulose, nitroglycerin, stabilizer and between about 15 and about 65% trinitrotoluene, said trinitrotoluene being incompletely soluble and non-colloidable in the ingredients and solvents used in preparing the colloided grains, and being uniformly distributed therethrough and sufficiently finely-divided to characterize the powder by an increased burning rate, the major portion of said trinitrotoluene being in the form of particles capable of passing through a United States Standard Sieve No. 200.

15. A progressive-burning smokeless powder according to claim 11 wherein said nitrocellulose has a nitrogen content of at least 13%.

16. A progressive-burning smokeless powder according to claim 12 wherein said nitrocellulose has a nitrogen content of at least 13%.

17. A progressive-burning smokeless powder according to claim 13 wherein said nitrocellulose has a nitrogen content of at least 13%.

18. A progressive-burning smokeless powder according to claim 14 wherein said nitrocellulose has a nitrogen content of at least 13%.

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