United States Patent Office 3,378,415
Patented Apr. 16, 1968

3,378,415

EXPLOSIVE SLURRY CONTAINING AN AGGLOMERATE OF AN INORGANIC NITRATE OXIDIZER AND A FUEL AND METHOD OF MAKING

George L. Griffith, Coopersburg, Pa., assignor, by mesne assignments, to Commercial Solvents Corporation, a corporation of Maryland

No Drawing. Filed Oct. 12, 1964, Ser. No. 403,365
20 Claims. (Cl. 149—2)

This invention relates to inorganic nitrate explosive slurries, and more particularly to explosive slurries based on sensitive particles of inorganic nitrate and a fuel and which accordingly do not require an explosive sensitizer.

Explosive mixtures containing relatively large amounts of water or oil or mixtures thereof have recently become of considerable interest in the explosive art. They have greater versatility than dry mixtures, because they can be used under conditions where water cannot be excluded, and the flowable slurries also may be brought more easily to certain types of sites such as bore holes and rock crevices. The water content or oil content is more than that which is absorbed by the components of the mixture, and is sufficient to act as a suspending agent for the mixture. Such a water or oil content in most cases ranges from about 10% to more than 50%, depending upon the materials present in the mixture and upon the consistency desired.

A slurry having a reasonably stiff consistency may be preferred for use in bulk in wet bore holes, where the composition may be diluted with water already present. Thickening or gelatinizing agents are employed when thick slurries are required containing high proportions of water. A slurry which can be poured may be desired for use in bulk in dry bore holes, and such a slurry is easily obtained by using a rather large proportion of fluid, for example 20 to 40%, without a thickening or gelatinizing agent.

Aqueous and oil based slurries as usually formulated contain an explosive sensitizer because of the relative insensitivity of ammonium nitrate, particularly in combination with large amounts of water or oil. Sensitized aqueous explosive slurries are described in U.S. Patent No. 2,930,685 to Cook and Farnam, patented Mar. 29, 1960. These compositions are based upon ammonium nitrate and sensitized with TNT, and may in addition contain powdered aluminum. Cook et al. point out that the explosives art has always taken extensive precautions both in formulating and in storing explosives to exclude moisture, and that they formulate their slurries very carefully using coarse grained TNT particles in order to obtain an acceptable sensitivity.

U.S. Patent No. 3,083,127 to Griffith and Wells, patented Mar. 26, 1963, describes aqueous explosive slurries based upon an inorganic nitrate and sensitized with nitrostarch. These slurries are superior in nearly all respects to similar slurries made with coarse grained TNT as described in the Cook and Farnam patent.

In accordance with the instant invention, explosive slurries are provided based on sensitive particles composed of an intimate mixture of an inorganic nitrate and a carbonaceous fuel as the principal ingredients. These particles keep these ingredients intimately mixed in the slurries, as a result of which sensitization with an explosive sensitizer is made unnecesary. However, an explosive sensitizer can be included if desired, for an enhanced explosive power.

The slurries of the invention consist essentially of a suspending fluid and particles of inorganic nitrate and a carbonaceous fuel in an amount at least 75% of the amount required to oxygen balance the inorganic nitrate.

Such particles are thus substantially oxygen-balanced crystals or agglomerates of inorganic nitrate and fuel, and because of the intimate admixture of these components have a high sensitivity, in contrast to slurries composed of separate particles of inorganic nitrate and fuel. Each particle suspended in the instant invention in effect is a full and balanced explosive in itself, and in this respect is distinguished from aggregates or mixtures of discrete particles suspended in slurry form.

Any inorganic nitrate can be employed as the nitrate component of the explosive particles of the invention. Ammonium nitrate is the nitrate normally used. However, any inorganic nitrate can be employed, in admixture with or in place of 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 additional inorganic nitrates. Mixtures of ammonium nitrate with alkali and/or alkaline earth metal nitrates, in proportions within the range from 25 to 75% of ammonium nitrate, and from 75% to 25% of the other nitrates, are preferred in many instances because of their high power. Compositions based on ammonium nitrate as the sole inorganic nitrate are also preferred.

In addition to the inorganic nitrates, the explosive particles include a solid carbonaceous fuel such as powdered coal, coal dust, charcoal, bagasse, dextrin, starch, wood meal, flour, bran, pecan meal or similar nut shell meals. Liquid fuels such as petroleum oil and paraffin oil can be used, with enough nitrate or solid fuel to act as a carrier therefor. The carbonaceous fuel is employed in an amount of at least 75% of that required to oxygen-balance the inorganic nitrate, and will usually comprise from about 5 to about 25% of the mixture. In addition to the carbonaceous fuel, a particulate metal can also be used, such as aluminum powder, flake aluminum and ferrosilicon. A metal fuel, when present, will usually comprise from about 1 to about 15% by weight of the mixture.

An antacid or stabilizer such as zinc oxide, calcium carbonate, aluminum oxide and sodium carbonate, may also be added, if desired, and sulfur can also be added. Amounts up to 5% of each of these are satisfactory for most purposes.

The inorganic nitrates employed may be fine, coarse or a blend of fine and coarse material. Mill and prill inorganic nitrates are quite satisfactory. The particle size is not critical, because this is invariably changed in the processing with the fuel to produce the explosive particles in accordance with the invention.

The inorganic nitrates and fuel are intimately blended and formed into particles, each of which contains both nitrate and fuel, and represents a balanced explosive in and of itself. This can be done in any of several ways.

In one procedure, the inorganic nitrate is liquefied or melted by heating, and there is then incorporated therewith the particles of fuel, to form particles composed of both the nitrate and the fuel. The nitrate can be hardened either before or after subdivision, as a result of which it recrystallizes and holds the particles of fuel as inclusions. If desired, the mass can be subdivided during transition from the plastic to the solid state by passing it through a screen, perforated membrane or plate while it is still hot. By first melting the liquefiable components of the composition, and then adding the fuel and other ingredients, the danger of spontaneous ignition is avoided, and the process can be carried out safely. If the fuel and other ingredients were to be associated with the crystalline nitrate, and the whole mass then heated to liquefy the latter, spontaneous ignition would occur almost instantaneously. For the same reason, it is neither neces-

sary nor desirable to heat the fuel and other solid ingredients before incorporation with the fluid nitrate.

The plastic mass before subdivision dissipates its heat quite slowly. However, due to the greater surface area of the subdivided particles, the particles set rather quickly, and in some instances a film or hard casing is formed upon them. The particles when hardened are then ready for use in the formation of a slurry in accordance with the instant invention.

In preparing the melt or viscous inorganic nitrate, it is not necessary to employ dried material, since any moisture that is present tends to be driven off during the heating and mixing in molten form in combination with the molten fuel. However, in some instances a small amount of moisture, for example up to about 1 or 2% by weight of the inorganic nitrate, can be employed for the purpose of decreasing the time required to make the melt. The added water aids in conducting water to the interior of the mass, and is driven off as the melting proceeds. Explosive particles made in accordance with the invention may contain up to about 6 to 8% of absorbed water. This water may be added at the time the melt is being formed, but is of course lost after the pellets have been formed. It is not in any case available for use as a suspending medium in formulating the slurry from the particles.

Ammonium nitrate alone melts at a temperature of about 305° F. Certain nitrates such as sodium nitrate and barium nitrate decrease the melting temperature by forming a lower melting eutectic mixture with the ammonium nitrate. Some fuels, for example, sugar and dextrin, can be used in place of the sodium or barium nitrate or in conjunction with it for the same purpose.

A steam-jacketed kettle can be used for melting the nitrate, in order to avoid open flames and provide for better control of the temperature. The kettle is preferably equipped with a mechanical mixer or agitator to ensure thorough blending with the solid material later.

In mixing the ingredients to which the melt is to be added, a trough or dough type mixer can also be used. The non-meltable components are placed in the trough, and mixed until the mass is of uniform consistency. The trough may be jacketed to prevent too rapid cooling, or to apply heat if desired, or to apply cooling water to lower the temperature. When the proportion of melted material in the mass is relatively high, the mass can be very plastic, in some instances too plastic to be formed easily into particles, and in these cases, cool water is applied to reduce the temperature and increase the viscosity. On the other hand, when the proportion of melted material is relatively low, the mass may tend to set or congeal very quickly, in which case the mixing trough may be warmed to prevent the mass from congealing into hard lumps before it is formed into particles. Improperly sized particles made during a previous run can be admixed with the fuel and other non-meltable materials and re-used.

The admixture of meltable and non-meltable material constitutes a finished explosive in a plastic state which is ready to be formed into particle. This dough-like substance next is conveyed to the particle-forming operation, such as a perforated plate or forming membrane, and is then formed, preferably as promptly as possible, into particles of the desired size.

By controlling the temperature of the atmosphere beyond the forming membrane, the rapidity with which the particles congeal and set into hard particles can be controlled. If the particles be expelled into a chilled or frigid atmosphere, then a hard casing is formed upon them rather quickly, and the particles, although frangible, retain their individuality rather well. In some instances, the particles present jagged, somewhat crystallitic surfaces. These surfaces are not disadvantageous in the slurries of the invention.

The plastic mass may be formed into particles using a screen or extrusion machine or a pelleting machine. Other equipment that can be used will be apparent to one skilled in the art.

The explosive particles thus formed can then be blended with the slurrying liquid, such as water, oil or a mixture of water and oil. When water is present, preferably a saturated solution of the inorganic nitrates present in the explosive particles is employed. The inorganic nitrates are extremely soluble in water, and unless dissolution is inhibited or prevented by use of a substantially saturated solution, the nitrate content of the particles may be dissolved sufficiently so that they will disintegrate, and thus defeat the purpose of the invention.

The slurry is readily prepared by simple mixing of the slurrying liquid and the explosive particles, adding sufficient thickener or gelatinizing agent, if required, to bring the mixture to the desired consistency, which can range from a gel or thick barely pourable mixture to a thin free-flowing liquid.

The explosive slurries of the invention contain enough fluid to act as a suspending medium for the solid ingredients. Some explosive mixtures are capable of absorbing surprisingly large amounts of fluid. The fluid added in the slurries of the invention is always enough more than this amount to suspend the mixture. Usually, 7% is enough to barely slurry the mixture, but more may be required to make the slurry flowable. The practical upper limit is set by excessive dilution and dissipation of the explosive power, taking into account any loss of fluid by volatilization and absorption into the ground. In most cases, the preferred range of fluid content will be from about 10% to about 40%, although in some cases as much as 50% might be used.

The amount of fluid employed will vary with the consistency desired. In the case of oil, the viscosity of the oil is a factor to be taken into consideration in determining the amount of fluid added. When mixtures of oil and water are used, there will generally be employed from 2 to 10% water and from 10 to 30% oil to give a slurry having a satisfactory fluidity.

The consistency of the slurry, particularly of a free-flowing slurry, can be increased to meet any need by incorporating a thickening or gelatinizing agent. In this way, it is possible to prepare a thick slurry containing a large proportion of fluid for use in bulk in dry bore holes. The thickening agent should be soluble or dispersible in the dispersing fluid, and inert to the other ingredients present. The thickened slurry can be used to form explosive cartridges in the same manner as the slurries normally having a semi-solid consistency.

An oil slurry can be thickened by any of the non-carbonaceous inorganic oil thickeners useful in making thickened oils and greases, such as finely divided silica, available under the trade names Cabosil and Ludox, and silica aerogels, for example Santocel Ard and Santocel C, and like inorganic gelling agents such as alumina, attapulgite and bentonite. Other oil gelling agents are disclosed in U.S. Patents Nos. 2,655,476 and 2,711,393. These are well-known materials, and any of those known to the art can be used.

The amount of such thickening agent will depend on the consistency desired, and usually will be within the range of 0 up to about 5%. Water-proofing agents such as are disclosed in U.S. Patents Nos. 2,554,222 and 2,655,476 and 2,711,393 also can be incorporated as well, to impart water-resistance to the oil slurry.

An aqueous slurry can be thickened by any water-soluble or water-dispersible thickener, such as for example sodium carboxymethyl cellulose, methyl cellulose, guar gum, psyllium seed mucilage, and pregelatinized starches such as Hydroseal 3B. The amount of such thickening agent will depend on the consistency desired, and usually will be within the range from 0 to about 5%.

It is frequently desired in formulating the slurries of the invention to employ an aqueous saturated solution of the nitrate present in the explosive particles. If, for

example, the particles are composed of ammonium nitrate as the only inorganic nitrate, then a saturated aqueous solution of ammonium nitrate would be used. If mixtures of sodium and ammonium nitrate are employed, then saturated solutions of each of these nitrates would be employed. Such solutions minimize dissolution of the water soluble components of the explosive particles.

The slurries of the invention in addition to the explosive particles or inorganic nitrate and fuel can contain supplemental quantities of noncommingled inorganic nitrate and/or fuel, which can be any of the inorganic nitrates and carbonaceous or metal fuels referred to above, as well as a sensitizing explosive, if desired. Such slurries will be considerably more sensitive than comparable slurries containing merely mixtures of inorganic nitrate and fuel.

Among the sensitizing explosives that can be employed are trinitrotoluene, dinitrotoluene, pentaerythritol tetranitrate, nitrostarch, trimethyloethane trinitrate, pentolite (a mixture of equal parts of weight of pentaerythritol tetranitrate and trinitrotoluene) cyclonite (RDX, cyclotrimethylenetrinitramine) nitrocellulose, Composition B (a mixture of up to 60% RDX and 40% TNT and 1 to 4% wax) cyclotol (Composition B without the wax), tetryl, and smokeless powders such as carbine ball powder. A sensitizing explosive when used will comprise from 0 to about 40% by weigth of the explosive composition and in such compositions the nitrate is used in an amount within the range from about 10 to 95%. From about 25 to about 30% sensitizing explosive, from about 50 to about 70% inorganic nitrate, and from about 5 to about 25% fuel, give the best results.

The sensitizing explosvie can be of any particle size. It can be for example fine, coarse, or a blend of fine and coarse material. Some materials such as nitrostarch are commercially available as very finely-divided powders, and so also is trinitrotoluene.

When the amount of sensitizing explosive is in the lower part of the range or zero, a large booster is needed. At amounts beyond 40%, the sensitizing effect falls off, and is no longer proportional to the amount of sensitizing explosive added. Therefore, amounts beyond 40% would not usually be used.

The explosive slurries of the invention are fired with the aid of a booster charge. Any conventional cap-sensitive booster charge available in the art can be employed. Pentaerythritol tetranitrate, Composition B and pentolite are exemplary. The booster charge preferably is non-shock or impact sensitive. The amount of booster charge required depends of course upon the amount and sensitivity of the explosive mixture.

The explosive slurries of the invention can be packaged in any type of container, formed of a material not dissolved or attacked by the slurry mixture or liquid. Heavy plastic is inexpensive and available in sufficient thickness of wall, and is therefore preferred. Typical plastic and cellulosic materials which can be used include polyethylene, ethyl cellulose, cellulose acetate, polypropylene, polytetrafluoroethylene, nylon, polyvinyl chloride polystyrene, and polyvinylidene chloride and nonferrous metals such as tin, copper and aluminum. Fibrous materials such as wood, paper and cardboard can be used if waterproofed or otherwise made resistant to the slurrying liquid.

When explosive slurries are prepared containing particulate components in addition to the explosive particles of commingled inorganic nitrate and fuel, the explosive mixture is readily prepared by simple mixing of the solid ingredients with the liquid. The solid materials, including the explosive commingled particles, additional inorganic nitrates, sensitizing explosives, and fuel, if any, would usually be mixed first to form a homogeneous blend, and the slurrying liquid then added, with the thickener, if required, to bring the mixture to the desired consistency. The mixtures themselves are filled into open-end containers, using conventional filling or extruding equipment, to produce the explosive package.

The following examples in the opinion of the inventors represent the best embodiments of their invention.

EXAMPLE 1

A blend was prepared containing 86.24 parts of ammonium nitrate and 7.84 parts of sodium nitrate. This was melted in a steam-jacketed kettle and then poured into a mixing trough in which there was blended therewith 4.3 parts of nut meal and 1.62 parts of water. The blend was thoroughly mixed and cooled slightly to a plastic consistency, whereupon it was screened through a 30 mesh screen and the granules thus formed allowed to harden. The resultant mass was composed of particles 49.25% of which were retained on a No. 10 screen, 39.25% on a No. 18 screen, 10.25% on a No. 35 screen, 1.25% on a No. 60 screen and none through a No. 60 screen.

The granular particles thus obtained were used to prepare the following explosive formulation:

	Percent by weight
Explosive particles	84.6
Oil No. 5	1.5
Dinitrotoluene	2.5
Jaguar 100 guar gum	5.0
Nitrostarch	6.1
Iron oxide	0.3
	100.0
Pouring density in H_2O g./cm.^{3}	0.74
Ballistic pendulum, No. 16 cap	10.60
"D" sensitivity gm.+	3

Eleven kilograms of the resultant dry-mixed explosive composition was mixed with 5.6 kilograms of water and allowed to stand overnight. A 5 inch x 5 lb. pentolite booster was poured in a 5 inch x 25 lb. "I.C.C. 25G 50" catridge, and to this was added 9725 grams of the above composition contained in an 8 mil polyethylene liner. The cartridge was detonated under 15 to 20 feet of water, with good explosive effect.

EXAMPLE 2

A mixture was prepared composed of 86.24 parts of ammonium nitrate and 7.84 parts of sodium nitrate. These were melted together in a steam-jacketed kettle and the melt then poured into a mixing trough where it was blended wtih a previously prepared mixture of 4.3 parts of nut meal and 1.62 parts of water. The resulting mix had a plastic consistency, and was forced through a 30 mesh screen and the particles that formed allowed to harden.

A mix was then prepared containing these particles and in addition other explosive ingredients and fuels to the following formulation:

	Percent by weight
Explosive particles	76.90
Calcium nitrate	4.00
Oil No. 5	3.20
Wheat flour	2.10
Sodium carboxymethyl cellulose	0.50
Water	13.30
	100.00

The resultant slurry was filled in a 3 inch x 27 inch polyethylene bag. This bag weighed approximately ten pounds, and gave a 2 ft. rise in a 3½ inch bore hole. A 1 lb. pentolite primer was capped and placed a distance from 4 to 6 feet from the bottom of the bore hole. Pentolite primers on a Primacord downline were strung at 4 ft. intervals, starting at 12 ft. from the bottom of the hole, and coming up to the tamping or 30 ft. from the bottom. This was done in order to have an alternate means of firing the shot, had the 1 lb. primer not caused

detonation. Propagation of the detonation wave along the column from the point of initiation at the 1 lb. primer to the string of smaller primers was considered tantamount to complete detonation of the column by the 1 lb. primer alone. No. 1/3 pentolite primers were used.

The following data applied to the loading of the shot: Depth, 34'6"; Water, dry; lb. expl./hole, 140; tamp, 8'; loading, solid.

Stone moved by shot:

Tons of stone	778.24
Tons/lb. explosive	1.3

The rock was moved out to a distance of 120 ft. This is an extraordinary distance, since a normal blast under the same conditions would heave to a distance of 60 ft. as a maximum. There were several rocks larger than those normally obtained.

Example 3

A mixture was prepared composed of 86.24 parts of ammonium nitrate and 7.84 parts sodium nitrate. This was melted in a steam-jacketed kettle and poured into a mixing trough. A previously prepared blend of 4.3 parts of nut meal and 1.62 parts of water were then mixed in the melt, and the resulting plastic mix screened through a 30 mesh screen, to remove all —20 mesh material, and the resulting granules allowed to harden.

The granules were mixed with the solid ingredients noted in the table below to produce a dry mix after which water was added to produce a slurry. Guar gum was then stirred in and dissolved in the mix to bring it to the desired consistency:

	Percent by weight
Explosive granules	71.50
Wet nitrostarch	15.00
Zinc oxide	1.00
Riffle coal	2.00
Oil No. 5	0.50
Guar gum, Jaguar EX=FC=1	0.75
Water	9.25
	100.00

"D" sensitivity, 1¼ x 8 inch pipe ——gm. B+	3
"D" sensitivity, ½ inch pipe ——gm. D+	3
Density, in 2 inch diam. pipe ——gm./cm.3	1.42
Ballistic pendulum No. 16 cap	10.2

This slurry became drier on standing, as though some of the water was absorbed by the dry materials. It was stored in a polyethylene bag for one week, without reversion to a watery consistency.

The primer used in shooting the explosive was ten grams of pentolite. Thus, this slurry was much more sensitive than a normal slurry containing the ingredients of the granular explosive particles, ammonium nitrate, sugar, wood pulp and aluminum, in admixture, which required 40 to 60 grams of pentolite before detonating completely.

EXAMPLE 4

A blend was prepared containing 86.24 parts of ammonium nitrate and 7.84 parts of sodium nitrate. This was melted in a steam-jacketed kettle, and then poured in a trough-type mixer, where it was mixed with a previously prepared blend of 4.3 parts nut meal and 1.62 parts water. This mixture was brought to a plastic consistency, and then forced through a 30 mesh screen. The resulting granules were allowed to harden, and then were blended with petroleum oil No. 5, guar gum and water to the following formulation:

	Percent
Explosive granules	82.00
Oil No. 5	4.30
Guar gum (Jaguar EX=FC=1)	0.70
Water	13.00
	100.00

This is a sensitizer-free formulation which, when shot, had a ballistic pendulum value, No. 16 cap, of 9.8. The density of the slurry was 1.25 grams per cc. when freshly prepared and 1.375 grams per cc. after setting for four hours.

EXAMPLES 5 and 6

85 parts of ammonium nitrate and 10 parts of sodium nitrate were thoroughly mixed and melted in a steam-jacketed kettle. This was poured into a trough type mixture, where it was blended with 5 parts nut meal flour. The mixture was mixed until brought to a plastic consistency, whereupon it was forced through a 30 mesh screen, and the resulting particles allowed to harden.

These particles were dry-blended with nitrostarch, zinc oxide, riffle coal and petroleum oil No. 5 in the proportions given the following table, and this mix then combined with water and guar gum:

	Example 5	Example 6
Explosive granules	67.40	67.40
Nitrostarch (wet), percent	20.00	20.00
Zinc Oxide	0.80	0.80
Riffle Coal	1.80	1.80
Oil No. 5	0.50	0.50
Guar gum (Jaguar EXFC 1)	0.75	1.00
Water	8.75	8.50
	100.00%	100.00%
Density (gm./cm.3)	1.37	1.43
Ballistic Pendulum value, No. 16 cap	10.4	10.0
"D" Sensitivity (½ inch Steel Pipe), gm. Pentolite	5	5

These mixes were packed in polyethylene bags. They pulled away from the bags very easily, and were quite rubbery. Example 6, containing 1% guar gum, retained the shape of the pleated end of the polyethylene bag two days after having been removed from it. Example 5 had an excellent body or cohesiveness.

Each of these examples was far more sensitive than the same slurry without the explosive particles, using a mixture of ammonium nitrate and sodium nitrate instead. Such a mixture required a 20 to 30 gram primer of pentolite, as compared to the 5 grams required by these examples.

EXAMPLE 7

A blend was prepared containing 86.24 parts of ammonium nitrate and 7.84 parts of sodium nitrate. This was melted in a steam-jacketed kettle and then poured into a trough type mixer in which there was blended therewith 4.3 parts of nut meal and 1.62 parts of water. The blend was thoroughly mixed and cooled to a plastic consistency whereupon it was forced through a 30 mesh screen and the particles thus formed allowed to harden. The resultant mass was composed of granular particles which was blended with the ingredients listed in the table below to form an explosive slurry.

	Percent by weight
Explosive granules	76.90
Calcium nitrate	4.00
Oil No. 5	3.20
Wheat flour	2.10
Sodium carboxymethyl cellulose	0.50
Water	13.30
	100.00

This mixture shot very well, and had a smooth, readily-pourable consistency.

Example 8

A mixture was prepared composed of 57.44 parts of ammonium nitrate, 5.22 parts sodium nitrate and 1.08 parts water, and melted in a steam-jacketed kettle and poured into a mixing trough. 2.86 parts of nut meal was then mixed in the melt, and the resulting plastic mix screened through a 30 mesh screen, to remove all —20 mesh material, and the resulting granules allowed to harden.

The granules were mixed with the solid ingredients noted in the table below to produce a dry mix, after which water was added to produce a slurry. Guar gum was then stirred in and dissolved in the mix to bring it to the desired consistency, together with Oil No. 5, riffle coal and Celite.

A similar formulation was prepared in which the nitrates and nut meal were added separately.

	Percent by Weight	
	Example 8	Control
Explosive granules	66.60	
Ammonoum nitrate, prills		57.44
Sodium nitrate		5.22
Nut meal		2.86
Water	10.98	12.06
Trinitrotoluene (flake)	17.32	17.32
Riffle coal	1.40	1.40
Oil No. 5	2.10	2.10
Guar gum, Jaguar EX-FC-1	0.20	0.20
Celite	1.40	1.40
	100.00K	100.00K

The control explosive was considerably less sensitive and less powerful than the composition of Example 8. The primer used in shooting the explosive was pentolite.

Using a standardized electric blasting comparison machine test, measuring explosive power in terms of energy output, and 157.2 grams of pentolite primer, with a core of 85 grams of the test composition, Example 8 detonated with an output of 0.83 volt, and the control with an output of 0.77 volt. The pentolite alone had an output of 0.53 volt. Using 135.6 grams of pentolite primer and a test core of 65 grams, Example 8 detonated with a 0.71 volt output, and the control with a 0.65 volt output. Thus, Example 8 has 7 to 8% more explosive energy than the control, due entirely to the commingled nitrate-nut meal particles, the only difference in the formulation.

The following is claimed:

1. An explosive slurry characterized by a high sensitivity comprising an agglomerate of an inorganic nitrate oxidizer and a fuel in particulate form, the fuel selected from the group consisting of carbonaceous fuels, meal fuels, and mixtures of carbonaceous fuels and metal fuels being present in an amount of at least 75% of the amount required to oxygen-balance the inorganic nitrate, and a fluid selected from the group consisting of water, oil, and mixtures of water and oil in an amount in the range from about 7 to about 50% by weight of the slurry sufficient to suspend the said particles and form a slurry.

2. An explosive slurry in accordance with claim **1** in which the inorganic nitrate is ammonium nitrate.

3. An explosive slurry in accordance with claim **1** in which the inorganic nitrate is a mixture of ammonium nitrate and an inorganic nitrate selected from the group consisting of alkali and alkaline earth metal nitrates.

4. An explosive slurry in accordance with claim **1** in which the fluid is water.

5. An explosive slurry in accordance with claim **1** in which the fluid is oil.

6. An explosive slurry in accordance with claim **1** in which the fluid is a mixture of water and oil.

7. An explosive slurry in accordance with claim **1** in which the fuel is a carbonaceous material.

8. An explosive slurry in accordance with claim **1** in which the fuel is a mixture of a particulate metal and a carbonaceous material.

9. An explosive slurry in accordance with claim **1**, including a thickening agent in an amount to appreciably increase the viscosity of the slurry.

10. An explosive slurry in accordance with claim **9** in which the amount of thickening agent is up to about 5% by weight of the slurry.

11. A blasting agent comprising an explosive slurry in accordance with claim **1**, in combination with a booster charge selected from the group consisting of pentaerythritol tetranitrate, a mixture of pentaerythritol tetranitrate and trinitrotoluene, and a mixture of cyclotrimethylenetrinitramine and trinitrotoluene.

12. A blasting agent in accordance with claim **11** in which the booster is pentaerythritol tetranitrate.

13. A blasting agent in accordance with claim **11** in which the booster is a mixture of pentaerythritol tetranitrate and trinitrotoluene.

14. An explosive slurry in accordance with claim **1** including an expolsive sensitizer in an amount to increase the sensitivity of the composition.

15. An explosive slurry in accordance with claim **14** in which the explosive sensitizer is nitrostarch.

16. An explosive slurry in accordance with claim **14** in which the explosive sensitizer is trinitrotoluene.

17. An explosive slurry in accordance with claim **1** comprising, in addition to the said particles, non-commingled particulate inorganic nitrate.

18. An explosive slurry in accordance with claim **1** comprising, in addition to the said particles, noncommingled particulate fuel.

19. A process for preparing an explosive slurry, comprising, in combination, forming a melt comprising an inorganic nitrate, blending therewith a fuel selected from the group consisting of carbonaceous fuels, metal fuels, and mixtures of carbonaceous fuels and metal fuels in an amount of at least 75% of the amount required to oxygen-balance the inorganic nitrate, forming the resulting blend into particles, and mixing the particles with a fluid selected from the group consisting of water, oil and mixtures of water and oil in an amount sufficient to suspend the particles and form a slurry.

20. A process in accordance with claim **19**, which comprises forming the blend into particles while the inorganic nitrate is still in a molten state, and allowing the resulting particles to harden.

References Cited

UNITED STATES PATENTS

3,166,450	1/1965	Kaufman	149—46
3,166,452	1/1965	Gordon	149—46
3,166,555	1/1965	Gordon	149—46 X
3,247,033	4/1966	Gordon	149—18
2,320,971	6/1943	Lindsley	149—43 X
3,004,842	10/1961	Rowlinson	149—43 X
3,103,457	9/1963	Grossmann	149—46
3,244,568	4/1966	Campbell	149—46
3,279,965	10/1966	Chatel	149—46

L. DEWAYNE RUTLEDGE, *Primary Examiner.*

BENJAMIN R. PADGETT, *Examiner.*

S. J. LECHERT, JR., *Assistant Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,378,415 April 16, 1968

George L. Griffith

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 59, "into particle" should read -- into particles --. Column 4, line 54, "Santocel Ard" should read -- Santocel ARD --. Column 6, line 38, "catridge" should read -- cartridge --. Column 7, lines 38 and 72, "EX=FC=1", each occurrence, should read -- EX-FC-1 --. Column 8, line 16, "given the following table" should read -- given in the following table --. Column 9, line 14, "Ammonoum nitrate" should read -- Ammonium nitrate --; in the table, second and third columns, line 11 thereof, "100.00K", each occurrence, should read -- 100.00% --; line 43, "meal fuels" should read -- metal fuels --; line 48, "in the range" should read -- within the range --.

Signed and sealed this 23rd day of September 1969.

(SEAL)
Attest:

EDWARD M. FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents