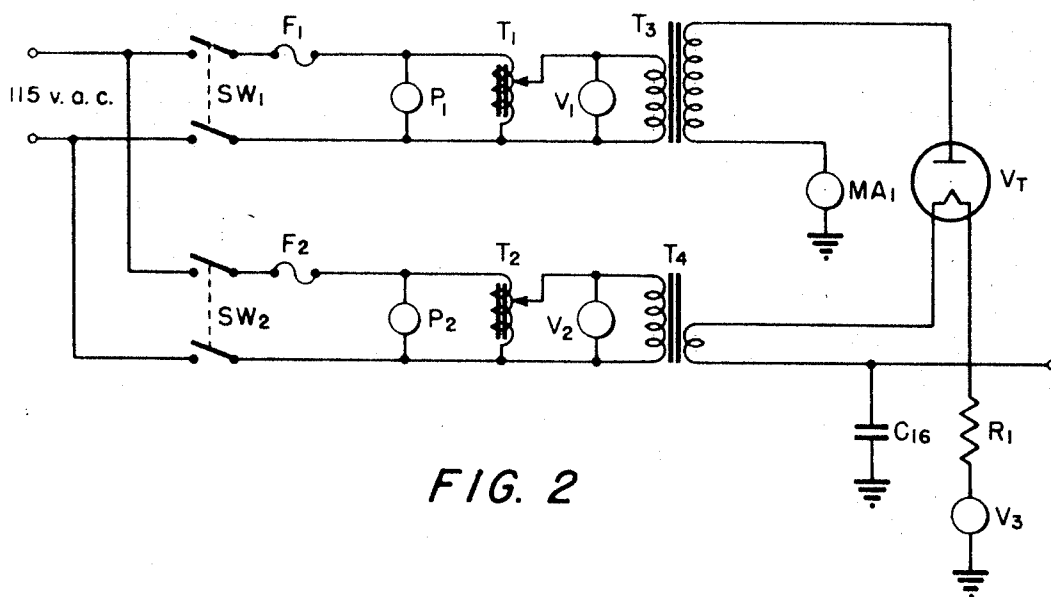
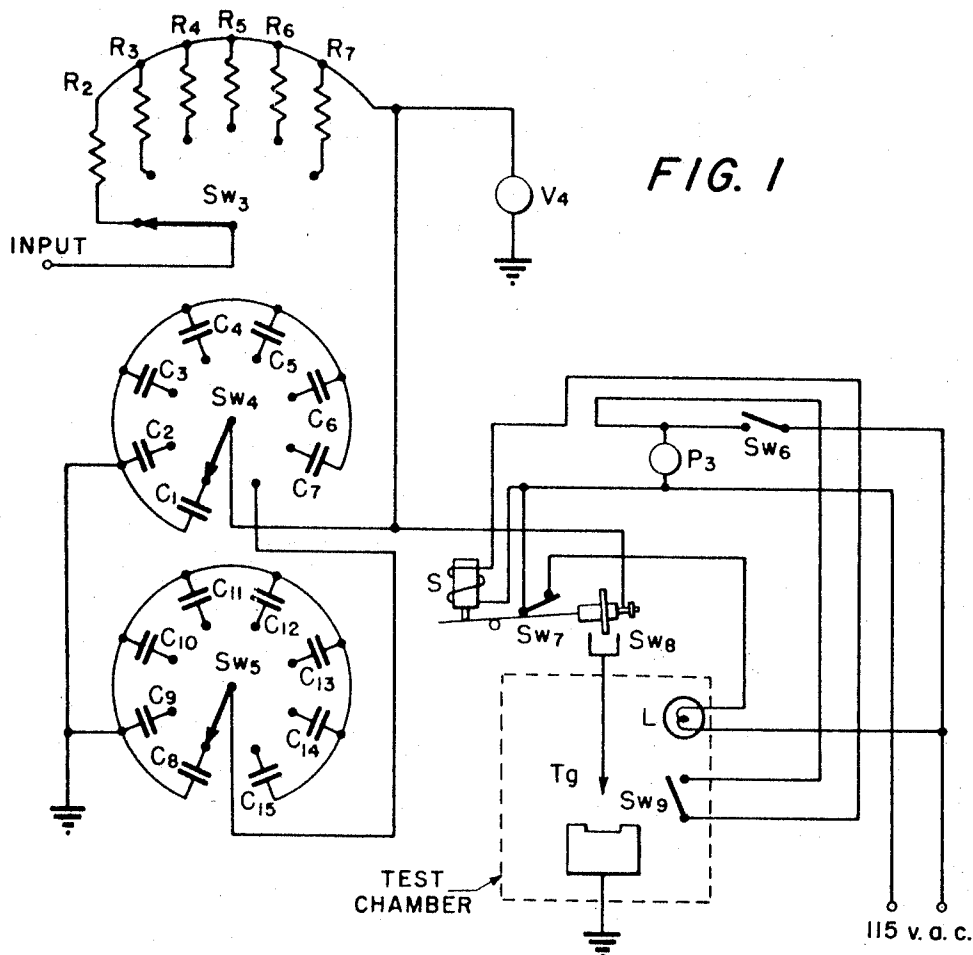


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REDUCING SENSITIVITY OF PRIMARY EXPLOSIVES
TO INITIATION BY ELECTROSTATIC DISCHARGES
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3,461,007

REDUCING SENSITIVITY OF PRIMARY EXPLOSIVES TO INITIATION BY ELECTROSTATIC DISCHARGES**William L. Schwoyer, Allentown, Pa., assignor to Commercial Solvents Corporation, New York, N.Y., a corporation of Maryland**

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28 Claims

ABSTRACT OF THE DISCLOSURE

The sensitivity of primary explosives to initiation by electrostatic discharges is reduced in accordance with the invention by combining therewith a small amount of a polyol polynitrate of low sensitivity, such as trimethylol-ethane trinitrate, and primary explosive compositions accordingly are provided containing a primary explosive and a polyol polynitrate of low sensitivity, such as trimethylol-ethane trinitrate, useful, for instance, as the initiating explosives in blasting caps, and for other purposes. A process also is provided for uniformly blending a polyol polynitrate with a primary explosive in particulate form, employing a solution of the polyol polynitrate in a non-gelatinizing nonsolvent for the primary explosive.

This invention relates to a process for reducing the sensitivity of primary explosives to initiation by electrostatic discharges, and to a primary explosive composition having a reduced sensitivity to initiation by electrostatic discharges by virtue of the combination therewith of a polyol polynitrate of low sensitivity, such as trimethylol-ethane trinitrate, in a small amount.

Brown, Kusler and Gibson, in "Sensitivity of Explosives to Initiation by Electrostatic Discharges," Bureau of Mines Report of Investigations No. 3852 (1946), reported an investigation by the Explosives Division of the Bureau of Mines of electrostatic hazards associated with the manufacture, storage and use of explosives. The report presents the data on the spark sensitivities of explosives, employing a specially designed test apparatus. In 1948, the apparatus was redesigned and rebuilt, to make the routine testing of explosives safer and more convenient, and the rebuilt apparatus is described in a re-issue of the former report, Report of Investigations No. 5002, published in September 1953.

Brown, Kusler and Gibson point out in the report that in normal procedures, without special precautions, it is possible for static charges to be accumulated on individuals or on ungrounded equipment or structures. Static charges may be produced in various ways, but they are most commonly produced by rubbing or successive contact and separation of unlike surfaces, at least one of which is usually an insulator. If an electrically conductive body, such as a piece of machinery or a person, is insulated from ground, it can act as a condenser or reservoir for the accumulating of electric charge. The close approach of another conductor may bring about discharge, in the form of a spark. Combustible or explosive materials in the path of the spark may be ignited, if they are sensitive enough, and the energy in the discharge is high enough.

Accidental spark initiation is a serious problem with blasting caps and other explosives, including highly sensitive primary explosives, such as lead azide, mercury fulminate, and lead styphnate. It would be desirable to reduce the tendency of such explosives to detonation by spark initiation, but this must be done without reducing the tendency of the explosive to initiation in a blasting cap by a hot wire or other conventional detonating means.

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This is easier said than done, and in fact no desensitizing ingredients have been found that will do the one without also doing the other.

In accordance with the invention, particulate primary high explosives are provided having a reduced tendency to initiation by spark discharge, but having substantially no diminution in their tendency to detonation by an exploding bridge wire or any of the other types of initiation customarily employed in a blasting cap or electric initiator. These objectives are accomplished by incorporating with the primary explosive in particulate form a small amount, usually less than 15%, of a polyol polynitrate of low sensitivity, such as trimethylol-ethane trinitrate. The effect is observed even when the particulate primary high explosive is under a high degree of confinement.

The reduced spark sensitivity is evidenced by the increase in spark energy (measured in joules) required for initiation, and this increased spark energy is at least 25% higher than the spark energy required to initiate the primary high explosive before combination with the polyol polynitrate. The spark energy is determined in joules in accordance with the invention, using an apparatus basically similar to that described in Report of Investigation No. 5002, with certain modifications.

FIGURE 1 represents a schematic diagram of the charging resistors, storage capacitors, and switching and test chamber units for the apparatus in accordance with the invention.

FIGURE 2 represents a schematic diagram of the high voltage power supply unit for this apparatus.

The apparatus is based on the principles explained by Brown, Kusler and Gibson in their reports, that the simplest and most useful means of testing samples of materials for their sensitivity to spark initiation is to subject them to single discharges from a condenser that has been charged to a high voltage. The maximum energy of the spark discharge to which the material can be subjected without being ignited has been chosen as a criterion of its sensitivity. Ignition of a material by an electrostatic discharge depends on other factors as well as energy of discharge, but the results obtained by Brown, Kusler and Gibson and by the present inventor indicates that the energy factor is the best single criterion.

The energy E in joules of the spark discharge from a condenser of capacity C in microfarads charged to a potential V in volts (assuming negligible losses) is given by the equation: $E = 5 \times 10^{-7} CV^2$.

During the test, the condenser (which can be any one of condensers C-1 through C-15 and C_{dist}) is left connected to the power source through a high resistance, which can be any one of resistances R-2 through R-5. The resistance is selected so that several seconds are required to charge any one of the condensers. The condenser remains connected to the source during a test, but the high resistance prevents any appreciable gain of charge on the condenser during its discharge. To obtain a discharge, the high voltage side of the condenser is connected to the point electrode with a specially designed remotely controlled mercury switch SW-8, and the needle is moved down by means of a single-stroke, mechanically operated electrode, preadjusted so that the gap is less than that required for discharge. This procedure prevents any loss of energy by sparking at the switch, minimizes the effect of leakage, and allows only one spark to occur.

Samples of the particulate primary high explosive with and without the desensitizing polyol polynitrate are tested under two degrees of confinement, designed as unconfined, and partly confined. In the unconfined tests, a sample of approximately 0.05 gram is poured into a shallow depression in a steel block, and flattened out with a non-sparking spatula. In the partly confined tests, the sample

of approximately 0.05 gram is introduced into a soft glass tube approximately 7 mm. in internal diameter by 18 mm. in length, which fits over a metal peg. In addition to providing moderate confinement, this system also minimizes dispersion of the material by the spark discharge, and reduces the effect of material being repelled from the needle point by the electrostatic field.

When a test is to be made, the mechanical electrode is adjusted until the gap between the electrodes is slightly less than the critical gap at the discharge voltage, as determined by observation. The sample is then placed in position. The high voltage terminal of the charged condenser is switched to the point electrode with the mercury switch, and the spring-loaded electrode release button is depressed.

For each type and condition of sample, an attempt is made to determine the maximum energy at a fixed voltage for which no ignitions occur. The energy at a given voltage is varied over a range by using condensers of different capacity (C-1 to C-15), so that a plot may be made of ignition probability versus energy, and the energy corresponding to zero ignition probability is determined from the curve. Most results are obtained by making ten tests of successive samples at each spark energy. In these tests, the following standard conditions are adopted:

- (1) Voltage—5000 volts.
- (2) No resistance in series with gap.
- (3) Confinement, both partly confined and unconfined, as stated above.
- (4) No overvoltage, gap corresponding to breakdown voltage.
- (5) Point electrode positive.

Using this apparatus, it has been determined that a polyol polynitrate of low sensitivity, such as trimethylolethane trinitrate, is effective materially to reduce spark sensitivity and increase the spark energy required for ignition of any primary explosive whose highest spark energy, in joules, for zero probability ignition, unconfined, using this test apparatus, is less than 1 joule. The reduction in spark sensitivity is measured as the increase in spark energy, in joules, required for initiation, using this test procedure, and the amount of polyol polynitrate that is used will be at least sufficient to increase the spark energy, in joules, required for initiation of the primary explosive by at least 25%.

As little as 0.2% polyol polynitrate by weight of the primary explosive has an effect on sensitivity. There is no critical maximum amount, except that the polyol polynitrate is not used in so high an amount that it begins to reduce the sensitivity to initiation of the primary explosive. Such a reduction in sensitivity does not appear in amounts from 0.2% up to 15% polyol polynitrate, and frequently, larger amounts than this can be used; up to about 20%, by weight of the primary explosive, is the usual maximum. However, there is no point in using more polyol polynitrate than is necessary to obtain the desired reduction in sensitivity to spark discharge, and thus amounts from about 0.2% to about 10% by weight of the primary explosive are preferred.

A further remarkable feature of the compositions of the invention is that in the presence of a sufficient amount of the polyol polynitrate, the compositions no longer turn over from burning to detonation. Thus, amounts of polyol polynitrate in excess of about 20% up to about 35% by weight of the primary explosive can be used to prepare deflagrating explosives or deflagrating fuse based on a primary explosive. These have most unusual properties.

Explosives falling within the class to which the invention is applicable include lead azide, mercury fulminate, an 80-20 mixture of mercury fulminate and potassium chlorate, lead styphnate, tetracene, a mixture of potassium chlorate and lead sulfocyanate, picric acid, lead picrate, ammonium picrate, lead trinitro resorcinate, n-nitrophenyl diazonium perchlorate, nitrogen resorcinate, n-nitrophenyl

diazonium perchlorate, nitrogen sulfide, copper acetylide, fulminating gold, nitroso guanidine, mercury tartrate, mercury oxalate, silver tartrate, silver oxalate, and mixtures of potassium chlorate and red phosphorus. The usual particle forms of high explosives such as trinitrotoluene, pentaerythritol tetranitrate, pentolite, tetryl, nitrocellulose and nitrostarch as sold commercially for use in explosive compositions are not sufficiently spark-sensitive by this test procedure to require inclusion of polyol polynitrate. In the test procedure employed in accordance with this invention, these high explosives do not detonate but merely deflagrate, as in a dust explosion, showing that these explosives fall in a different category from the primary high explosives named above. The invention is particularly applicable to finely divided particulate primary high explosives, less than 100 mesh and preferably less than 325 mesh in size; particulate primary high explosives as coarse as 10 mesh can be employed, and will display a reduced spark sensitivity.

In addition to reducing spark sensitivity, the polyol polynitrate appears to increase the fracturing power of these primary high explosives, while at the same time making the explosive safer to handle.

There can be used in the invention any liquid polyol polynitrate that is aliphatic in structure, and has from two to six carbon atoms, and not more than one nitro group for each carbon atom of the polyol, and from two up to a total of about six nitro groups per molecule. Typical polyol polynitrates of this class include trimethylolethane trinitrate (which is preferred), ethylene glycol dinitrate, diethylene glycol dinitrate, dipropylene glycol dinitrate, dimethylolethane dinitrate, and glyceryl trinitrate.

It is not entirely clear why the polyol polynitrate has this effect. The polyol polynitrates of the invention such as trimethylolethane trinitrate are liquids, while the primary explosives referred to above are all solids. It is possible that the liquid polyol polynitrate coats the particles of solid explosive, and in this manner reduces their sensitivity to spark discharge. There may also be a close physical association between the liquid polyol polynitrate and the primary explosive. Evidently, if the effect is due to a coating, a very thin coating is sufficient, inasmuch as as little as 0.2% polyol polynitrate is effective.

The most important uses for primary high explosives are in initiators or blasting caps and in military explosives, such as hand grenades and in shaped charges. In such cases, the primary high explosive has the function of accepting the flame from an ignition agent, and then turning over from burning to detonation, whereupon the base charge, which inter alia is composed of RDX, nitrostarch, PETN, tetryl, cyclonite, amatol, sodatol, or like secondary high explosive, is detonated. The primary high explosive serves this function either in electrically initiated devices or in devices that are set off by an ordinary deflagrating fuse. The primary high explosive compositions of the invention serve these functions with undiminished effectiveness. If the polyol polynitrate of low sensitivity, such as trimethylolethane trinitrate, is used in a small enough amount, so that it is wholly absorbed on the solid particulate primary high explosive, even the dry-appearing solid characteristic of the primary explosive is unaffected.

The particulate primary high explosive and polyol polynitrate can be blended by simple mixing in many cases. It is, however, a hazardous operation since the primary high explosive is sensitive to shock, heat, and friction, and every usual precaution must be used.

It is also desirable that uniform blending be achieved. This can be difficult to accomplish, especially if small amounts of polyol polynitrate are used, below about 0.5% by weight of the primary high explosive, because the polyol polynitrate is a liquid, and tends to stick to the particulate primary high explosive in a nonuniform distribution.

In accordance with the invention, a process is provided that ensures uniform distribution of these components. The polyol polynitrate is blended first with a volatile solvent in which the polyol polynitrate is soluble but the primary explosive is not. A sufficient volume of solvent is used to wet all of the particulate primary explosive. The primary explosive is then mixed with and thorough-

outside diameter by 18 mm. long soft glass tube. This is listed in Table I as Minimum Detonating Spark Energy.

The formulations were filled as the initiating explosive into No. 1 fuse caps formulated with the usual ignition charge. The caps were then shot in 60% powder, desensitized with from 0 to 6% raw cornstarch. The results obtained are given in Table I.

TABLE I

Example No.:	Minimum detonating spark energy (Joules)				Lead azide test cap	Desensitized 60% powder			
	TMETN, percent	Unconfined	Percent increase	Confined, percent		Increase	Raw cornstarch		
							Shot, percent	Split, percent	Failed, percent
A.....	0	0.0123	-----	0.0123	-----	No. 1---	2	-----	3
1.....	0.5	0.0313	155	0.0225	88	No. 1---	3	-----	4
2.....	1.0	0.0800	534	0.0450	268	No. 1---	2	3	-----
3.....	2.0	0.0900	632	0.0225	88	No. 1---	2	3	-----
4.....	4.0	0.5000	3,970	0.3063	2,390	No. 1---	3	-----	4
5.....	6.0	4.0000	32,200	0.8000	6,310	No. 1---	3	4	-----

ly wetted by the solution, and the solvent is removed. If the solvent is volatile at room temperature, it can be allowed to evaporate. If not, it can be drawn off under vacuum. Heating can be used, but is dangerous, and is preferably avoided.

Any inert solvent can be used that does not alter the particulate characteristic of the primary explosive. The solvent thus will depend upon the primary explosive. However, the solvent and gelatinizing characteristics of the inert solvents for primary explosives are known, and suitable nongelatinizing nonsolvents for the primary explosive used that are solvents for polyol polynitrates are easily selected from the literature. Toluene, for example, and the liquid nitroparaffin solvents, such as nitromethane, are suitable for use with any polyol polynitrate and lead azide, mercury fulminate, and lead styphnate.

It is evident from the data that from 0.5% up to 6% trimethylolethane trinitrate increased spark energy (in joules) by more than 25%, and did not reduce the initiating ability of the lead azide.

The above mixtures were also prepared using powdered mercury fulminate and using powdered lead styphnate in place of lead azide. The results obtained confirmed the effectiveness of the trimethylolethane trinitrate with these primary explosives in the same manner as with lead azide.

EXAMPLES 6 TO 8

A series of blasting caps were made up using powdered lead azide with and without 6% trimethylolethane trinitrate and with varying amounts of ignition mixture ranging from 0.010 gram to 0.050 gram. The caps were shot on pure lead plates 1½ inch x 1½ inch x ⅜ inch thick. The following results were obtained:

TABLE II

Example No.:	Content of cap	Amount of Ignition Mixture, g.	Percent shot	Percent failed	Depth (inch)	Hole in lead plate
						Diameter (inch) (average)
B.....	Lead azide.....	0.050	All....	0	(1)	0.337
C.....	do.....	0.025	All....	0	0.092	0.310
D.....	Lead azide w/6% TMETN....	0.025	All....	0	0.110	0.314
E.....	Lead azide.....	0.015	All....	0	0.097	0.306
F.....	Lead azide w/6% TMETN....	0.015	All....	0	0.103	0.320
G.....	Lead azide.....	0.010	All....	0	0.101	0.322
H.....	Lead azide w/6% TMETN....	0.010	All....	0	0.107	0.323

¹ 0.090 and .047 small hole.

The proportion of solvent need not exceed that which wets all of the particulate primary explosive. More than this will merely be wasted, since it will be unnecessary for uniform distribution. However, the amount is not critical, and in a commercial process where solvent is recovered and recycled, there can be used a large excess, if desired. A weight ratio of primary explosive:solvent of from about 5:1 to 1:1 is quite satisfactory.

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

EXAMPLES 1 TO 5

A series of lead azide compositions were prepared containing from 0 to 6% trimethylolethane trinitrate. These compositions were prepared by first mixing the trimethylolethane trinitrate with enough toluene to wet thoroughly the amount of powdered lead azide used (a 2.5:1.5 lead azide:TMETN-toluene weight ratio) and then mixing in the lead azide. The trimethylolethane trinitrate was thus absorbed on the lead azide powder, after which the toluene was allowed to evaporate from the mixture, leaving a uniform coating of the trimethylolethane trinitrate on the lead azide.

The minimum spark energy at which a detonation occurred was determined for each mixture, confined and unconfined, using a 7 mm. inside diameter by 10 mm.

It is evident from the data that there is no significant difference in sensitivity but an increase in power between lead azide and lead azide with 6% trimethylolethane trinitrate.

EXAMPLES 9 TO 12

Primary explosive mixtures were prepared, containing powdered lead azide with and without ethylene glycol dinitrate and diethylene glycol dinitrate in amounts of 3% and 6%.

The minimum Detonating Spark Energy was determined for these mixtures, using the procedure outlined in Examples 1 to 5. The results are given in Table III.

TABLE III

Example No.:	Percent polyol polynitrate	Minimum detonating spark energy (Joules)		
		Nothing	Detonate	Percent increase
G.....	0.....	0.0125	0.0160	-----
9.....	3% EGDN.....	0.0160	0.0203	27
10.....	6% EGDN.....	0.0506	0.0625	290
11.....	3% DEGDN.....	0.2813	0.3063	1,810
12.....	6% DEGDN.....	0.6300	0.8000	4,900

A series of No. 1 blasting caps was prepared, using these mixtures. These caps were subjected to the sand bomb test, and were also shot using 60% powder de-

sensitized with from 1 to 3% raw cornstarch. The caps were also shot on the small lead squares, as in Examples 6 to 8. The results obtained are set out in Table IV:

TABLE IV.—SAND BOMB TEST

Example No.:	Percent polyol polynitrate	Screen +30	Screen -30	Desensitized powder (60%)				Hole in lead with pressure on cap		Hole in lead, no pressure on cap	
				Raw cornstarch				Depth (inch)	Diameter (inch)	Depth (inch)	Diameter (inch)
				0%	1%	2%	3%				
G.....	0.....	87.3	12.7	Shot.....	Split.....	Failed.....		0.114	0.335	0.118	0.315
9.....	3% EGDN.....	86.8	13.2	do.....	do.....	do.....		0.124	0.315	0.114	0.315
10.....	6% EGDN.....	86.8	13.2	do.....	do.....	do.....		0.119	0.315	0.115	0.335
11.....	3% DEGDN.....	85.1	14.9	do.....	do.....	do.....		0.129	0.354	0.122	0.335
12.....	6% DEGDN.....	85.1	14.9	do.....	Shot.....	Shot.....	Failed.....	0.138	0.335	0.131	0.354

It is evident that in all cases, the effect of the diethylene glycol dinitrate and ethylene glycol dinitrate did not manifest itself in a reduction in initiating ability of the lead azide, and the spark energy was increased by more than 25%.

EXAMPLES 13 TO 15

A series of lead azide compositions was prepared containing from 0 to 6% nitroglycerine. These compositions were prepared by first mixing the nitroglycerine with enough nitromethane to wet, thoroughly, the amount of powdered lead azide used (a 2.5:1.5 lead azide:nitromethane-nitroglycerine weight ratio) and absorbed in the lead azide powder, after which the nitromethane was allowed to evaporate from the mixture, leaving a uniform coating of nitroglycerine on the lead azide.

The minimum spark energy at which a detonation occurred was determined for each mixture, unconfined. This is listed in Table V as minimum detonating spark sensitivity.

The formulations were filled, as the initiating explosive, into No. 1 fuse caps formulated with usual ignition charge. The caps were then shot against lead squares, 1½" x ¾". The results obtained are given in the table.

TABLE V

Ex. No.:	Nitro-glycerine, percent	Minimum detonating spark energy (Joules)		Depth (inches) average	Diameter (inches) average
		Unconfined	Percent increase		
H.....	0	0.0123		0.100	0.382
13.....	0.5	1.1250	9,010	1.121	0.345
14.....	3.0	22.5000	184,000	1.310	0.377
15.....	6.0	62.5000	507,000	1.180	3.750

It is evident that in all cases, the effect of the nitroglycerine was to decrease the spark sensitivity, and increase spark energy more than 25%, while not reducing the initiating ability of the lead azide, as evidenced in the standard Lead Plate Test.

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

1. A primary high explosive composition having a reduced susceptibility to initiation by spark discharge, but having substantially no diminution in susceptibility to initiation by an exploding bridge wire, high voltage, or fuse, comprising a primary high explosive in particulate form and an amount of a liquid polyol polynitrate of low sensitivity sufficient to increase by at least 25% the spark energy in joules required to initiate the primary explosive, confined or unconfined, in the modified Brown-Kusler-Gibson apparatus.

2. A primary high explosive in accordance with claim 1, in which the polyol polynitrate has from two to about six carbon atoms, and from two to about six nitro groups.

3. A primary high explosive in accordance with claim 2, in which the polyol polynitrate is trimethylolethane trinitrate.

4. A primary high explosive in accordance with claim 2, in which the polyol polynitrate is ethylene glycol dinitrate.

5. A primary high explosive in accordance with claim

2, in which the polyol polynitrate is diethylene glycol dinitrate.

6. A primary high explosive in accordance with claim 2, in which the polyol polynitrate is nitroglycerine.

7. A primary high explosive in accordance with claim 1, in which the polyol polynitrate is in an amount from 0.2% to about 20% by weight of the primary high explosive.

8. A primary high explosive in accordance with claim 1, in which the polyol polynitrate is in an amount from about 20% to about 35% by weight of the primary explosive, sufficient to prevent the primary high explosive from turning over from burning to detonation.

9. A primary high explosive in accordance with claim 1, in which the primary high explosive is lead azide.

10. A primary high explosive in accordance with claim 1, in which the primary high explosive is mercury fulminate.

11. A primary high explosive in accordance with claim 1, in which the primary high explosive is lead styphnate.

12. A blasting cap comprising as the initiating explosive, a primary high explosive composition in accordance with claim 1.

13. A blasting cap in accordance with claim 12 in which the blasting cap is an electric initiator.

14. A blasting cap in accordance with claim 12, in which the blasting cap is a fuse-type blasting cap.

15. A blasting cap in accordance with claim 12, in which the blasting cap is an exploding bridge wire-type blasting cap.

16. A process for reducing the spark sensitivity of primary high explosives, which comprises mixing with the primary high explosive in particulate form an amount of a liquid polyol polynitrate of low sensitivity sufficient to increase by at least 25% the spark energy in joules required to initiate the primary high explosive, confined or unconfined, in the modified Brown-Kusler-Gibson apparatus.

17. A process in accordance with claim 16 in which the polyol polynitrate has from two to about six carbon atoms, and from two to about six nitro groups.

18. A process in accordance with claim 17 in which the polyol polynitrate is trimethylolethane trinitrate.

19. A process in accordance with claim 17 in which the polyol polynitrate is diethylene glycol dinitrate.

20. A process in accordance with claim 17 in which the polyol polynitrate is nitroglycerine.

21. A process in accordance with claim 17 in which the polyol polynitrate is ethylene glycol dinitrate.

22. A process in accordance with claim 16 in which the polyol polynitrate is in an amount from 0.2% to about 20% by weight of the primary explosive.

23. A process in accordance with claim 16, in which the polyol polynitrate is in an amount from about 20% to about 35% by weight of the primary high explosive, sufficient to prevent the primary high explosive from turning over from burning to detonation.

24. A process for mixing polyol polynitrate and primary explosives, which comprises blending the primary high explosive in particulate form with a solution of the

polyol polynitrate in a solvent that is a nongelatinizing nonsolvent for the primary explosive, the solution being used in an amount sufficient to wet uniformly substantially all of the particulate primary high explosive, and then removing the solvent.

25. A process in accordance with claim 24, in which the polyol polynitrate is of low sensitivity and is in an amount sufficient to increase by at least 25% the spark energy, in joules, required to initiate the primary high explosive, confined or unconfined, in the modified Brown-Kusler-Gibson apparatus.

26. A process in accordance with claim 24, in which the solvent is toluene.

27. A process in accordance with claim 24 in which the solvent is a nitroparaffin.

28. A process in accordance with claim 27, in which the solvent is nitromethane.

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U.S. Cl. X.R.

15 102—29; 149—34, 35, 88, 101, 102, 105

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,461,007 Dated August 12, 1969

Inventor(s) William L. Schwoyer

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 59, "accumulating" should be -- accumulation --.
Column 8, Table IV, above last two columns headed
"Hole in lead with pressure on cap" and "Hole in lead, no
pressure on cap", there should be
inserted: --Small Lead Square--.

SIGNED AND
SEALED
APR 28 1970

(SEAL)

Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents