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UNITED STATES PATENT OFFICE

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GELATINOUS EXPLOSIVE COMPOSITION

Jack M. Downard, Wilmington, Del., assignor to Hercules Powder Company, Wilmington, Del., a corporation of Delaware

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6 Claims. (Cl. 52—1)

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This invention relates to explosives and more particularly to a gelatinous explosive and a method for manufacturing such an explosive.

Gelatinous and semigelatinous dynamites have been made for years using a nitrocellulose-nitroglycerin gel. As early as 1878, A. Nobel developed a dynamite of this type. For many years the lowest strength of gelatin dynamite made was a forty per cent straight gelatin dynamite containing 35% of nitroglycerin.

In the development of economical gelatin dynamites which still retained good water resistance, the nitroglycerin content was gradually reduced to 25%–27%, while incorporating large percentages of ammonium nitrate to maintain a high strength. This was about the minimum nitroglycerin content that could be achieved while maintaining a really plastic gelatinous consistency adapted to packing on the gelatin-type cartridging machine. However, subsequently, semiplastic explosives of high strength and good water resistance were obtained with as little as 20% of gelatinized liquid explosive. These are called semigelatin dynamites, and are generally packed on a Hall-type packing machine which is more economical than using the gelatin-type cartridging machine.

Thus, the principal object of this invention is to produce a gelatinous explosive even lower in nitroglycerin content or even without nitroglycerin but of the same high strength.

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Another object of this invention is to produce a low nitroglycerin content dynamite having the properties of a nitrocellulose-nitroglycerin gelatinous dynamite.

Another object of this invention is to improve and maintain uniformity of the properties of nitrocellulose-nitroglycerin gelatinous dynamites.

Still another object of this invention is to provide a methmod of manufacturing a dynamite possessing the qualities set forth in the aforementioned objects.

Other objects of the invention will appear hereinafter, the novel features and combinatitons being set forth in the appended claims.

Now, in accordance with this invention, there is provided an improved gelatinous explosive comprising high explosive material and a small amount of a nonexplosive gel. The nonexplosive gel comprises a water-soluble nonvolatile petroleum hydrocarbon base material, thickened and tackified with a petroleum-soluble elastomeric gelling agent. Also, in accordance with this invention, there is provided a method for incorporating the nonexplosive gel into a high explosive composition to give a gelatinous explosive possessing good sensitivity and plasticity.

The objects and nature of the invention have been indicated in a general way. Preferred embodiments of the invention are specifically set forth in the following tables and examples.

TABLE I

	Regular Semigelatin Dynamite	Low NG Content Dynamite	Low NG Content Dynamite Containing Nonexplosive Gel	
Example	1	2	3	4
Ingredients				
Nitroglycerin	18.0	13.4	14.0	13.4
Dinitrotoluene (DNT Oil)	2.0		1.5	
Nitrocellulose	0.35	0.1	0.2	0.1
Ammonium Nitrate	65.4	72.5	71.5	72.5
Sodium Nitrate	8.2	5.0	8.8	8.5
Wood Pulp	1.0	0.5	1.0	0.5
Cornstarch	2.0	4.0	1.0	1.0
Ivory Meal	2.55	4.0		1.5
Chalk	0.5	0.5	0.5	0.5
Nonexplosive Gel:				
Heat Exchange Oil			1.42	1.9
Polyisobutylene (M. W. 140,000)			0.08	0.1
Oxygen Balance, Per Cent	+7.1	+5.9	+7.7	+6.9
Count, 1¼ in. x 8 in.	112	120	109	114
Detonation Velocity, m./sec.	3,100	3,500	2,900	3,100
Sensitiveness, in.	24	24	20	16
Water Resistance, Per Cent Good	77	55	67	52
Plasticity	Excellent	None	Excellent	Good

Examples shot with No. 6 strength blasting cap.

With reference to Table 1, it will be seen that the regular semigelatin dynamite of Example 1 had excellent plasticity while the low nitroglycerin content dynamite of Example 2 had no plasticity and was unsuitable. In contrast thereto the low nitroglycerin content dynamites of Examples 3 and 4 containing a nonexplosive gel had excellent and good plasticity characteristics, respectively, and in addition had good gap sensitiveness. The dynamites of Examples 3 and 4 make excellent semigelatins despite their low nitroglycerin content.

with properties approximating those of the standard semigelatin. The special dynamites 10, 11, 12 and 13 further show the influence of higher nonexplosive gel contents and/or reduced nitroglycerin contents. It is possible to produce quite plastic explosives in this way, although with reduced sensitiveness, which are desirable for special applications.

TABLE 3

The effect on properties of high ammonia dynamites when the percentage of nonexplosive gel is varied

Example	14	15	16	17	18	19	20
Ingredients	Standard	Plastic	Plastic	Plastic	Plastic	Plastic	Plastic
Nitroglycerin—per cent	13.4	14.8	14.0	14.0	14.0	14.8	13.0
Nitrocellulose	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Nonexplosive Gel		[1] 1.0	[1] 1.5	[1] 1.7	[1] 2.0	[1] 3.0	[2] 5.0
Ammonium Nitrate	72.5	71.5	71.5	71.5	71.5	71.0	72.3
Sodium Nitrate	5.0	7.0	8.8	8.6	8.3	10.0	8.0
Wood Pulp	0.5	1.0	1.0	1.0	1.0	0.5	1.0
Ivory Meal	4.0	3.0					
Cornstarch	4.0	1.0	1.0	1.0	1.0		
Chalk	0.5	0.5	0.5	0.5	0.5	0.5	0.5
DNT Oil			1.5	1.5	1.5		
Oxygen Balance—per cent	+5.9	+7.1	+7.7	+7.0	+5.8	+6.7	−1.4
Count	120	114	109	108	109	103	120
Detonation Velocity (m./sec.)	3,500		2,920	2,885	2,820	2,530	2,440
Sensitiveness—inches	24	36	20	16	8	3	½
Water Resistance, Per cent Good	55	57	67	71	71	77	10
Plasticity	None	Good	Excellent	Excellent	Good	Excellent	Excellent

[1] Heavy heat exchange oil 95%, polyisobutylene 5% (M. W. 140,000).
[2] Light lubricating oil 95%, polyisobutylene 5% (M. W. 80,000).

The examples in Table 3 show that a good degree of plasticity is obtained with as little as 1% of the nonexplosive oil gel, and indicate a preferred range of 1½ to 3% for the gel content in order to secure good plasticity and water resistance without excessive loss in sensitiveness.

TABLE 2

The effect on properties of high ammonia dynamites containing nonexplosive gel when the nitroglycerin content is varied

Example	5	6	7	8	9	10	11	12	13
Ingredients	Standard Semigelatin	Special Plastic	Special Plastic	Special Plastic	Special Plastic	Special Plastic	Special Plastic	Special Plastic	Special Plastic
Nitroglycerin—percent	18.0	16.8	14.8	14.0	13.4	13.0	9.0	7.0	5.0
DNT Oil	2.0								
Nitrocellulose	0.3	0.2	0.2	0.2	0.1	0.2			
Nonexplosive Gel		[1] 2.0	[1] 2.0	[1] 2.0	[1] 2.0	[2] 5.0	[3] 3.0	[4] 3.0	[3] 3.0
Ammonium Nitrate	65.5	68.6	71.5	71.5	72.5	72.3	80.0	81.5	86.0
Sodium Nitrate	8.3	9.5	8.5	8.3	8.5	8.0	7.0	6.5	5.0
Wood Pulp	1.0	1.0	1.0	1.0	0.5	1.0	0.5	1.5	0.5
Ivory Meal	2.4								
Cornstarch	2.0	1.4	1.5	1.0	2.5				
Chalk	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Oxygen Balance	+7.0	+7.1	+7.1	+5.8	+6.9	−1.4	+7.0	+6.7	+7.0
Count, 1¼ x 8 in	106	106	113	109	103	120	120	130	120
Detonation Velocity (m./sec.)	3,100	3,110	3,230	2,820	2,765	2,440		2,200	
Sensitiveness, in	14	16	24	8	24	½	0	8	Shot No. 8
Water Resistance, Per Cent Good	78	79	58	71	73	10		32	
Plasticity	Good	Excellent	Very Good	Good	Very Good	Excellent	Excellent	Excellent	Good

Examples shot with a No. 6 strength blasting cap unless otherwise noted.
[1] Heavy heat exchange oil 95%, polyisobutylene 5% (M. W. 140,000).
[2] Light lubricating oil 95%, polyisobutylene 5% (M. W. 80,000).
[3] Petrolatum 95%, polyisobutylene 5% (M. W. 80,000).
[4] Naphthenic lubricating oil 95%, polyisobutylene 5% (M. W. 80,000).

With reference to Table 2 for dynamites containing nitrocellulose, it will be observed that semigelatin dynamites 6, 7, 8, and 9 can be made

TABLE 4

The effect on the properties of extra gelatin dynamites of substituting nonexplosive gel for a portion of the nitroglycerin

Example	21	22	23	24	25	26	27
Grade	60%	60%	60%	40%	40%	40%	40%
Ingredients	Standard	Plastic	Plastic	Standard	Plastic	Plastic	Plastic
Nitroglycerin	28.5	25.0	23.5	25.0	22.0	20.0	20.0
Nitrocellulose	0.45	0.35	0.35	0.35	0.30	0.30	0.30
Ammonium Nitrate	30.8	35.8	37.8	11.0	15.00	18.0	18.0
Sodium Nitrate	28.25	29.85	29.35	46.75	49.2	28.2	28.2
Ivory Meal	5.0			4.4	2.5	2.5	2.5
Cornstarch	5.0	5.0	5.0	7.0	7.0	7.0	7.0
Wood Pulp	1.0	1.0	1.0	0.5	1.0	1.0	1.0
Sulfur				4.0			
Chalk	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nonexplosive Gel		[1] 2.0	[1] 2.0		[1] 2.0	[1] 2.0	[2] 2.0
Oxygen Balance—per cent	+6.5	+6.3	+6.7	+6.6	+6.5	+6.4	+6.4
Count	100	100	96	90	95	90	88
Leakiness (10 days at 120° F.)	None	None	None	None	None	None	None
Sensitivity, in	20	16	8	20	16	6	10
Detonation Velocity, m/sec	4,870	3,630	2,850	2,550	2,230	2,500	2,285
Plasticity and Packing	Satisfactory.	Satisfactory.	Satisfactory.	Satisfactory.	Satisfactory.	Satisfactory.	Satisfactory.

[1] Petrolatum 95%, polyisobutylene, 5% (M. W. 140,000).
[2] Heavy heat exchange oil 95%, polyisobutylene 5% (M. W. 140,000).

The examples in Table 4 show the partial replacement of nitroglycerin in ammonia gelatin dynamites which give explosives with a reduced nitroglycerin content. These explosives are still classed as gelatin-type dynamites and have satisfactory plasticity and packing characteristics so that they may be packed on a gelatin cartridging machine.

With reference to Table 5, the examples show the use of gelling agents including polyisobutylene and others. Particular examples of other nonexplosive gels are petrolatum-natural rubber gels and petrolatum-synthetic rubber gels. These gels gave properties which were satisfactory, although not so good as the petrolatum-polyisobutylene gel.

TABLE 5

The effect on the plasticity and water resistance of low nitroglycerin content dynamites containing nonexplosive gels with various tackifying agents

Example	28	29	30	31
Ingredients	Standard	Plastic	Plastic	Plastic
Nitroglycerin	13.4	13.5	13.5	13.5
Nitrocellulose	0.1	0.2	0.2	0.2
Ammonium Nitrate	72.5	73.0	73.0	73.0
Sodium Nitrate	5.0	8.8	8.8	8.8
Wood Pulp	0.5	1.0	1.0	1.0
Starch	4.0			
Ivory Meal	4.0			
Chalk	0.5	0.5	0.5	0.5
Nonexplosive Gel:				
Polyisobutylene M. W. 80,000 (5% in petrolatum)		3.0		
Natural Rubber (10% in petrolatum)			3.0	
Synthetic Rubber [1] (10% in petrolatum)				3.0
Oxygen Balance—per cent	+5.9	+6.0	+6.0	+6.0
Count	120	120	120	120
Water Resistance, Per Cent Good	54	81	56	74
Plasticity	None	Very Good	Fair	Fair

[1] A butadiene-styrene copolymer designated as Buna S.

TABLE 6

Gelatinous explosives without nitroglycerin

Example	32	33	34	35	36	37	38	39
Ingredients								
Trinitrotoluene (flaked)—per cent		11.5						
Nitrostarch—do	30.0							
Pentaerythritol Tetranitrate—do				95	25	30		
Cyclonite—do							95	30
Ammonium Nitrate—do	47.0	86.5	97.0		65	63		63.0
Sodium Nitrate—do	19.0							
Aluminum (flaked)—do	1.0							
Nonexplosive Gel—do	[1] 3.0	[1] 2.0	[1] 3.0	[2] 5.0	[3] 10	[3] 7	[2] 5.0	[3] 7.0
Oxygen Balance—do	−3.17	0	+7.34	−26.9	−25.3	−15.8	−37.9	−19.2
Count		141	142	120	117	118	117	121
Sensitivity [4]	[5]	[6]	[6]	No. 6	[7]	[8]	No. 6	[8]
Detonation Velocity, m./sec	4,730					4,880		5,140
Plasticity	Good	Very Good	Very Good	Very Good	Excellent	Excellent	Excellent	Excellent

[1] Petrolatum 95%, polyisobutylene 5% (M. W. 80,000).
[2] Light lubricating oil 95%, polyisobutylene 5% (M. W. 80,000).
[3] Medium lubricating oil 92%, polyisobutylene 8% (M. W. 140,000).
[4] Shows strength of cap or booster required to detonate charge and diameter of package which is 1¼ in. by 8 in with paper wrapper unless otherwise indicated.
[5] No. 8 1½ in. by 8 in. paper.
[6] 5 g. PETN 2 in. by 8 in. can.
[7] 5 g. PETN.
[8] 5 h. Army cap.

The data in Table 6 show that explosives with good plasticity and varying degrees of sensitivity can be prepared with explosives other than nitroglycerin by addition of the nonexplosive gel.

The foregoing examples show that a variety of gelatinous explosive compositions may be made in accordance with the present invention including dynamites low in nitroglycerin content, high ammonia dynamites, and explosives without nitroglycerin. The examples further show that improved gelatinous explosive compositions may be formulated comprising high explosive ingredients, such as nitroglycerin or a mixture of nitric esters, such as nitroglycerin-nitroglycol, to obtain low freezing characteristics, dinitrotoluene, nitrocellulose, ammonium nitrate, sodium nitrate, trinitrotoluene nitrostarch, pentaerythritol tetranitrate, cyclonite, and equivalent materials, by incorporating in the composition a small proportion of a nonexplosive gel. Miscellaneous ingredients, such as wood pulp, cornstarch, ivory meal, chalk, aluminum (flaked or powdered), sulfur, and the like, may be included as conventionally utilized for the various types of explosives.

The nonexplosive gel in accordance with this invention is present in an amount from about 1% to about 10% by weight of the explosive composition. The gel comprises a water-insoluble, nonvolatile petroleum hydrocarbon base material, such as petrolatum, paraffin-base oils, naphthene-base oils, and mixed or intermediate-base oils, and a petroleum-soluble elastomeric gelling agent, such as polyisobutylene, natural rubber, and synthetic rubber. Cylinder oil and the so-called "bright stock," obtained in the distillation of petroleum into fractions, which is used in the manufacture of lubricating oils have also given good results. Amber petrolatum having a melting point in the order of 49° C. and oils having a viscosity of from about 200 to about 5000 centipoises at 25° C. have given good results. The preferred base material is a naphthene-base oil having a viscosity of from about 1000 to about 2000 centipoises at 25° C. The preferred gelling agent is polyisobutylene having a molecular weight (M. W.) range of from about 80,000 to about 140,000. It will, of course, be understood that in combination with a given base, as the molecular weight of the polyisobutylene utilized is increased, a lesser amount is necessary to give a desired degree of thickening and tack. It has been found that good results are obtained when the gelling agent is present in an amount of from about 2% to about 12% by weight of the nonexplosive gel.

The method for preparing the gelatinous explosive of this invention comprises mixing the nonexplosive water-insoluble base material and the nonexplosive gelling agent to form a gel, reducing the gel into individual units, and mixing the units with explosive ingredients. In a preferred embodiment of the invention the carbonaceous ingredients of the explosive composition are premixed with the gel. The gel mixture is then reduced to individual units and then mixed with the other ingredients of the explosive composition.

An example for preparation of the nonexplosive gel is as follows: One pound of polyisobutylene was added to a small Banbury mixer heated to about 325° F. and run for about 5 minutes. One pound of a naphthenic oil was slowly added, and mixing was continued for a half hour at 350°–400° F. Cold water was circulated through the jacket of the mixer to facilitate discharging the mix. This composition was then cut into small pieces and added to 18 pounds of the same oil in which it dissolved during 8 hours' stirring at 400°–420° F. This mixture after cooling can be used in the preparation of the dynamite. However, since the mixture is quite sticky and, to facilitate handling, the cooled mixture was added to a Werner-Pfleiderer mixer and mixed with 10 pounds of cornstarch and 10 pounds of wood flour. This gave a dough which was easy to handle. This dough (nonexplosive gel) was formed into individual units resembling loaf-shaped masses.

An example for preparation of a semigelatin dynamite is as follows: A 140 pound charge of nitroglycerin was placed in a Talley mix bowl, 3½ pounds of nitrocellulose was added, and the mixture stirred for 5 minutes. Then the ammonium nitrate and carbonaceous ingredients (dope ingredients) were added, followed immediately by the dough (nonexplosive gel), which was added in four 10 pound loaf-shaped masses. Mixing was continued for 5 minutes longer. The mixed dynamite was then packed on a Hall packing machine in standard size cartridges.

Although cornstarch and wood flour are specifically set forth as desirable constituents to prevent excessive stickiness of the prepared gel, other pulverized nonexplosive materials may be used for this purpose. If sufficient carbonaceous ingredients are present in the explosive composition, they materially aid in preventing stickiness and in improving handling.

It will be appreciated that in carrying out the method of the present invention, considerable latitude for incorporation of the ingredients of a specific explosive composition is afforded. Procedures other than the example given above which were tried with good results include the following: The gel and dry ingredients were mixed and then added to the nitroglycerin-nitrocellulose pregel; the gel and dry ingredients were mixed and then the nitroglycerin and nitrocellulose were added at the same time and the mixing completed; and the nitroglycerin and nitrocellulose were gelled in a mixing bowl, the dry ingredients were then added and mixed, and then the gel was added and the mixing completed.

Thus it is seen that the method of this invention may be carried out with various modifications without departing from its spirit and scope.

The advantages of the invention are multifold. By introducing the nonexplosive gel into gelatinous nitroglycerin dynamites, less of the explosive nitrocellulose-nitroglycerin gel need be used to produce a finished gelatinous dynamite. By using a nonexplosive gel in addition to the nitrocellulose-nitroglycerin colloid the gelatinous properties and water resistance of the dynamite are improved and consistency remains uniform from batch to batch. Due to the decrease in nitroglycerin content, less high nitroglycerin-absorbent carbonaceous material is required. The removal of a portion of these absorbent materials makes way for an increased percentage of ammonium nitrate which is needed to maintain the original percentage weight strength of the dynamite. At the same time the addition of the nonexplosive gel which has a large negative oxygen balance makes up for the loss of the absorbent ingredients which have a somewhat smaller negative oxygen balance. The particle size and type of the dry ingredients may be conventionally selected to produce the required oxygen balance, density and absorbency. Moreover,

the nonexplosive gel may be used as a binding agent with dry powdery dynamites and with granular or crystalline explosives or explosive mixtures to insure easy packaging and handling. Moreover, the method for manufacturing the gelatinous explosives of this invention insures uniformity and enhanced characteristics of the finished explosives.

In the foregoing examples the initiating device used was a No. 6 blasting cap unless otherwise noted. Where the explosive was too insensitive to be fired by such a cap, a No. 8 cap or an Army Engineer Corps special cap was used, as indicated. The No. 8 cap has about twice the strength of the No. 6 cap and the special Army cap has about twice the strength of the No. 8 cap. In examples where the explosive was formulated to be quite insensitive, a cap containing a charge of 5 g. of PETN was used, as indicated.

The "sensitivity" of the explosive, as given in the tables, was determined by the halved-cartridge gap test. In this test, a 1¼ inch by 8 inch cartridge is cut transversely in half. The two halves are separated at various distances until the separation at which propagation will just take place from one half of the cartridge to the other half is obtained. This distance is given in inches.

The "count" of the explosive, as given in the tables, is the number of 1¼ inch by 8 inch cartridges contained per fifty pounds of the explosive.

The "water resistance" of the explosive, as given in the tables, was determined by filling a Gooch crucible with the explosive and immersing it in water for a period of 24 hours. After immersion, the percentage of dry explosive was determined. This is designated as "per cent good" followed by the numerical percentage of dry explosive. All ammonium nitrate used in the examples was coated with a rosin-paraffin mixture.

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

1. A gelatinous explosive comprising high explosive material of the group consisting of liquid explosive nitric esters, nitrocellulose, nitrostarch, and crystalline high explosives, and from about 1 to about 10% of a nonexplosive gel containing at least one substantially nonvolatile, water-insoluble petroleum hydrocarbon of the group consisting of petrolatum, paraffin base oils, naphthene base oils, intermediate base oils, cylinder oil, and bright stock, and at least one petroleum-soluble elastomeric gelling agent of the group consisting of natural rubber, petroleum-soluble synthetic rubber, and polyisobutylene.

2. A gelatinous explosive according to claim 1 in which the nonexplosive gel essentially comprises a naphthene base oil and natural rubber.

3. A gelatinous explosive according to claim 1 in which the nonexplosive gel essentially comprises a naphthene base oil and a petroleum-soluble synthetic rubber.

4. A gelatinous explosive according to claim 1 in which the nonexplosive gel essentially comprises a naphthene base oil and polyisobutylene.

5. A gelatinous explosive according to claim 1 in which the nonexplosive gel essentially comprises a naphthene base oil having a viscosity of 1000 to 2000 centipoises at 25° C. and from 2% to 12% by weight of the gel of polyisobutylene.

6. A gelatinous explosive according to claim 1 in which the nonexplosive gel essentially comprises petrolatum and polyisobutylene.

JACK M. DOWNARD.

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Certificate of Correction

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 2, line 9, for "methmod" read *method*; line 13, for "combinatitons" read *combinations*; line 19, for "water-soluble" read *water-insoluble*; columns 5 and 6, Table 6, footnote [8] thereto, for "5 h. Army cap." read *Sp. Army Cap.*; and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 20th day of March, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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