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EXPLOSIVE

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The present invention relates to a new and improved blasting explosive, and more particularly to a slow-acting explosive of improved water resistance.

In the blasting of shatterable materials such as shale, soft lime stone, and the like, the explosive to be employed should possess two properties which have hitherto been regarded as mutually exclusive. In the first place, the explosive to be used should have a relatively low rate of pressure development in order to minimize the shattering effect of the explosion on the material blasted down. In the second place, the explosive should have a high water-resistance, since water is frequently encountered in the bore holes in this type of blasting operation.

Heretofore no slow-acting explosive of high water-resistance has been available. Indeed, it appeared to be impossible to obtain this combination of properties in the same dynamite. On the one hand, gelatin dynamites were available which possessed satisfactory water-resistance, but explosives of this character were much too rapid as regards rate of pressure development. On the other hand, explosives containing relatively coarse ammonium nitrate were available which produced the desired heaving rather than shattering effect, but the water-resistance of this type of dynamite was very unsatisfactory.

Several attempts were made to improve the water-resistance of the latter type of explosive containing coarse ammonium nitrate. Thus, for example, colloided nitroglycerin was employed in the composition with a view to protecting the individual particles of the coarse ammonium nitrate with a water-impervious covering. The results, however, were totally unsatisfactory. The porous nature of the coarse ammonium nitrate required for the low rate of pressure development appeared to render it impossible to obtain the desired degree of water-resistance in a slow-acting explosive.

The object of the present invention is a new and improved water-resistant explosive composition. A further object is a water-resistant explosive having a relatively low rate of pressure development. A still further object is a water-resistant ammonium nitrate dynamite suitable for the blasting of shatterable materials. Other objects will appear as the invention is hereinafter more fully disclosed.

We have found that these objects may be accomplished by taking advantage of some hitherto unexpected properties resulting from the blending of the solid ingredients of an ammonium nitrate dynamite.

We have found that a dynamite having a high degree of water-resistance may be obtained by incorporating a colloided liquid nitric ester with a composition comprising, in part, a relatively large proportion of coarse ammonium nitrate, the other solid ingredients of said composition being in a finely divided state. This composition comprises a blend of relatively fine and relatively coarse particles, the finer particles being distributed in the interstices formed by the coarser particles and filling a substantial proportion of the voids therebetween. Incorporated with this explosive is a small percentage of a water-insoluble soap. The resulting explosive has a water-resistance which is very markedly superior to any slow-acting explosive heretofore known in the art.

In the co-pending applications of Kirst and Woodbury, Serial No. 759,765 filed December 29, 1934 and Serial No. 759,766 filed December 29, 1934 the process of blending coarse and fine ammonium nitrate in several explosive compositions comprising the resultant blends is described. These inventions are concerned primarily with the effect of blending on the density of the resulting explosive. The present invention, on the other hand, is concerned with the remarkable improvement in the water-resistance achieved by the use of a blend of the coarse and fine solid ingredients thereof, when incorporated with a water-insoluble soap and colloided liquid nitric ester.

In accordance with our invention, the explosive comprises three essential ingredients, namely: (1) a dope comprising a relatively large proportion of blended ammonium nitrate as hereinafter more fully described; (2) a water-insoluble soap; and (3) a small percentage of a colloided liquid nitric ester.

The ammonium nitrate may consist entirely of relatively coarse particles if desired, or of a prepared blend of the coarse and fine grades. To produce the slow heaving action, however, a

substantial amount of the ammonium nitrate should be coarse in order to insure a low rate of pressure development. In any event the coarse ammonium nitrate should be blended with the remaining solid ingredients of the dope, and to obtain the best results at least 30% of the total solid ingredients should be present in a relatively fine state of division. The composition is blended until the fine particles fill substantially all the voids between the coarse ammonium nitrate particles. This may be accomplished, if desired, during incorporation by adding the coarse and fine particles of which the balance dope is to be made, together with the water-insoluble soap to the colloided liquid nitric ester, and incorporating the ingredients in the usual manner.

As illustrative of the preferred ranges within which the various ingredients of our explosive may be used, reference is made to Table I.

Table I

	Per cent
Liquid nitric ester	5 to 25
Nitrocellulose	0.1 to 0.5
Ammonium nitrate	35 to 85
Sodium nitrate	0 to 40
Water-insoluble soap	0.01 to 2
Carbonaceous combustible	0 to 15

In the foregoing table the carbonaceous materials may consist of oat hulls, corn meal, bran, expanded cereal products, ground coal, wood pulp, cottonseed hulls, rice hulls, ivory nut meal, starch, flour, and the like, or any mixtures thereof. Antacids such as calcium carbonate, magnesium carbonate, magnesium oxide, and the like; nitrobodies such as dinitrotoluene, trinitrotoluene, nitronaphthalene, and the like; and other ingredients may be added to the composition if desired. A substantial proportion of the ammonium nitrate specified in the foregoing table should consist of relatively coarse particles. Preferably a substantial proportion of the ammonium nitrate should consist of particles which pass, for example, through a 10-mesh screen but are held on a 35-mesh screen. It is also desirable that at least 30% of the remaining solid ingredients should pass a 100-mesh screen. The coarse ammonium nitrate, together with the other ingredients of the dope, including the finer ingredients and the water-insoluble soap, is added to the colloided nitric ester, and incorporated in the usual manner.

In order to illustrate the details of our invention more clearly, reference is made to Table II, containing a number of typical dynamite compositions in accordance with our invention. This is done solely by way of illustration and is, therefore, not to be regarded as a limitation on the scope of our invention which has many important embodiments other than those hereinafter more fully disclosed.

Table II

	A	B	C	D
	Percent	*Percent*	*Percent*	*Percent*
Nitroglycerin	8.0	12.0	12.0	18.0
Nitrocotton	0.2	0.2	0.2	0.2
Ammonium nitrate	84.0	38.4	80.0	68.0
Calcium stearate	0.1	0.4	0.1	0.1
Sodium nitrate	0.0	35.9	------	5.0
Absorbents, antacids, nitrobodies, etc.	7.7	13.1	7.7	8.7
	100.0	100.0	100.0	100.0

In the above table the ammonium nitrate employed comprises in all cases a relatively large proportion of the coarse variety, for example, material which passes through a 10-mesh screen, but is held on a 35-mesh screen. In Example A, half of the ammonium nitrate employed comprises the relatively coarse variety, the remainder being sufficiently fine to pass a 65-mesh screen. In Example B, all the ammonium nitrate is of the coarse variety, the voids between the particles being filled substantially completely by the sodium nitrate which is sufficiently fine to pass a 65-mesh screen. In Example C, two-thirds of the ammonium nitrate consists of the coarse variety. In Example D, three-fourths of the ammonium nitrate consists of the coarse variety. In Examples B, C, and D the remainder of the ammonium nitrate, as well as the other solid ingredients of the composition, is in a state of fine division in order substantially completely to fill the voids between the coarse particles of the ammonium nitrate.

In all the above examples the coarse and fine ingredients together with the water-insoluble soap and the other ingredients of the dope, are added to and incorporated with the nitroglycerin-nitrocotton colloid. The resulting explosive in each case has a relatively high density, a low rate of pressure development, and a remarkably high water-resistance.

In order to illustrate the influence of the various factors in the explosive according to our invention, reference is made to Table III.

Table III

	A	B	C	D
	Percent	*Percent*	*Percent*	*Percent*
Nitroglycerin	12.0	12.0	12.0	12.0
Coarse ammonium nitrate	80.0	40.0	40.0	48.0
Fine ammonium nitrate	------	40.0	40.0	32.0
Calcium stearate	0.1	------	0.1	0.1
Nitrocotton	0.2	0.2	------	0.2
Carbonaceous absorbent	7.2	7.3	7.4	7.2
Chalk	0.5	0.5	0.5	0.5
	100.0	100.0	100.0	100.0
Water-resistance—(hours)	¼—(failed)	OK ½	¼—(failed)	OK-16

As can be seen from the foregoing table, composition D according to our invention has a water-resistance far greater than compositions A, B, or C in which one of the essential elements of the present invention is omitted. In A, the fine salts are omitted; in B, the insoluble soap is left out; while in C, the nitrocotton is omitted. As a result, the water-resistance of all these powders is poor. However, when the three essential ingredients of our invention are present, as in D, the powder is satisfactory even after 16 hours submersion in water.

The effect of the amount of nitroglycerin present in the explosive is illustrated in Table IV.

Table IV

	A	B	C
	Percent	*Percent*	*Percent*
Nitroglycerin	8.0	10.0	14.0
Nitrocotton	0.2	0.2	0.2
Coarse ammonium nitrate	42.0	41.0	39.0
Fine ammonium nitrate	41.5	40.5	38.5
Calcium stearate	0.5	0.5	0.5
Carbonaceous combustible	7.3	7.3	7.3
Chalk	0.5	0.5	0.5
	100.0	100.0	100.0
Water-resistance—(hours)	OK-16	OK-16	OK-16

From this table it is apparent that the amount of nitroglycerin present is a relatively unimportant factor in the water-resistance of the explosive.

The effect of the relative proportion of coarse and fine solid ingredients is shown in Table V.

Table V

	A	B	C	D	E
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Nitroglycerin	12.0	12.0	12.0	12.0	12.0
Nitrocotton	0.2	0.2	0.2	0.2	0.2
Coarse ammonium nitrate	80.0	56.0	48.0	40.0	32.0
Fine ammonium nitrate		24.0	32.0	40.0	48.0
Carbonaceous combustible	7.23	7.23	7.23	7.23	7.23
Calcium stearate	.07	.07	.07	.07	.07
Chalk	0.5	0.5	0.5	0.5	0.5
	100.0	100.0	100.0	100.0	100.0
Water-resistance (hours)	F-1/4	OK-1/2	OK-16	OK-12	OK-16

From this table it is apparent that satisfactory results are obtained only if the solid ingredients comprise greater than 30% "fines."

By the term "water-resistance" as hereinbefore employed in the description of our invention, we refer to the property of the composition to resist the effect of water in which the cartridge is immersed. In each case the figure represents the time in hours during which the various dynamites were immersed and at the end of which time no failures to detonate were obtained in four attempts, the detonation being brought about by a commercial blasting cap.

In the foregoing detailed description of our invention, it is apparent that many variations may be made without departing from the spirit and scope thereof. Thus, for example, ethylene glycol dinitrate or any of the common explosive oils or mixtures thereof may be employed in place of nitroglycerin specified in the examples. Likewise, while calcium stearate is preferred, other water-insoluble soaps may be employed, for example, the oleates, stearates, palmitates, ricinoleates, resinates and the like of calcium, magnesium, iron, zinc, tin and other metals. Other variations will be apparent to any one skilled in the art. We, therefore, intend to be limited only in accordance with the following patent claims:

We claim:

1. A water-resistant, semi-gelatinous ammonium nitrate dynamite containing at least one liquid explosive nitric ester colloided by means of nitrocellulose, a water-insoluble soap, and a composition comprising a relatively large proportion of coarse ammonium nitrate, said composition comprising a blend of relatively fine and relatively coarse particles, the finer particles being distributed in the interstices formed by the coarser particles, the total solid ingredients of said composition comprising greater than 30% fines.

2. A water-resistant, semi-gelatinous ammonium nitrate dynamite containing at least one liquid explosive nitric ester colloided by means of nitrocellulose, a water-insoluble soap, and a composition comprising a substantial proportion of relatively coarse ammonium nitrate, the remaining solid ingredients of said composition being in a relatively fine state of division and filling a substantial proportion of the voids between said coarse particles of ammonium nitrate, the total solid ingredients of said composition comprising greater than 30% fines.

3. The composition of claim 2, in which said explosive nitric ester comprises nitroglycerin colloided by means of nitrocellulose.

4. A water-resistant, semi-gelatinous ammonium nitrate dynamite characterized by relatively high density and relatively low rate of pressure development, containing at least one liquid explosive nitric ester colloided by means of nitrocellulose, a water-insoluble soap, and a composition comprising a substantial proportion of relatively coarse ammonium nitrate, the remaining solid ingredients of said composition being in a relatively fine state of division and distributed in the interstices formed by the coarser particles, the total solid ingredients of said composition comprising greater than 30% fines.

5. The composition of claim 4, in which said liquid nitric ester comprises nitroglycerin colloided by means of nitrocellulose.

6. A water-resistant, semi-gelatinous ammonium nitrate dynamite characterized by relatively high density and relatively low rate of pressure development, comprising 8 to 20% of at least one liquid explosive nitric ester colloided by means of nitrocellulose, not more than 2% of a water-insoluble soap, 40 to 85% relatively coarse ammonium nitrate, and not more than 40% relatively fine sodium nitrate, said fine sodium nitrate being blended with said coarse ammonium nitrate and filling a substantial proportion of the voids between said coarse particles, the total solid ingredients of said composition comprising greater than 30% fines.

7. The composition of claim 6, in which said liquid explosive nitric ester comprises nitroglycerin and said water-insoluble soap comprises calcium stearate.

8. A water-resistant, semi-gelatinous ammonium nitrate dynamite characterized by relatively high density and relatively low rate of pressure development, comprising approximately 12% of at least one liquid explosive nitric ester, 0.2% nitrocellulose, 80% ammonium nitrate, 6.8% carbonaceous combustible, 0.1% calcium stearate, and 1% antacid, said ammonium nitrate consisting of a blend of a substantial proportion of relatively coarse particles and a small proportion of relatively fine particles, the fine particles being distributed in the interstices formed by the coarser particles, the total solid ingredients of said composition comprising greater than 30% fines.

9. The composition of claim 8, in which said liquid explosive nitric ester comprises nitroglycerin.

10. The composition of claim 8, in which said liquid explosive nitric ester comprises a mixture of nitroglycerin and ethylene-glycol-dinitrate.

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