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EXPLOSIVE COMPOSITIONS

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The present invention relates to an improvement in the production of safety ammonium nitrate blasting explosive powders such as are used in fiery or dusty mines and of the kind wherein the sensitizing explosive ingredient is trinitrotoluene and the flame quenching ingredient comprises sodium chloride.

An example of such a safety ammonium nitrate explosive is Douglas powder, which is made by grinding together trinitrotoluene, ammonium nitrate and sodium chloride substantially in the proportions 15:69:16 by weight and which has a power equivalent to 65% of that of blasting gelatine as determined in the ballistic mortar, and which just passes a Home Office gallery test in which the cartridge is fired unstemmed from a steel gun or cannon with a 47 inch bore into a gallery containing a mixture of 9% by volume of methane in air. The velocity of detonation of Douglas powder is about 3,000 metres/second. However, the improvement in safety characteristics exhibited by more modern explosives and especially sheathed nitroglycerine explosives and the increasingly high safety characteristics expected in recent years have resulted in attempts to make safer explosives based on trinitrotoluene and ammonium nitrate by increasing the sodium chloride content, but hitherto because of the resulting diminution in sensitivity to propagation it has not been practicable to increase the sodium chloride content beyond approximately 25% as in the explosive Gathurst powder which contains 15% trinitrotoluene, 60% ammonium nitrate and 25% sodium chloride by weight and has a power equivalent to 53% of that of blasting gelatine and a velocity of detonation of about 2,800 metres/second. In order to circumvent this difficulty there have also been introduced wrapped cartridges of explosives containing ammonium nitrate, trinitrotoluene and sodium chloride sheathed with a layer of sodium bicarbonate on their longitudinal surfaces between the wrapper and an outer wrapper, the sodium bicarbonate layer serving to assist in preventing ignition of the firedamp atmosphere and of reducing the power developed by the cartridges without substantially reducing their sensitiveness to propagation. Sheathed explosives have, however, the disadvantage that they necessitate the provision of wider boreholes and their manufacture is troublesome owing to the necessity for preventing the sheathing material from covering the end surfaces of the cartridges and the necessity of an extra wrapper, apart from the fact that accidental damage to the sheath may result in a loss of its safety advantage.

The manufacture of ammonium nitrate explosive compositions in which the sensitizing ingredient is trinitrotoluene differs from the manufacture of those in which the sensitizing explosive ingredient is a liquid explosive nitric ester in that in the former grinding is necessary

in order to achieve that intimate admixture of the trinitrotoluene and the ammonium nitrate required to render the mixture sensitive to initiation by a detonator whereas the incorporation of the ingredients of explosives containing a liquid explosive nitric ester must be carried out with only gentle mechanical mixing action and without the exercise of appreciable pressure.

Hitherto in the manufacture of ammonium nitrate trinitrotoluene explosives containing sodium chloride or other ingredients, the ingredients have all been ground together. We have now found that the fine state of division of the sodium chloride particles resulting from their comminution in the grinding operation greatly enhances the desensitizing effect of sodium chloride on the explosive containing it.

In general the object of the present invention is to provide ammonium nitrate blasting explosives of the kind containing trinitrotoluene and sodium chloride which will have improved sensitiveness for any desired degree of safety.

According to the present invention a safety ammonium nitrate blasting explosive powder of the kind comprising trinitrotoluene and sodium chloride wherein the ammonium nitrate and the trinitrotoluene consist of fine particles in intimate admixture is characterized in that at least a portion of the sodium chloride is retainable on a 120 B. S. S. sieve.

It is preferred that at least 10% of the sodium chloride in the composition should be of a fine grist, i. e. passes a 120 B. S. S. sieve since under freely suspended firing conditions in a gallery test explosives according to the invention containing this amount of fine sodium chloride give better results than those containing no fines at all, and are equally satisfactory in the test in which they are fired from a cannon.

It is well known that for safety explosive compositions consisting of a mixture of trinitrotoluene, ammonium nitrate and sodium chloride not to give off poisonous fumes on initiation, that these compositions should have a calculated oxygen balance between —0.5 and +3 gms./100 gms. of the composition.

It is also often desirable to include in such compositions up to 4.5% of fibre in order to lower the bulk density of the composition and to restore oxygen balance in explosives where the trinitrotoluene content is reduced to give enhanced safety

From the stipulated oxygen of —0.5 to +3 gms. oxygen per 100 gms. of the composition it can be deduced that the percentage by weight of trinitrotoluene must be between 5 and 15.5 and the percentage by weight of ammonium nitrate must be between 40 and 60 (if no other oxygen producing salt is included) and having regard to the total quantity of flame quenching ingredients of a sheathed explosive of the non-nitroglycerine, trinitrotoluene, ammonium nitrate type it can be assumed that the sodium chloride content for at least the same degree of safety should be at least 30%.

Furthermore, it has been experimentally ascertained that ammonium nitrate compositions of the aforesaid kind having at least 30% sodium chloride must have a velocity of detonation of at least 2,000 metres/second to be certain that propagation of detonation will take place along a file 1 metre long made from 1¼ inch diameter cartridges of said compositions.

It has also been experimentally ascertained that in order to have an explosive containing only ammonium nitrate, trinitrotoluene and sodium chloride equivalent in safety to

sheathed Douglas powder, so that 4 ozs. of the explosive when fired freely suspended in a gallery test should fail to ignite a 9% by volume methane-air mixture, at least 35% of sodium chloride should be included.

More particularly the object of the present invention is to provide ammonium nitrate blasting explosives of the kind containing trinitrotoluene and at least 35% sodium chloride which will have a velocity of detonation of at least 2,300 metres/second and not more than 2,900 metres/second.

Said ammonium nitrate blasting explosives which have a velocity of detonation less than 2,300 metres/second are less sensitive than is usually desirable for commercial purposes, while those which have a velocity of detonation greater than 2,900 metres/second have an adverse effect on the suspended gallery test.

More particularly, according to the present invention a safety ammonium nitrate blasting explosive powder of the kind comprising trinitrotoluene and sodium chloride wherein the ammonium nitrate and the trinitrotoluene consist of fine particles in intimate admixture is characterized in that the amount of sodium chloride is at least 35% by weight on the explosive powder and in that such portion of the sodium chloride is retainable on a 120 B. S. S. sieve that the explosive powder has a velocity of at least 2,300 metres/second and not more than 2,900 metres/second.

For example, for a composition containing 35% sodium chloride it is desirable to have at least 10% of sodium chloride on the explosive powder retainable on said sieve; and for a composition containing 40% sodium chloride it is desirable to have at least 17.5% of sodium chloride on the explosive retainable on said sieve.

It is to be understood that if for example sodium nitrate is included less than 35% sodium chloride may give the desired degree of safety.

Preferably the grist is such that all of the sodium chloride passes a 16 B. S. S. sieve in order to prevent segregation in transport.

By limiting the amount of the sodium chloride ground with the trinitrotoluene and the ammonium nitrate or otherwise introduced into the final explosive mixture to a division fine enough to pass a 120 B. S. S. sieve to not more than 25% of the weight of the final explosive mixture there may be obtained explosives containing from 30 to 60% sodium chloride and from 5 to 12% trinitrotoluene, the remainder consisting mainly of ammonium nitrate. If necessary sufficient of an oxidizing salt of a metal, e. g. sodium nitrate and if desired also non-explosive solids in small proportions to give a satisfactory oxygen balance may also be included, these resulting explosives having satisfactory initiation and propagation sensitiveness and having better safety characteristics than any of the known unsheathed ammonium nitrate, trinitrotoluene, sodium chloride explosives.

Although the whole amount of the sodium chloride present in the explosive composition may be of a grist too coarse to pass a 120 B. S. S. sieve, it is preferred that at least 10% of the sodium chloride in the composition should be of a finer grist since under freely suspended firing conditions in a gallery test explosives according to the invention containing this amount of fine sodium chloride give better results than those containing no fines at all, and are equally satisfactory in the test in which they are fired from the cannon.

A process for the production of a safety ammonium nitrate blasting explosive powder according to the present invention comprises grinding together trinitrotoluene and ammonium nitrate in known manner and thereafter lightly mixing into the milled mixture thus produced sodium chloride at least a portion of which is retainable on a 120 B. S. S. sieve.

In putting the invention into effect the trinitrotoluene and the ammonium nitrate may be first ground in known manner, for example in an edge runner mill in the absence of sodium chloride and thereafter the sodium chloride, which may be wholly or partly of grist too coarse to pass a 120 B. S. S. sieve, may then be lightly mixed with the milled mixture without further grinding, for instance by transferring the said mixture to an "Atlas" (registered trademark) mixer and working in the sodium chloride after the fashion employed in incorporating the ingredients of explosives containing liquid explosive nitric esters, or alternatively if an edge runner mill has been used for milling the ammonium nitrate and trinitrotoluene by working in the salt with the plows alone after raising the rolls clear of the mixture.

When it is desired that some of the sodium chloride in the final explosive should be fine enough to pass a 120 B. S. S. sieve, that portion of the sodium chloride added in any desired state of division may be ground with the trinitrotoluene and ammonium nitrate in the usual way, the portion too coarse to pass the 120 B. S. S. sieve being thereafter lightly mixed in as such without milling. Another method is to mill the ammonium nitrate and trinitrotoluene with or without some sodium chloride in known manner and then introduce into the mill a quantity of sodium chloride having a grist size so that all is retained by a 120 B. S. S. sieve and continue to mill for the short time until mixing is completed and so that the main portion of the sodium chloride in the resulting composition still has a grist size which is retained on a 120 B. S. S. sieve.

The blasting explosives according to the invention retain their sensitiveness, i. e. their firing properties for a period of at least 6 months.

The following tables embody experimental data which indicate the properties of compositions consisting of sodium chloride in admixture with mixtures of trinitrotoluene and ammonium nitrate in a ratio of 18.2:81.8.

A positive sign indicates that the gas tests (suspended test and gun test) have been passed with respect to safety, a negative sign indicates that the gas test has not been passed with respect to safety.

TABLE 1

Sodium chloride content, percent	Power (percent Blasting Gelatine) Experimentally determined	Grist size of sodium chloride: Retained on 120 B. S. S. sieve, Passes 16 B. S. S. sieve, retained by 60 B. S. S. sieve (parts)	Grist size of sodium chloride: Finely milled (parts)	Velocity of detonation (m./sec.)	Safety in gas
25	53		25	2,800	−
		25		3,500	−
			30	2,500	−
		2	28	2,600	−
		5	25	2,700	−
		10	20	2,800	−
30	47	15	15	2,900	−
		20	10	3,100	−
		25	5	3,200	−
		30		3,300	−
			35	2,100	+
		5	30	2,200	+
		10	25	2,300	+
35	43	20	15	2,600	+
		30	5	2,900	+
		35		3,100	−
			40	(1)	
		10	30	2,000	+
		15	25	2,200	+
40	39	20	20	2,400	+
		30	10	2,700	+
		40		2,900	+
		25	25	2,000	+
50	29	40	10	2,400	+
		50		2,700	+
		40	20	2,000	+
60	20	60		2,400	+

[1] Fails to propagate.

TABLE 2

Sodium chloride content, percent	Power, percent B/G	Grist size of sodium chloride: Passes 60 B. S. S. sieve, retained by 120 B. S. S. sieve (parts)	Grist size of sodium chloride: Finely milled (parts)	Velocity of detonation (m./sec.)	Safety in gas
30	47	----------	30	2,500	–
		30	----------	3,000	–
35	43	----------	35	2,100	+
		10	25	2,300	+
		15	20	2,400	+
		17.5	17.5	2,500	+
		28	7	2,700	+
		35	----------	2,900	+
40	39	----------	40	[1]	+
		20	20	2,300	+
		40	----------	2,700	+

[1] Fails to propagate.

Example 1

In an edge runner mill set for close grinding there are ground together 11.9 parts flake trinitrotoluene and 53.1 parts ammonium nitrate having a fine surface deposit of the ammonium salt of trisulphonated pararosaniline amounting to 0.1% of its weight, the grinding being continued for 25 minutes by which time substantially the whole mixture is fine enough to pass a 150 B. S. S. sieve. Further grinding has no beneficial effects on its sensitiveness. After the grinding is stopped the wheels are raised free of the mixture, into which there are worked by means of the plows 35 parts sodium chloride having a grist size so that all of it passes a 60 B. S. S. sieve and only 58% passes a 120 B. S. S. sieve.

The resulting explosive has a velocity of detonation of 2,400 metres/second, is sensitive to a No. 3 commercial fulminate detonator and in the form of a 1.25 inch cartridge 3 inches long communicates detonation to a similar spaced 1 inch end to end from it. Its power is 43% of that of blasting gelatine and it has a density of 1.15 gms./ml. at 20 lbs./sq. in. 6 ozs. when fired freely suspended in a gallery test fail to ignite a 9% by volume methane-air mixture.

A explosive of a similar composition but containing 35% sodium chloride in a finely divided form has a velocity of detonation of 2100 metres/second, is not sensitive to a No. 3 commercial fulminate detonator, and in the form of a 1.25 inch cartridge 3 inches long, communicates detonation to a similar cartridge spaced 0.5 inch end to end from it. 5 ozs. when fired freely suspended in the gallery test fail to ignite a 9% by volume methane-air mixture.

Example 2

11.5 parts of trinitrotoluene are milled with 11.5 parts of ammonium nitrate for 10 minutes in an edge runner mill set for close grinding. 40 parts ammonium nitrate and 8 parts sodium chloride are added and the mixture milled for a further 20 minutes by which time substantially the whole mixture is fine enough to pass a 150 B. S. S. sieve. The wheels of the mill are then raised free of the mixture, and 29 parts sodium chloride, having a grist size so that all of it passes a 60 B. S. S. sieve and is retained on a 120 B. S. S. sieve, are worked into the mixture by means of the plows.

The resulting explosive has a velocity of detonation of 2600 metres/second, is sensitive to a No. 3 commercial fulminate detonator, and in the form of a 1.25 inch diameter cartridge 3 inches long, communicates detonation to a similar cartridge spaced 1 inch end to end from it. Its power is 41% of that of blasting gelatine and it has a density of 1.15 gms./ml. at 20 lbs./sq. in. 5 ozs. when fired freely suspended in a gallery test fail to ignite a 9% by volume methane-air mixture.

An explosive of similar composition containing 37% sodium chloride finely milled into the mixture has a velocity of detonation of 2,000 metres/second, is not sensitive to a No. 3 commerical fulminate detonator, and in the form of a 1.25 inch diameter cartridge 3 inches long, fails to communicate detonation to a similar cartridge spaced 0.5 inch end to end from it. 6 ozs. when fired freely suspended in the gallery test fail to ignite a 9% by volume methane-air mixture.

Example 3

11 parts of trinitrotoluene are milled with 11 parts of ammonium nitrate for 10 minutes as in Example 2. 38 parts ammonium nitrate are added and the mixture milled for a further 20 minutes. The wheels of the mill are raised free of the mixture and 40 parts sodium chloride having a grist size so that all of it passes a 60 B. S. S. sieve and is retained on a 120 B. S. S. sieve are worked into the mixture by means of the plows.

The resulting explosive has a velocity of detonation of 2700 metres/second, is sensitive to a No. 3 commercial fulminate detonator, and in the form of a 1.25 inch diameter cartridge 3 inches long, communicates detonation to a similar cartridge 1.5 inches end to end from it. Its power is 39% blasting gelatine and it has a density of 1.15 gms./ml. at 20 lbs./sq. in. 5 ozs. when fired freely suspended in a gallery test failed to ignite a 9% by volume methane-air mixture.

An explosive of similar composition containing 40% sodium chloride in a finely milled state fails to propagate.

Example 4

11 parts of trinitrotoluene and 11 parts of ammonium nitrate are milled for 10 minutes. 38 parts ammonium nitrate and 20 parts sodium chloride are added and the mixture milled for a further 20 minutes. 20 parts sodium chloride having a grist size so that all of it passes a 16 B. S. S. sieve and is retained on a 60 B. S. S. sieve, are added and milling continued for a further 3 minutes by which time mixing is completed and little comminution of the sodium chloride has taken place.

The resulting explosive has a velocity of detonation of 2400 metres/second, is sensitive to a No. 3 commercial fulminate detonator and in the form of a 1.25 inch diameter cartridge 3 inches long communicates detonation to a similar cartridge spaced 1 inch end to end from it. Its power is 39% blasting gelatine and it has a density of 1.15 gms./ml. at 20 lbs./sq. in. 6 ozs. when fired freely suspended in the gallery test fail to ignite a 9% by volume methane-air mixture.

An explosive of similar composition containing 40% sodium chloride in finely divided form fails to propagate.

Example 5

5.6 parts of trinitrotoluene and 5.6 parts ammonium nitrate are milled for 10 minutes in an edge runner mill. 48.9 parts ammonium nitrate and 16.4 parts sodium chloride are added and milled for a further 20 minutes. 3.5 parts of woodmeal are then added and the mixture milled for a further 5 minutes. 20 parts of sodium chloride of a grist size so that all of it passes a 16 B. S. S. sieve and is retained on a 60 B. S. S. sieve are added and milling continued for a further 3 minutes by which time mixing is completed and little comminution of the sodium chloride has taken place.

The resulting explosive has a velocity of detonation of 2600 metres/second, is sensitive to a No. 2 commercial fulminate detonator and in the form of a 1.25 inch diameter cartridge 3 inches long communicates detonation to a similar cartridge spaced 1 inch end to end from it. Its power is 41% of that of blasting gelatine and it has a density of 0.98 gm./ml. at 20 lbs./sq. in. 6 ozs. when fired freely suspended in the gallery test fail to ignite a 9% by volume methane-air mixture.

An explosive of similar composition containing 36.4 parts sodium chloride in a finely divided form has a ve-

locity of detonation 2100 metres/second, is not sensitive to a No. 3 commercial fulminate detonator and in the form of a 1.25 inch cartridge 3 inches long communicates detonation to a similar cartridge spaced 0.5 inch end to end from it. 6 ozs. when fired freely suspended in the gallery test fail to ignite a 9% by volume methane-air mixture.

What we claim is:

1. A safety ammonium nitrate blasting explosive powder consisting essentially of about 5 to 12% by weight trinitrotoluene, about 28 to 65% by weight ammonium nitrate, and greater than 35% by weight sodium chloride, wherein the ammonium nitrate and trinitrotoluene consist of fine particles in intimate admixture and wherein at least 10% by weight of the sodium chloride is retainable on a 120 B. S. S. sieze and not more than 25% by weight of the sodium chloride passes a 120 B. S. S. sieve.

2. A safety ammonium nitrate blasting explosive powder as claimed in claim 1 and including not more than 4.5% by weight of inert fibre.

3. A safety ammonium nitrate blasting explosive powder as claimed in claim 1 wherein at least 10% of the sodium chloride passes a 120 B. S. S. sieve.

4. A safety ammonium nitrate blasting explosive powder as claimed in claim 1 wherein the composition contains 40% sodium chloride and at least 17.5% of the sodium chloride on the explosive is retainable on a 120 B. S. S. sieve.

5. A safety ammonium nitrate blasting explosive powder as claimed in claim 1 wherein all of the sodium chloride passes a 16 B. S. S. sieve.

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