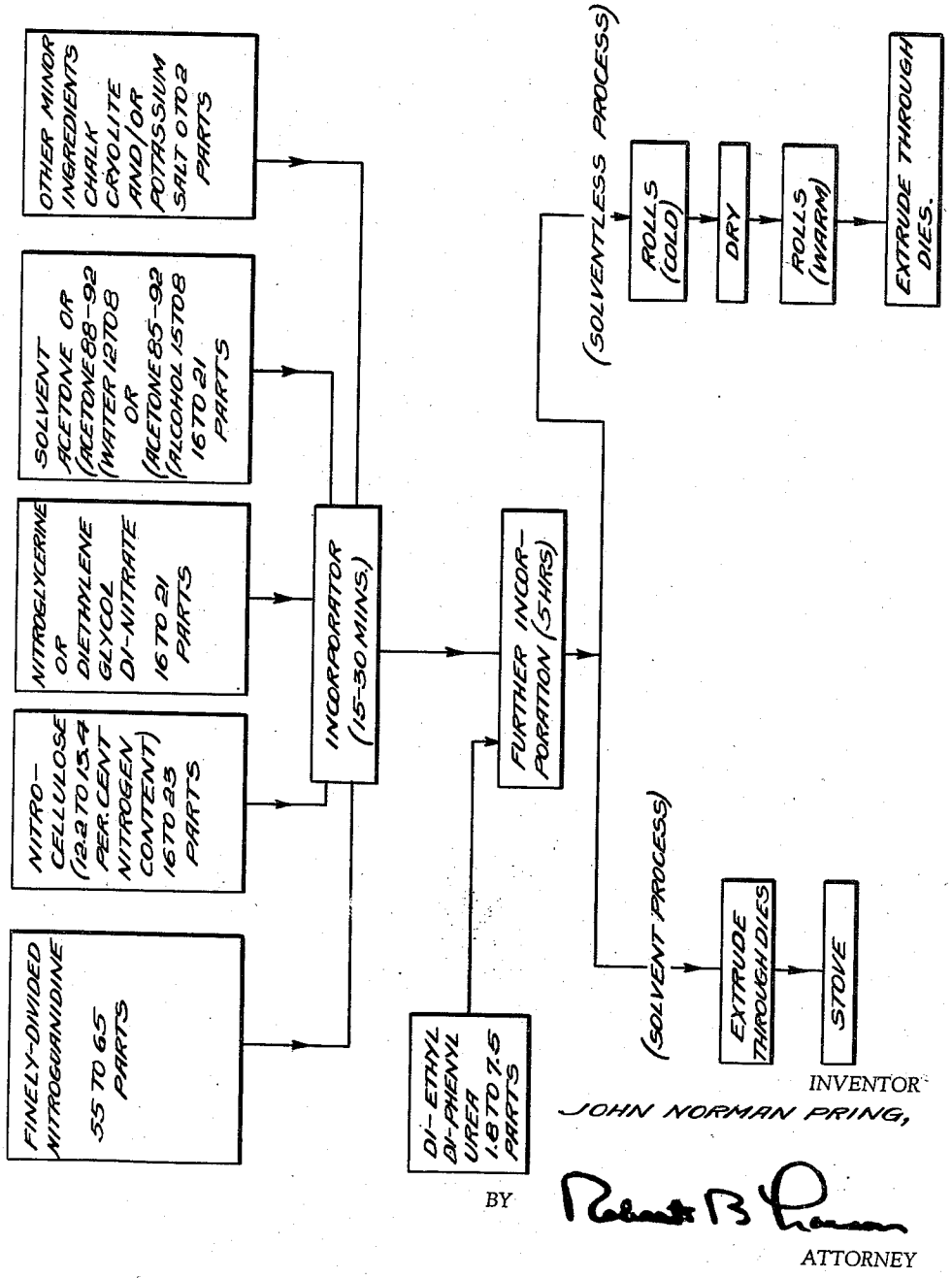
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PROPELLANT COMPOSITION AND PROCESS OF MAKING SAME

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PROPELLANT COMPOSITION AND PROCESS OF MAKING SAME

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This invention is concerned with propellant compositions for use in guns, howitzers and the like weapons employed for the propulsion of projectiles, and in particular with such compositions as are designed to give reduced muzzle flash as compared with cordite.

Previously it has been proposed to employ a large proportion of nitroguanidine in propellant compositions of a nitro-cellulose basis for the purpose of lowering the heat evolved on combustion. With such propellant compositions containing, for example 40 per cent or more of nitroguanidine, a good measure of muzzle flash reduction can be obtained in guns of medium size. In attempting to prepare propellant composition for guns of large calibre or for high velocity projectiles, difficulties have been encountered in eliminating flash, in obtaining good coherence and homogeneity of large size cords and in obtaining satisfactory mechanical properties and ballistic regularity, approaching that of cordite, for example.

We have now observed that substantial improvement may be obtained in coherence, homogeneity, mechanical properties and ballistic regularity of propellant compositions containing large quantities of nitroguanidine when the latter compound is employed in a very finely divided form having a specific surface of at least 9,000 sq. cm. per c. cm. and is dispersed in nitrocellulose which is gelatinized by means of substantially 0.8 to 1.5 times its weight of an explosive substance; and further that to reduce muzzle flash substantially the calorimetric value should be in the range 650 to 825 calories per gramme (W. G.) the greatest extent of flash reduction being obtained with such values in the range 650 to 750 calories per gramme (W. G.)

Hence in accordance with the invention a propellant composition comprises substantially 50 to 65 per cent. of nitroguanidine having a specific surface of at least 9,000 sq. cm. per cu. cm. dispersed in nitrocellulose which is gelatinized by means of from about 0.8 to 1.5 times its weight of an explosive substance, the composition having a calorimetric value of substantially 650 to 825 calories per gramme (W. G.).

Preferably the nitroguanidine has a specific surface of from 18,000 to 50,000 sq. cm. per cu. cm. The finer the nitroguanidine in fact, the greater are the reduction of flash, the ballistic regularity, the density of large size cords, and the speed of dough formation.

To obtain the greatest muzzle flash reduction the preferred calorimetric value is substantially

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from 650 to 750 calories per gramme (W. G.) and for use in guns where flash elimination is still a difficulty, the inclusion on the propellant composition of a small amount (for example from 1 to 3 per cent) of a potassium compound, preferably potassium sulphate or potassium aluminium fluoride has been found to effect a further improvement. As the addition of such compounds will usually increase the amount of smoke produced on firing, it may be desirable to employ the smallest amount needed to give the desired effect.

The degree of nitration of the nitrocellulose preferably should be such that the nitrogen content is in the range 12.2 to 13.4 per cent. The preferred content of nitrocellulose is 16 to 23 per cent. Adjustment of the calorimetric value may be effected by adjustment of the proportions of the components within the limitations defined above, by choice of nitrogen content of the nitrocellulose and with the assistance of a moderant, which may also conveniently act as a stabilizer for the composition, for example a derivative of urea or urethanes, preferably diethyldiphenyl urea. Partial substitution of the latter by an inert cooling agent, e. g. dibutyl phthalate, diamyl phthalate, cellulose acetate or oxamide is also possible.

The preferred explosive substances for gelatinizing the nitrocellulose are nitroglycerine and diethylene glycol dinitrate, or other compatible liquid explosive nitric ester. The above may be replaced wholly or in part by other compatible explosive substances, for example dinitrotoluene. The preferred content of the explosive substance is 16 to 23 per cent.

An addition of a small amount of carbon black or graphite to the composition for example 0.5 to 3.0 per cent. has been found to assist in ignition and regularity of burning.

The compositions of the invention may be prepared by the methods employed for cordite manufacture. Thus in operating in accordance with the so-called solvent method, the weighed components apart from the stabilizer after preliminary mixing in a convenient mixing apparatus, may be introduced into an incorporator with a quantity of solvent, preferably aqueous acetone, (e. g. 89 to 92 parts of acetone to 8 to 11 parts of water). After mixing for 15 to 30 minutes the stabilizer (preferably diethyl diphenyl urea) is added and incorporation continued until a plastic dough is formed, about 5 hours being required for this change to take place. The dough may then be extruded from a press through dies

to give the desired size cord, tube, slotted tube or multiperforated grain, from which solvent is removed by stoving for a few days at about 45° C.

An alternative method of preparation, which is applicable when using nitrocellulose of a low nitrogen content within the range specified herein, involves incorporation of the components as described above to obtain a dough, which may then be rolled into the form of sheets. After removal of solvent from the sheets by stoving as for the cords, tubes, or the like, the sheets may be again rolled between heated rolls (50° to 60° C.) and while the sheets are still at about that temperature, they are cut into discs, and filled into the cylinder of a warm press from which they are extruded through dies to give the desired size of cord, tube or other section. This method permits of a higher degree of regularity of size and an increase in the smoothness of the surface of the extruded product.

The addition of the diethyl diphenyl urea is preferably withheld until the remaining constituents have been mixed for 15 to 30 minutes. This is due to the property which has been observed of the formation of a double compound between the diphenyl diethyl urea and the nitroguanidine and unless the latter is first intimately mixed with the nitrocellulose and nitroglycerine the double compound forms aggregates which are not well-dispersed in the colloidal matrix and higher rates of burning result.

The accompanying drawing is a flow chart diagrammatically representing the steps of the process.

The following examples of propellant compositions will serve to illustrate the invention, the parts being by weight.

Example 1

	Parts
Nitroguanidine of specific surface 9,000 to 22,000 sq. cm. per c. c.	55
Nitrocellulose (13.1 to 13.2 per cent. N.)	19
Nitroglycerine	18.7
Diethyl diphenyl urea	7.3

The composition has a calorimetric value of about 700 calories per gramme (water gaseous) a force constant of 1773 and the calculated quantity of carbon monoxide and hydrogen in the muzzle gas is approximately 53.8 per cent.

Example 2

	Parts
Nitroguanidine of specific surface 9,000 to 22,000 sq. cm. per c. c.	55
Nitrocellulose (12.2 per cent N.)	16.5
Nitroglycerine	21
Diethyl diphenyl urea	7.5

The calorimetric value is about 690 calories per gramme (water gaseous), the force constant 1750 and the calculated percentage of carbon monoxide and hydrogen in the muzzle gases about 54.6.

Example 3

	Parts
Nitroguanidine of specific surface 9,000 to 22,000 sq. cm. per c. c.	55
Nitrocellulose (13.1 to 13.2 per cent N.)	20.8
Nitroglycerine	20.5
Diethyl diphenyl urea	3.7

The calorimetric value is about 806 calories per gramme (water gaseous), the force constant 1898 and the calculated amount of carbon monoxide and hydrogen in the muzzle gases 44.4 per cent.

Example 4

	Parts
Nitroguanidine of specific surface 9,000 to 22,000 sq. cm. per c. c.	55
Nitrocellulose (12.2 per cent N.)	21
Nitroglycerine	21
Diethyl diphenyl urea	3

The calorimetric value is about 800 cals./per grm. (water gaseous), the force constant 1886 and the carbon monoxide and hydrogen content of the muzzle gases 44.3 per cent.

Example 5

	Parts
Nitroguanidine of specific surface 30,000 sq. cm. per c. c.	65
Nitrocellulose (13.1 to 13.2 per cent N.)	16.7
Nitroglycerine	16.5
Diethyl diphenyl urea	1.8

The calorimetric value is about 803 calories per gramme (water gaseous), the force constant 1901 and the calculated amount of carbon monoxide and hydrogen in the muzzle gases 40.6 per cent.

Example 6

	Parts
Nitroguanidine of specific surface 30,000 sq. cm. per c. c.	60
Nitrocellulose (13.1 to 13.2 per cent N.)	16.6
Nitroglycerine	16.4
Diethyl diphenyl urea	7

The calorimetric value is 668 calories per gramme (water gaseous), the force constant 1747 and the calculated amount of hydrogen and carbon monoxide in the muzzle gas 53–7 per cent.

Example 7

	Parts
Nitroguanidine of specific surface 30,000 sq. cm. per c. c.	60
Nitrocellulose (13.1 to 13.2 per cent N.)	18.1
Diethylene glycol dinitrate	18.1
Diethyl diphenyl urea	3.8

The calorimetric value is 661 calories per gramme (water gaseous), the force constant 1734 and the calculated amount of carbon monoxide and hydrogen in the muzzle gases 53.3 per cent.

Example 8

	Parts
Nitroguanidine of specific surface 30,000 sq. cm. per c. c.	60
Nitrocellulose (12.2 per cent nitrogen)	18.5
Diethylene glycol dinitrate	18.5
Diethyl diphenyl urea	3

The calorimetric value is 660 calories per gramme (water gaseous), the force constant 1730 and the calculated amount of carbon monoxide and hydrogen in the muzzle gases 52.7 per cent.

All of the above compositions may be made by the "solvent method" as described above, while those of Examples 1 and 8 may also be prepared by the alternative method described above.

The force constant specified in the examples is defined by the expression $nRTo$, where "n" is the number of gramme molecules of gas produced by 1 gramme of propellant, "R" is the universal gas constant and "To" the temperature of the uncooled gases when formed at constant volume. The value of To is calculated from the calorimetric value and the volume and specific heats of the gases by the simplified method of Hirschfelder and Scherman.

Of the compositions exemplified, those of Examples 1, 2, 6, 7 and 8 will give the most satis-

factory reduction of flash at the muzzle, and of these Examples 6, 7 and 8 have given very little or no muzzle flash when employed in the guns, which offer the most difficulty, particularly also when 2 per cent of potassium sulphate has been included in the composition of the propellant.

The compositions of Examples 3 and 4 and 5 are suitable for the charges of guns and howitzers which are more easily rendered flashless the higher calorimetric value allowing of a correspondingly lower charge weight. These compositions may also be employed in the more difficult guns, where complete flashlessness may not be obtained but such flashes as occur will not cause serious dazzling of personnel and may be acceptable in view of the low bulking volume of the charges.

It should be noted that while in general, reduction in the calorimetric value of a propellant composition containing a large amount of nitroguanidine may be expected to be accompanied by reduction in muzzle flash, other undesirable features may be introduced. Thus the bulk of the charge for a given performance will increase, the extent of smoke and toxic fumes formation may increase and ease of ignition may be impaired with resulting loss of regularity in firing intervals.. The compositions exemplified are thought to give a satisfactory degree of flash suppression for the weapons specified without any serious tendency towards the undesirable features indicated.

The propellant compositions of the invention have the following advantages over propellants of the cordite type in addition to their low muzzle flash.

(*a*) a reduced erosion of the gun.

(*b*) an increased chemical and ballistic stability resulting in a longer life.

(*c*) a saving in the amount of solvent required in manufacture and in the time of storing.

(*d*) a smaller change of ballistics with temperature.

The calorimetric values referred to herein are those obtained on combustion of the propellant composition in a closed vessel in the absence of the added oxygen.

I claim:

1. A propellant explosive composition having a calorific value of substantially from 650–850 calories per gramme, water gaseous, and of suppressed flash and erosive characteristics for use with large guns, comprising substantially 50–65% nitroguanidine, the particles of which have a specific surface of at least 9,000 sq. cm. per c. c. dispersed in 16–23% nitrocellulose gelatinised by 0.8 to 1.5 times its weight of a liquid explosive nitric ester, and diethyl diphenyl urea in the form of a finely divided, homogeneously distributed double compound with nitroguanidine.

2. A propellant as in claim 1, there being 1.8–7.5% of diethyl diphenyl urea present.

3. A propellant as in claim 2, wherein said liquid explosive nitric ester is nitroglycerine.

4. A propellant as in claim 3, wherein the nitrocellulose has a nitrogen content of 12.2–13.4%.

5. A method for the manufacture of propellant explosive compositions having a calorific value of substantially 650–850 calories per gramme water gaseous and of suppressed flash and erosive characteristics for use with large guns, comprising first thoroughly dispersing 50–65% nitroguanidine, the particles of which have a specific surface of at least 9,000 square centimeters per c. c. in 16–23% nitrocellulose gelatinised with 0.8–1.5 times its weight of a liquid explosive nitric ester, and thereafter stabilizing the composition with diethyl diphenyl urea added only after mixing the nitroguanidine and nitrocellulose-liquid explosive nitric ester thoroughly for substantially fifteen to thirty minutes, the withholding of the addition of the diethyl diphenyl urea resulting in homogeneous distribution, throughout the composition, of a finely divided double compound formed by interaction of the nitroguanidine and the diethyl diphenyl urea.

6. A method according to claim 5, wherein said diethyl diphenyl urea is added in an amount comprising 1.8–8.1% by weight of the nitroguanidine-nitrocellulose-liquid explosive nitric ester weight.

7. A method according to claim 5, wherein the liquid explosive nitric ester is nitroglycerine.

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