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TMETN-INORGANIC NITRATE EXPLOSIVES BLENDED WITH ALUMINUM

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ABSTRACT OF THE DISCLOSURE

Explosive mixtures are provided, based on trimethylolethane trinitrate and an inorganic nitrate, having a high rate of detonation and good sensitivity due to the incorporation of aluminum particles in the explosive.

A process also is provided for preparing such explosive mixtures, by mixing the inorganic nitrate and particulate aluminum with the trimethylolethane trinitrate.

This invention relates to explosive mixtures comprising trimethylolethane trinitrate and ammonium nitrate or other inorganic nitrate, having a high rate of detonation and good sensitivity due to the presence of particulate aluminum, and to a process for manufacturing such explosive mixtures by blending the trimethylolethane trinitrate with inorganic nitrate and aluminum particles.

Trimethylolethane trinitrate is a liquid explosive having a high rate of detonation and a low sensitivity. It has found use in blending with other explosive sensitizers of high sensitivity, so as to make them safe to handle, without, however, reducing the sensitivity of the other explosive sensitizer to initiation by a detonator, as disclosed in U.S. Pat. No. 3,344,005, patented Sept. 26, 1967, to Bronstein and Griffith. However, the sensitivity of trimethylolethane trinitrate is such that it has not come into widespread use except in admixture with other explosive sensitizers.

In accordance with the invention, trimethylolethane trinitrate explosive mixtures are prepared, based on an inorganic nitrate oxidizer and trimethylolethane trinitrate as the principal if not the only explosive sensitizer. These explosive compositions have a high rate of detonation and good sensitivity because of the presence of particulate aluminum in the explosive.

It has been determined in accordance with the invention that if trimethylolethane trinitrate and the inorganic nitrate are blended with particulate aluminum, the resulting explosive mixture has a considerably higher rate of detonation and a good sensitivity.

The explosive mixtures of the invention are formulated as dry or dry-appearing particulate mixtures, as slurries, or as gels. In particulate mixtures, the trimethylolethane trinitrate although a liquid is wholly absorbed on the solid particles of inorganic nitrate and any other solid components that may be present. In slurries, enough liquid is used, in excess of that which can be absorbed by the solid ingredients (usually up to 5%) to slurry the mixture,

and the amount of liquid therefore is from about 5% to about 30%.

Water in an amount up to about 5% reduces rate of detonation, but does not usually affect sensitivity. In amounts in excess of 5% sensitivity is also reduced. Petroleum oils have a similar effect.

Any inorganic nitrate can be employed as the oxidizer in the compositions of the invention. Ammonium nitrate is the nitrate normally used. However, other inorganic nitrates can be employed, alone or in admixture with the ammonium nitrate. Nitrates of the alkali and alkaline earth metals, such as sodium nitrate, potassium nitrate, calcium nitrate, strontium nitrate, and barium nitrate, are exemplary inorganic nitrates. Mixtures of ammonium nitrate with alkali and/or alkaline earth metal nitrates in proportions within the range from about 25 to about 95% of ammonium nitrate, and from about 75 to about 5% of the other nitrates, are preferred in many instances, because of their high explosive power. Compositions based on ammonium nitrate as the sole inorganic nitrate are also preferred because of their high power.

Mill and prill inorganic nitrates are quite satisfactory. The inorganic nitrate can be fine, coarse, or a blend of fine and coarse materials.

The physical form of the aluminum, on the other hand, does have an effect. Any particulate aluminum can be used, such as flake, powdered, and atomized aluminum. However, aluminum having a particle size within the range from —120 to —320 mesh appears to impart the highest rate of detonation and sensitivity for a given weight of aluminum. Milled flake aluminum and flake aluminum are within this size range, and are preferred. Particles within the range from —6 mesh to virtually fine dust in size can also be used.

Since aluminum larger than 90 mesh and smaller than 18 mesh is less effective, blends of aluminum particles of such sizes with aluminum of optimum particle size, i.e., from —120 to —325 mesh, is a means of further controlling the effect of the aluminum on rate of detonation.

In addition to the trimethylolethane trinitrate, the inorganic nitrate and the aluminum, which are the essential ingredients, the explosive mixtures of the invention can include one or more supplemental solid fuels, such as an additional metal fuel, or a solid carbonaceous fuel, or both. Illustrative of other particulate metals, for example, are ferrophosphorus, ferromanganese, and ferrosilicon. The metal fuel including the aluminum usually comprises from about 0.5 to about 30% of the mixture.

Useful solid carbonaceous materials are powdered coal, coal dust, charcoal, bagasse, dextrin, starch, wood meal, flour, bran, pecan meal, and similar nutshell meals. The carbonaceous fuel when present usually comprises from about 0.5 to about 30% of the mixture. Mixtures of such fuels can also be used in amounts within the range from about 0.5 to about 30%.

Sulfur can also be added. An amount of from about 0.5 to about 5% can further increase the rate of detonation.

Liquid carbonaceous fuels such as petroleum oil display a depreciating effect on rate of detonation, but may in-

crease sensitivity, and if these are used, these effects are taken into account. By combined use of liquid carbonaceous fuel and particulate aluminum, in appropriate amounts, it is possible to control rate of detonation and sensitivity rather precisely.

Stabilizers can be included in an amount within the range from about 0.1 to about 2% of the composition. Zinc oxide, ethyl centralite, diphenylamine, carbazole, calcium carbonate, aluminum oxide and sodium carbonate are useful stabilizers.

The relative proportions of inorganic nitrate and trimethylolethane trinitrate as well as any additional explosive sensitizers will depend upon the sensitivity and explosive effect desired, and are not critical. These in turn are dependent upon the particular nitrate or nitrates used. For optimum effect, the inorganic nitrate is used in amounts within the range from about 50 to about 90%, and the total explosive sensitizer including the trimethylolethane trinitrate in an amount within the range from about 10 to about 50%. The preferred ratio of nitrate to total explosive sensitizer is from about 5:1 to about 2:1. However, from about 35 to about 75% inorganic nitrate, and from about 25 to about 65% explosive sensitizer, give quite satisfactory results in the explosive mixtures of the invention.

The effect of the aluminum on rate of detonation and sensitivity is found to be the greatest with trimethylolethane trinitrate, and is less evident with other explosive sensitizers, so far as is presently known. Consequently, the trimethylolethane trinitrate is the major, if not the only, explosive sensitizer, and preferably comprises at least 90% of the explosive sensitizer that is present. However, small amounts of other explosive sensitizers can be used, up to a maximum of 25% of the total explosive sensitizer, of which dinitrotoluene, trinitrotoluene, pentaerythritol tetranitrate, pentolite (an equal parts by weight mixture of pentaerythritol tetranitrate and trinitrotoluene), cyclonite (RDX), Composition B (a mixture of up to 60% RDX, up to 40% TNT, and 1 to 4% wax), cyclotol (Composition B without the wax), nitrostarch, nitrocellulose, tetryl, smokeless powder, and carbine ball powder are exemplary. Nitrocellulose is of particular interest in the formulation of gels, as is described below.

For some purposes, the compositions of the invention can be formulated as slurries, using an inert liquid such as water as the suspending liquid. The amount of liquid that is used is more than is absorbed by the solid ingredients, and sufficient to produce a slurry. The slurry can have any desired consistency, from a thin, readily flowable material, to a viscous material of a semi-solid consistency. As little as 0.5% liquid may suffice. Usually, not more than 30% liquid need be used. Water may have a desensitizing effect, and this is taken into account in formulating the mixture.

In order to prevent large amounts of unabsorbed liquid from decreasing the consistency unduly, a liquid-soluble or liquid-dispersible thickener can be added to take up the liquid. The particular material employed will depend upon the liquid that is used, water-soluble or water-dispersible thickeners being used when water is the liquid, and oil-soluble or oil-dispersible thickeners being used when the oil is the liquid. Various gums, such as guar gum and cross-linked guar gum, can be used, as well as carboxymethylcellulose, methyl cellulose, psyllium seed mucilage, polyacrylamide and pregelatinized starches, such as Hydroseal 3B, as well as silica aerogels, finely-divided silicas, inorganic gelling agents such as alumina, attapulgite, bentonite, and like materials. Small amounts of from 0.1 to 10% by weight, are sufficient.

The explosive mixtures of the invention are prepared by blending at room or at an elevated temperature, mixing the inorganic nitrate and trimethylolethane trinitrate while heating them to a temperature within the range from about 100 to about 150° F. will further increase rate of detonation. In this case, the trimethylolethane trinitrate and inorganic nitrate oxidizer are added to the mixer, and mixing then effected at a temperature within the stated range. It is not necessary to heat the ingredients beyond the time required to ensure thorough mixing, using from about fifteen minutes to about one-half hour.

It is desirable to blend the trimethylolethane trinitrate and the inorganic oxidizer under these conditions without the presence of the other explosive ingredients, so as to ensure an intimate association of the trimethylolethane trinitrate and inorganic nitrate. Since, however, the trimethylolethane trinitrate and inorganic oxidizer usually by far compose the major proportion of the composition, in order to shorten the time of mixing, minor amounts of any other explosive ingredients that are to be present can also be added at the same time. These additional components comprise the aluminum, supplemental fuel, if any, the stabilizer, and any additional explosive sensitizers. Alternatively, after mixing of the trimethylolethane trinitrate and inorganic oxidizer is complete, the other explosive ingredients can be added and thoroughly blended with the mixture.

The base explosive mixture of the invention, composed of trimethylolethane trinitrate, inorganic nitrate, and petroleum oil, can be formulated to form a variety of explosives, including dry particulate mixes, such as permissible explosives, and gels, such as gelatin dynamites, ammonia dynamites, and ammonia gels. Various types of formulations are illustrated in the examples.

The compositions of the invention are particularly useful in the form of explosive gels of the trimethylolethane trinitrate in combination with nitrocellulose. The nitrocellulose and trimethylolethane trinitrate are combined with a volatile nitroparaffin solvent in a sufficient amount to dissolve the nitrocellulose and the trimethylolethane trinitrate. The solvent is then removed from the resulting composition, and as this is done, the solution thickens, and a gel of the trimethylolethane trinitrate and nitrocellulose is obtained eventually. This gel composition is then formulated with additional explosive ingredients, including inorganic nitrate, and any other inorganic oxidizers, other sensitizing explosives, aluminum, and other fuels, as described above, and can be brought to any desired consistency or physical condition.

Any type of nitrocellulose can be employed in the formulation of these gels. A fully nitrated trinitrocellulose has the highest nitrogen content (14.14% nitrogen) but the commercially available trinitrocelluloses having from 13.5 to 14% nitrogen are quite satisfactory. Any nitrocellulose having from 0.5 to 3 nitro groups per anhydroglucose unit of the cellulose can be employed, with excellent results. The preferred nitrocelluloses have from about 8% to about 14.14% nitrogen.

The amount of nitrocellulose can be varied over a wide proportion, according to the sensitivity and consistency desired.

The nitroparaffin employed has no effect on the consistency of the final gel, but the relative proportions of trimethylolethane trinitrate and nitrocellulose do. Inasmuch as the trimethylolethane trinitrate is a liquid, and the nitrocellulose is a solid, the larger the proportion of trimethylolethane trinitrate, the greater the tendency of the final gel to be a thick, semi-fluid, thixotropic or soft gel. Very hard gels can be obtained employing a large proportion of nitrocellulose. In general, the proportions of trimethylolethane trinitrate and nitrocellulose required for a gel of given hardness are best determined by trial and error, because the hardness of the gel depends to a considerable extent upon the nitrogen content of the nitrocellulose.

Satisfactory hard explosive gels are obtained, of high sensitivity and adequate explosive power, when the composition contains from about 10 to about 60 parts of nitrocellulose and from about 40 to about 90 parts of trimethylolethane trinitrate. Soft gels are obtained when

the nitrocellulose proportion is from 0.2 to 10 parts, and trimethylolethane trinitrate can be varied to a considerable extent, and any proportion within the range from about 40 parts to about 99.8 parts of trimethylolethane trinitrate to from about 0.2 part to about 60 part of nitrocellulose can be used.

The higher the proportion of nitrocellulose, the higher the sensitivity and explosive power of the composition. The trimethylolethane trinitrate has a desensitizing effect. In general, the upper limit of the amount of trimethylolethane trinitrate will depend upon the explosive power and sensitivity that is desired, and the lower proportion will depend upon the degree of desensitization of the nitrocellulose that is required, for the end use of the composition.

The nitroparaffin that is employed should be sufficiently volatile at atmospheric temperatures, or at a temperature below about 60° C., under vacuum, if necessary, so that it can be removed virtually quantitatively from the composition after the trimethylolethane trinitrate and nitrocellulose have been dissolved therein, so as to form the desired gel. Such nitroparaffins have from one to about six carbon atoms and one nitro group, and include nitromethane, nitroethane, 1-nitropropane, 2-nitropropane, 1-nitrobutane and 1-nitrohexane. These nitropartffins have a boiling point below about 150° C., but higher boiling nitroparaffins can be used, if they are removed under vacuum. They are not explosive, and cannot be exploded with detonating caps, differing in this respect from the trimethylolethane trinitrate. A further distinction is their volatility, despite their high boiling point. Nitromethane, for example, the lowest molecular weight compound of this series, has a boiling point of 101.2° C., and yet it is quantitatively volatilized from the solution on standing in the atmosphere for from eight hours to three days. The relatively high boiling point is important to the formation of a gel, because it means that the nitroparaffin is only slowly volatilized from the solutions employed as a starting material in the preparation of the nitrocellulose gels. A slow volatilization of the nitroparaffin may facilitate the formation of the final explosive gel.

The amount of nitroparaffin solvent is not critical. A sufficient amount is employed to dissolve the nitrocellulose and trimethylolethane trinitrate. Depending upon the solubility of the nitrocellulose and the trimethylolethane trinitrate, as little as 20% by weight of the composition can be employed. There is no upper limit, inasmuch as all of the nitroparaffin solvent will eventually be removed, but there is obviously no need to employ more than is necessary to dissolve the components, since any excess nitroparaffin must also be evaporated in forming the gel, with a resultant increase in the time required to form the gel, as well as in the cost of its preparation. Thus, the upper limit is normally not in excess of about 500% by weight of the nitrocellulose-trimethylolethane trinitrate.

Such gels in accordance with the invention can be employed with aluminum and inorganic nitrate oxidizer in the formation of a wide variety of explosive formulations, including gelatin dynamites, smokeless powders, permissible explosives, and nitrocarbonitrate explosives.

Gelatin and semigelatin dynamites contain, in addition to the trimethylolethane trinitrate-nitrocellulose gel, the inorganic oxidizer and aluminum and or other combustible material. The following is a general formulation:

	Percent by weight
Trimethylolethane trinitrate	5–95
Nitrocellulose	0.1–15
Inorganic oxidizer	5–95
Combustible material or fuel (including aluminum)	0–25

Gelatin dynamites can be packaged in block form by filling the solution of trimethylolethane trinitrate-nitrocellulose and any other components in the nitroparaffin solvent into containers of the desired size, and then allowing the solution to gel by removal of the solvent. This can be expedited by warming the containers in a vacuum oven. Then, after the gels have set, the containers are capped and sealed. Stick gelatin dynamites are easily prepared in this way.

Some hard gelatin dynamites can be prepared by first mixing the nitrocellulose, nitroparaffin, and trimethylolethane trinitrate, and then allowing the nitroparaffin to evaporate, forming a viscous liquid or gel. The viscous liquid or gel is then blended with the inorganic oxidizer, aluminum and any other fuels, and any additional sensitizers desired, forming a damp granular mixture, in which the liquid or gel is coated or absorbed on the solid components. The mixture is then packaged in cartridges, using conventional dynamite pack machines.

Smokeless powders are in particulate form, and are based on the trimethylolethane trinitrate-nitrocellulose gel as one component, in combination with the usual components to control the rate of burning. The type of smokeless powders that can be formulated, using the gels and hot inorganic nitrate in accordance with the invention, include double base powders and ball grain powders. Typical general formulations are as follows:

Double base powder:	Percent by weight
Polyol polynitrate	5–60
Nitrocellulose	5–95
Inorganic oxidizer	0–50
Combustible material or fuel (including aluminum)	0–5

Ball grain powder:	
Polyol polynitrate	5–60
Nitrocellulose	95–40
Inorganic oxidizer	0–20
Combustible material or fuel (including aluminum)	0–15

Gelled pellets of smokeless powder can be prepared by stirring the solution composed of trimethylolethane trinitrate, nitroparaffin, solvent and nitrocellulose rapidly with hot water, heating the mixture at an elevated temperature in order to remove the nitroparaffin and set the gel particles, while at the same time dispersing the solution into small droplets, so that the gel particles are formed in finely-divided dispersed form in the water. The particles can then be separated from the water by screening and drying. The resulting composition is a pelleted smokeless powder, the size of whose pellets depends upon the degree of dispersion and the mesh size of the screen through which the composition is passed.

The explosive mixtures of the invention are sufficiently sensitive so that frequently they can be detonated with an ordinary initiator or blasting cap. However, when not, the compositions can be fired with the aid of a small booster charge. Combinations of the explosive mixtures as powders together with an initiator and/or booster in the same container can be prepared and marketed as a combined blasting agent. The explosive compositions and the booster or initiator can be separately packaged as a composite in a single container, and can also be marketed in this form. Any conventional initiator or booster charge available in the art can be employed. Pentaerythritol tetranitrate, pentolite, tetryl and cyclonite, preferably in cast form, are exemplary booster charges.

The following examples in the opinion of the inventor represents the best embodiments of the invention.

The power of the explosives of the examples was determined using the standard tests for determining sensitivity, density, rate of detonation, and stick weight.

EXAMPLES 1 TO 3

A group of three formulations was prepared, containing flake aluminum. The ammonium nitrate, trimethylolethane trinitrate, flake aluminum, and other ingredients were all mixed together at 130° F. for twenty minutes.

These compositions had the following formulation:

TABLE I

Example	Parts by weight: Control	1	2	3
Composition:				
Trimethylolethane trinitrate	15.00	15.00	15.00	15.00
Ammonium nitrate—grained	80.00	80.00	80.00	80.00
Aluminum—flake (−320 mesh)		2.00	2.00	2.00
Nut meal	5.00	5.00	5.00	5.00
Water		1.00	1.00	1.00
Total	100.00	103.00	103.00	105.00
Test results:				
Sand density (g./cc.)	0.955	0.885	0.992	0.94
Stick weight (g.) (1⅛ inches x 8 inches)	134	125	139	132
Sensitivity (1 inch x 4 inches)	(1)	(1)	(1)	(1)
Rate of detonation (1⅛ inches x 8 inches) (meters/second)	2,556	2,749	2,782	2,364

[1] No. ½ cap.

It is evident from a comparison of Examples 1, 2 and 3 with the control that the addition of aluminum considerably increased the rate of detonation. All these compositions had good sensitivity.

EXAMPLES 4 TO 6

Three formulations were prepared at 120° F., having amounts of trimethylolethane trinitrate ranging from 10% to 20%, and using powdered and flake aluminum. These formulations had the following composition:

TABLE II

Example Number	Parts by weight: 4	5	6
Composition:			
Trimethylolethane trinitrate	10.00	15.00	20.00
Ammonium nitrate—grained	75.00	70.00	59.60
Sodium nitrate	10.00	10.00	10.00
Almeg 90-30 aluminum powder (30 mesh)	1.00	1.00	2.00
Flake aluminum	1.00	1.00	
Sulfur	2.00	2.00	2.60
Wheat flour			5.00
Water	1.00	1.00	1.00
Total	100.00	100.00	100.00
Test results:			
Sand density (g./cc.)	0.935	0.975	1.23
Stick weight (g.) (1⅛ inches x 8 inches)	127	132	165
Sensitivity (1 inch x 4 inches)	(1)	(1)	(1)
Rate of detonation (1⅛ inches x 8 inches) (meters/second)	2,200	2,425	2,482

[1] No. ½ cap.

These compositions had good rates of detonation and good sensitivity.

It is evident from Example 6 that aluminum powder is less effective than flake aluminum, since it gives a composition having a lower rate of detonation relative to the stick weights. Blending with flake aluminum (Examples 4 and 5) lowers density and improves rate of detonation.

EXAMPLES 7 TO 10

A group of four formulations was prepared at 120° F., having amounts of trimethylolethane trinitrate ranging from 15 to 20% by weight, and different forms of aluminum. These formulations were as follows:

TABLE III

Example Number:	Parts by weight: 7	8	9	10
Composition:				
Trimethylolethane trinitrate	20.00	20.00	20.00	20.00
Ammonium nitrate—grained	63.00	63.00	63.00	63.00
Sodium nitrate—mill	10.00	10.00	10.00	10.00
Flake aluminum (−320 mesh)	2.00	2.00	2.00	2.00
Wheat flour	5.00	5.00	5.00	5.00
Oil No. 5		1.00	0.30	2.00
Test results:				
Sand density (g./cc.)	1.19	1.19	1.19	1.19
Stick weight (g). (1⅛ inches x 8 inches)	160	160	160	160
Sensitivity (1 inch x 4 inches)	(1)	(1)	(1)	(1)
Rate of detonation (1⅛ inches x 8 inches) (meters/second)	4,112 / 3,908	2,866	3,867	1,954

[1] No. ½ cap.

The trimethylolethane trinitrate, sodium nitrate and ammonium nitrate were blended with the other ingredients simultaneously, and the mixing time at 120° F. was one-half hour.

All four compositions had good rates of detonation, and good sensitivity. The effect of the oil in reducing rate of detonation is evident from a comparison of Examples 8, 9 and 10 with Example 7. Thus, by a blend of particulate aluminum and oil, in appropriate amounts, it is possible to closely control rate of detonation, without affecting sensitivity.

EXAMPLES 11 TO 15

A group of five formulations was prepared using aluminum in various forms of particle, ranging from flake to atomized aluminum. These formulations had the following composition, including Example 7 for comparison:

TABLE IV

Example Number	Parts by weight: 7	11	12	13	14	15
Composition:						
Trimethylolethane trinitrate	20.00	20.00	20.00	20.00	20.00	20.00
Ammonium nitrate	63.00	63.00	63.00	63.00	63.00	63.00
Sodium nitrate	10.00	10.00	10.00	10.00	10.00	10.00
Wheat flour	5.00	5.00	5.00	5.00	5.00	5.00
Flake aluminum (−320 mesh)	2.00					
Almeg 90-18 aluminum powder (−180-90 mesh)		2.00				
M-30 aluminum powder (30 mesh)			2.00			
Atomized 12120 aluminum (120 mesh)				2.00		
100 P aluminum powder (230 mesh)					2.00	
Alcoa 606 aluminum fine flake (−320 mesh)						2.00
Test results:						
Sand density (g./cc.)	1.19	1.11	1.11	1.11	1.11	1.19
Stick weight (g.) (1⅛ inches × 8 inches)	160	150	150	150	150	160
Sensitivity (1 inch x 4 inches)	(1)	(1)	(1)	(1)	(1)	(1)
Rate of detonation (1⅛ inches x 8 inches (meters/second)	4,112 / 3,908	3,503	3,195	3,111	3,427	3,750

[1] No. ½ cap.

These formulations were mixed at 130° F. for one-half hour. The trimethylolethane trinitrate and ammonium nitrate and sodium nitrate were blended with the aluminum and the wheat flour, and the entire mixture was heated at 130° F. for the full mixing time.

All six compositions had good sensitivity, and good rates of detonation.

It is evident that the form of the aluminum has a considerable effect upon the detonation. The highest rate of detonation is obtained with flake aluminum, and the lowest with atomized aluminum. This shows that the aluminum particles should be relatively fine, in the range of −325 up to −120 mesh, for a high rate of detonation.

EXAMPLES 16 AND 17

Two compositions were prepared, mixing the ingredients at room temperature, and having the formulation set out in Table V:

TABLE V

Example Number	Parts by weight 16	17
Composition:		
Trimethylolethane trinitrate	10.00	10.00
Ammonium nitrate—grained	88.00	88.00
Almeg 90-30 aluminum granules (30 mesh)		2.00
Flake aluminum (−325 mesh)	2.00	
Total	100.00	100.00
Test results:		
Sand density (g./cc.)	1.01	1.01
Sensitivity (1 inch x 4 inches)	(1)	(1)
Rate of detonation (1⅛ inches x inches) (meters/second)	2,702	2,102
Stick weight (g.) 1⅛ inches x 8 inches)	137	137

[1] No. ½ cap.

These formulations had good rates of detonation, and high sensitivity. The superiority of flake aluminum to granular aluminum is evident.

EXAMPLES 18 TO 24

A group of seven thickened slurried formulations was prepared, and compared with a dry formulation of like composition. These formulations were mixed at room temperature, the explosive ingredients being mixed for fifteen minutes, and the water and guar gum then blended in. The formulations were as follows:

TABLE VI

Example Number	Parts by weight 18	19	20	21	22	23	24
Composition:							
Trimethylolethane trinitrate	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Ammonium nitrate—grained	83.00	80.90	78.80	76.70	74.60	72.50	70.40
Flake aluminum (−325 mesh)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Water	0.00	2.00	4.00	6.00	8.00	10.00	12.00
Guar gum (537-Z-8)		0.10	0.20	0.30	0.40	0.50	0.60
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Test results:							
Sand density (g./cc.)	1.03	1.18	1.32	1.46	1.46	1.46	1.46
Sensitivity (1 inch x 4 inches)	(1)	(2)	(3)	(2)	(3)	(4)	(4)
Rate of detonation (1⅛ inches x 8 inches) (meters/second)	3,031	2,832	2,489	2,489	2,388	(5)	(5)
Stick weight (g). (1⅛ inches x 8 inches)	140	160	177	195	195	195	195

[1] No. ½ cap. [2] No. 2 cap. [3] No. 5 cap. [4] No. 16 cap. [5] No ROD.

These were all thick slurries, and had good rates of detonation and good sensitivity, compared to the dry formulation. The effect of water in reducing rate of detonation and sensitivity is apparent.

EXAMPLES 25 TO 27

A group of six permissible explosive formulations was prepared, at room temperature, having the composition shown in Table VII. Three were controls without aluminum.

TABLE VII

Example Number	Parts by weight Control A	25	Control B	26	Control C	27
Trimethylolethane trinitrate	7.50	7.50	15.00	15.00	20.00	20.00
Ammonium nitrate—grained	61.45	60.10	56.45	55.10	53.70	52.60
Sodium nitrate	10.00	10.00	10.00	10.00	10.00	10.00
Sodium chloride	10.00	10.00	10.00	10.00	10.00	10.00
Zinc oxide	0.30	0.30	0.30	0.30	0.30	0.30
Oil No. 5	0.75	0.10	0.75	0.10	1.00	0.10
Bagasse	10.00	10.00	5.00	5.00	0.00	0.00
Flake aluminum (−325 mesh)	0.00	2.00	0.00	2.00	0.00	2.00
Wheat flour	0.00	0.00	2.50	2.50	5.00	5.00
Total	100.00	100.00	100.00	100.00	100.00	100.00
Test results:						
Sand density (g./cc.)	0.665	0.680	0.880	0.880	1.310	1.310
Sensitivity (1 inch x 4 inches)	(1)	(2)	(2)	(2)	(1)	(2)
Rate of detonation (1⅛ inches x 8 inches) (meters/second)	1,630	1,930	2,364	2,482	2,072	2,888
Stick weight (g.) (1⅛ inches x 8 inches)	86	94	120	120	175	175

[1] No. 1 cap. [2] No. ½ cap.

These formulations had excellent rates of detonation, compared to the controls, and sensitivity also was high.

EXAMPLES 28 TO 31

A group of four ammonia dynamites was prepared, mixing the ingredients together at room temperature and having the following formulations:

TABLE VIII

Example Number	Parts by weight 28	29	30	31
Trimethylolethane trinitrate	14.00	14.00	14.00	14.00
Ammonium nitrate—grained	42.10	51.60	61.10	65.60
Sodium nitrate	35.00	25.00	15.00	10.00
Zinc oxide	0.30	0.30	0.30	0.30
Oil No. 5	0.10	0.10	0.10	0.10
Bagasse	5.00	5.00	5.00	5.00
Wheat flour	2.00	2.00	2.00	2.00
Flake aluminum (−325 mesh)	1.50	2.00	2.50	3.00
Total	100.00	100.00	100.00	100.00
Test results:				
Sand density (g./cc.)	0.88	0.86	0.82	0.82
Stick weight (g.) (1⅛ inches x 8 inches)	120	117	112	112
Sensitivity (1 inch x 4 inches)	(1)	(1)	(1)	(1)
Rate of detonation (1⅛ inches x 8 inches) (meters/second)	2,124	2,161	2,303	2,405
Ballistic pendulum value (No. 6 cap)	9.1	10.2	11.2	11.9

[1] No. ½ cap.

These formulations had good rates of detonation, good sensitivity, and good ballistic pendulum values.

EXAMPLES 32 TO 34

A group of six water-resistant permissible explosives was prepared, mixing the ingredients at room temperature. These had the following formulation:

TABLE IX

Example Number	Parts by weight: Control A	32	Control B	33	Control C	34
Composition:						
Trimethylolethane trinitrate	7.50	7.50	15.00	15.00	20.00	20.00
Ammonium nitrate—grained	59.45	58.10	54.45	53.10	51.70	50.60
Sodium nitrate	10.00	10.00	10.00	10.00	10.00	10.00
Sodium chloride	10.00	10.00	10.00	10.00	10.00	10.00
Zinc oxide	0.30	0.30	0.30	0.30	0.30	0.30
Oil No. 5	0.75	0.10	0.75	0.10	1.00	0.10
Bagasse	10.00	10.00	5.00	5.00	0.00	0.00
Flake aluminum (−325 mesh)	0.00	2.00	0.00	2.00	0.00	2.00
Jaguar 100 guar gum	2.00	2.00	2.00	2.00	2.00	2.00
Wheat flour	0.00	0.00	2.50	2.50	5.00	5.00
Total	100.00	100.00	100.00	100.00	100.00	100.00
Test results:						
Sand density (g./cc.)	0.65	0.64	0.88	0.88	1.29	1.29
Stick weight (g.) (1⅛ inches x 8 inches)	88	88	120	120	172	172
Ballistic pendulum value (No. 6 cap)	9.3	9.6	9.5	9.7	9.6	9.9
Sensitivity (1 inch x 4 inches)	(1)	(2)	(2)	(2)	(2)	(3)
Rate of detonation (1⅛ inches x 8 inches) (meters/second)	1.443	1,572	2,210	2,358	2,133	2,838

[1] No. 2 cap. [2] No. ½ cap. [3] No. 5 cap.

These had good rates of detonation, compared to the controls, and good sensitivity and ballistic pendulum value.

EXAMPLES 35 TO 38

Four water-resistant ammonia dynamites were prepared, having the following formulation. The ingredients were mixed together at room temperature for fifteen minutes.

TABLE X

Example Number	Parts by weight: 35	36	37	38
Composition:				
Trimethylolethane trinitrate	14.00	14.00	14.00	14.00
Ammonium nitrate—grained	42.10	51.60	61.10	65.60
Sodium nitrate	35.00	25.00	15.00	10.00
Zinc oxide	0.30	0.30	0.30	0.30
Oil No. 5	0.10	0.10	0.10	0.10
Nut meal (fine)	5.00	5.00	5.00	5.00
Jaguar 100 guar gum	2.00	2.00	2.00	2.00
Flake aluminum (−325 mesh)	1.50	2.00	2.50	3.00
Total	100.00	100.00	100.00	100.00
Test results:				
Sand density (g./cc.)	1.19	1.15	1.11	1.11
Stick weight (g.) (1⅛ inches x 8 inches)	160	155	150	150
Ballistic pendulum value (No. 6 cap)	8.5	9.8	11.2	11.8
Sensitivity (1 inch x 4 inches)	(1)	(1)	(1)	(1)
Rate of detonation (1⅛ inches x 8 inches) (meters/second)	2,542	2,803	2,903	3,028

[1] No. ½ cap.

These formulations had good rates of detonation, good sensitivity, and good ballistic pendulum value.

EXAMPLES 39 TO 42

Four ammonia dynamites having low rates of detonation were prepared, mixing the ingredients at room temperature for fifteen minutes. These had the following formulations:

TABLE XI

Example Number	Parts by weight: 39	40	41	42
Composition:				
Trimethylolethane trinitrate	14.00	14.00	14.00	14.00
Ammonium nitrate—grained	41.20	50.70	60.20	64.70
Sodium nitrate	35.00	25.00	15.00	10.00
Zinc oxide	0.30	0.30	0.30	0.30
Oil No. 5	1.00	1.00	1.00	1.00
Nut meal (fine)	5.00	5.00	5.00	5.00
Wheat flour	2.00	2.00	2.00	2.00
Flake aluminum (−325 mesh)	1.50	2.00	2.50	3.00
Total	100.00	100.00	100.00	100.00
Test results:				
Sand density (g./cc.)	1.15	1.11	1.11	1.11
Stick weight (g). (1⅛ inches x 8 inches)	155	150	150	150
Ballistic pendulum value (No. 6 cap)	9.2	10.2	11.1	11.5
Sensitivity (1 inch x 4 inches)	(1)	(2)	(2)	(2)
Rate of detonation (1⅛ inches x 8 inches) (meters/second)	2,210	2,381	2,582	2,787

[1] No. 1 cap. [2] No. ½ cap.

These formulations had good rates of detonation and high sensitivity.

EXAMPLE 43

A trimethylolethane trinitrate-nitrocellulose gel was prepared by dissolving 4 parts of nitrocellulose (12.5%

N) in 120 parts of nitromethane. To this was added with stirring 16 parts of trimethylolethane trinitrate. The mixture was then spread in a thin layer in a tray, allowing the nitromethane to evaporate, leaving a pliable, clear gel.

A gelatin dynamite was prepared from this gel, having the following formulation:

Gel:	Percent by weight
Trimethylolethane trinitrate	16.0
Nitrocellulose (12.5% N)	4.0
Ammonium nitrate (grained)	57.6
Sodium nitrate	15.0
Zinc oxide	0.3
Oil No. 5	0.1
Aluminum (flake)	3.0
Guar gum	1.0
Water	3.0

The ammonium nitrate was brought to 130° F. and mixed hot with the gel. The remaining ingredients were then mixed in. This composition had a good sensitivity, a high density, and a low rate of detonation.

Having regard to the foregoing disclosure, the following is claimed as the inventive and patentable embodiments thereof:

1. A trimethylolethane trinitrate explosive composition having a high rate of detonation and good sensitivity, comprising a mixture of an inorganic nitrate oxidizer, trimethylolethane trinitrate as the sole explosive sensitizer, and particulate aluminum.

2. A trimethylolethane trinitrate explosive composition in accordance with claim **1**, in which the inorganic nitrate is ammonium nitrate.

3. A trimethylolethane trinitrate explosive composition in accordance with claim **1** in which the inorganic nitrate is a mixture of ammonium nitrate and sodium nitrate.

4. A trimethylolethane trinitrate explosive composition in accordance with claim **1**, in which the inorganic oxidizer is in an amount from about 50 to about 90%, and the trimethylolethane trinitrate is in an amount from about 10 to about 50%.

5. A trimethylolethane trinitrate explosive composition in accordance with claim **4**, in the form of an aqueous slurry.

6. A trimethylolethane trinitrate explosive composition in accordance with claim **5** comprising a solid carbonaceous fuel in an amount from about 0.5 to about 30% of the mixture.

7. A trimethylolethane trinitrate explosive composition in accordance with claim **5** in which the total metal fuel including the aluminum is in an amount from about 0.5 to about 30% of the mixture.

8. A trimethylolethane trinitrate explosive composition in accordance with claim **7** in which the metal fuel is aluminum having a particle size within the range from —6 to —325 mesh.

9. A trimethylolethane trinitrate explosive composition in accordance with claim **8**, in which the aluminum is flake aluminum.

10. A trimethylolethane trinitrate explosive composition in accordance with claim **4** comprising an additional sensitizing explosive selected from the group consisting of dinitrotoluene, trinitrotoluene, an equal parts by weight mixture of pentaerythritol tetranitrate and trinitrotoluene, a mixture of up to 60% cyclorimethylenetrinitramine, up to 40% trinitrotoluene, and 1 to 4% wax, a mixture of up to 60% cyclotrimethylenetrinitramine and up to 40% trinitrotoluene, nitrostarch, trinitrophenylmethylnitramine, smokeless powder, and carbine ball powder in an amount up to about 25% of the total sensitizing explosive.

11. A process for forming a trimethylolethane trinitrate explosive composition having a high rate of detonation and good sensitivity, comprising blending trimethylolethane trinitrate, an inorganic nitrate oxidizer at from 100° to 150° F. and mixing in particulate aluminum.

12. A process in accordance with claim **11**, in which the blending is carried out in the presence of water, in an amount not exceeding about 1%.

13. A process in accordance with claim **11**, wherein the inorganic nitrate is ammonium nitrate.

14. A process in accordance with claim **11**, wherein the inorganic nitrate is a mixture of ammonium nitrate and sodium nitrate.

15. A process in accordance with claim **11**, which includes blending a solid carbonaceous fuel with the blend of inorganic nitrate and trimethylolethane trinitrate in an amount of from 0.5 to about 30%.

16. A process in accordance with claim **11**, which includes blending the aluminum in an amount of from 0.5 to about 30%.

17. A process in accordance with claim **11**, wherein the blending is continued for from fifteen minutes to one-half hour.

References Cited

UNITED STATES PATENTS

2,821,466	1/1958	Russell	149—8
3,344,005	9/1967	Bronstein et al.	149—88X
3,423,256	1/1969	Griffith	149—47X
3,489,623	1/1970	Griffith et al.	149—91X

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