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BLASTING EXPLOSIVE

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This invention relates to blasting explosives containing high percentages of ammonium nitrate, and more particularly to such explosives characterized by high density and high strength.

This case is a continuation in part of our copending application, Serial No. 612,383, filed May 19, 1932, and which has since matured into Patent No. 1,992,217.

An essential property of an explosive adapted for use in commercial blasting in hard rock is relatively high strength per unit of volume, inasmuch as the consumer is interested, for economic reasons, in concentrating the required energy in as small a drill hole as possible. High density in an explosive composition for this purpose is therefore a desirable attribute and contributes directly to this concentration of energy, since a given weight of the same composition will develop the same gas volume and exert its disruptive effects in a smaller volume bore-hole in the case of higher density explosive charges.

Explosives of high bulk strength which have been found heretofore to be most suitable for such types of commercial blasting have comprised the high grade straight and ammonia dynamites and the gelatin dynamites. The straight dynamites are high in nitroglycerin content (for example, 60% nitroglycerin content in the 60% grade), and are of relatively high density. The ammonia dynamites are similar to the straight dynamites in weight strength and density, ammonium nitrate being utilized to replace a portion of the nitroglycerin. A sufficient amount of nitroglycerin is present, however, to develop the complete explosive strength of the ammonium nitrate. The gelatin dynamites possess inherent high density characteristics, and have always been considered as the outstanding examples of explosives of high volume strength.

Such explosives as have just been described, however, have certain disadvantages. All are relatively high in cost and have the further objection and disadvantage of possessing headache-producing properties because of the substantial percentages of nitroglycerin present. Because of their nitroglycerin content, also, these dynamites are more sensitive to shock and rough handling than explosives would be that were substantially free from liquid nitric esters such as nitroglycerin.

Ammonium nitrate has heretofore been considered an extremely desirable explosive ingredient for the main portion of a commercial explosive, particularly because of its economic advantages, its high degree of insensitiveness to shock, even under conditions of rough handling, and because of its high explosive strength, when properly brought to detonation. Ammonium nitrate has been used in percentages up to about 80% in certain types of blasing explosives and in ammonia permissible dynamites together with about 10% nitroglycerin as a sensitizing agent. These ammonia permissibles have been low in density, for example 1.0 or less. Higher percentages of nitroglycerin produce ammonium nitrate explosives of higher density, but obviously at the expense of the ammonium nitrate.

Explosive compositions high in ammonium nitrate and of high density have been disclosed by Favier in his U. S. Patent 393,634, who suggested a mixture of ammonium nitrate with a waterproofing hydrocarbon, compressed to a high degree, to a density for example as high as 1.6. Such a compressed composition, in order to be detonated, required an auxiliary center-core primer throughout the entire length of the explosive charge, since the high density main explosive was insensitive to detonation with a commercial blasting cap, and furthermore the composition at such density would not propagate the explosive throughout the column, except with the presence of a continuous primer in contact therewith.

In our aforesaid copending application Serial No. 612,383, we have disclosed new types of explosives high in ammonium nitrate and having such a sensitiveness that they will propagate with high blasting efficiency provided they are produced and detonated in diameters having a cross-sectional area greater than approximately three (3) square inches.

We have now found that high ammonium nitrate explosives having the characteristics of the compositions of our said co-pending application, provided they have at the same time relatively high densities (1.1 to 1.3), will propagate with such high blasting efficiency that they can be used in quarry blasting where heretofore it has been necessary to use such high strength, high density explosives as 60% and 75% gelatin.

An object of our present invention is therefore a new and improved explosive containing a high percentage of ammonium nitrate, and characterized by relatively high density and high bulk strength. A further object is such an explosive that is substantially free from headache-producing properties. A further object is a high density ammonium nitrate explosive of a degree of sensitiveness such that the detonation, when once initiated, will, by the inherent characteristics of the explosive, be propagated throughout the charge without the aid of an auxiliary charge. A still further object of our invention is a high density explosive of the nature described herein, wherein the high density effect is induced without employing undesirably high pressures in producing the explosive. Additional advantages will become apparent as our invention is described more fully hereinafter.

These objects may be accomplished and the desired explosives produced in accordance with this invention by the use of high density compositions high in ammonium nitrate (for example, over 80% and preferably above 85%), together with a sensitizing ingredient. Our new explosives will preferably have a density above 1.10 and may have a density as high as 1.3, and in the case of explosives of low degree of sensitiveness, they will also preferably be made in predetermined diameters in excess of two (2) inches, so that the explosive column will have a cross-sectional area greater than approximately three (3) square inches. For explosives of relatively higher degree of sensitiveness the principle of high density may be applied not only to the relatively large diameter cartridges but also to smaller cartridges, such as, for example, 1¼ diameters or thereabouts.

The use of such high density explosives is particularly advantageous in cases where large diameter columns are employed and compositions are highly efficient in the large diameters that are not sufficiently sensitive to propagate the detonation wave, after it has once been initiated, in the smaller diameters of 1¼ inches and thereabouts.

With relatively insensitive explosives such as are disclosed in our aforesaid copending application Serial No. 612,383, we have found that it is not only safe but also economical to apply presses to raise the density to the desired and predetermined point. This is not true with such explosives as those containing nitroglycerin, nitrostarch, and similar sensitizing materials which may be sensitive to an ordinary commercial blasting cap. We have found that in the case of the latter compositions, as well as with the insensitive type of explosive, that exceptionally high density can be readily obtained by using selected size grains of nitrate of ammonia.

We have found that explosives made in accordance with the present invention are particularly effective when the high density is induced by a method not heretofore employed for such compositions. According to our preferred method, relatively high density is attained by the use of a predetermined blend of coarse and fine ammonium nitrate particles, the proportions and relative sizes being so chosen that the finer particles are distributed in the interstices of the coarse ones to fill a substantial proportion of the voids caused by the coarser particles.

The use of ammonium nitrate in the form of a predetermined blend of coarse and fine particles makes it possible to obtain densities higher than would result otherwise, without the use of excessive packing pressures. While various proportions of coarse and fine particles of varying degrees of fineness will give the results contemplated by our invention, we find it satisfactory to utilize blends of coarse particles such that substantially the greater amount is held on a 40-mesh screen and finer particles such that the greater part will pass a 60-mesh screen. Advantageous results are obtained using mixes of these two different granulations in the ratio of 80 to 20 parts of the coarse and 20 to 80 parts of the fine. A 50—50 blend of the two granulations gives a satisfactorily high apparent density, and we find that values considerably in excess of 1.10 for the finished explosive are readily obtained in this way.

Explosives made in accordance with our invention will not be limited to those insensitive to the action of a commercial blasting cap but under all conditions will be of sufficient sensitiveness to propagate the explosion completely throughout the explosive column, when detonation has once been initiated. The explosives therefore may in some instances be capable of detonation by means of a blasting cap. Even under such circumstances, it may be desirable to employ a priming cartridge of a high velocity dynamite of a greater degree of sensitiveness, for use with the blasting cap.

Explosives made according to our invention are particularly effective when packed in cartridges of large diameters. The attainment of high densities in such large diameter cartridges is particularly desirable, since heretofore this has been practically impossible except by pressing in blocks under excessively high pressures. To attain for cartridges of 3'' diameter the high densities obtained in the case of 1¼'' diameter cartridges, where a 25-lb. tamp is used, would require, for example, a tamp weighing approximately 150 lbs., a weight considered undesirably high from a safety point of view under most circumstances. The advantage resulting from our invention is apparent, therefore, since, by its application, densities heretofore obtainable in large diameters only by specially designed presses can be reached with tamping equipment now in actual use.

An effective and desirable density resulting from the use of a blend of coarse and fine grains of ammonium nitrate may be illustrated by the following tabulation:—

	1	2	3	4
Nitroglycerine	5.0	5.0	5.0	5.0
Coarse ammonium nitrate	91.5 (100%)	56.5 (60%)	35.0 (40%)	
Fine ammonium nitrate		35.0	56.5 (60%)	91.5 (100%)
Engine oil	3.0	3.0	3.0	3.0
Chalk	0.5	0.5	0.5	0.5
	100.0%	100.0%	100.0%	100.0%

The foregoing were obtained from ammonium nitrate giving the following screen analyses:

	Percent coarse	Percent fine
Held on 10-mesh screen	0.6	0.0
Passed 10, held on 14-mesh screen	9.6	0.4
Passed 14, held on 20-mesh screen	35.3	0.1
Passed 20, held on 28-mesh screen	30.1	0.6
Passed 28, held on 35-mesh screen	12.3	0.5
Passed 35, held on 65-mesh screen	8.0	19.4
Passed 65, held on 100-mesh screen	1.8	33.5
Passed 100-mesh screen	2.3	45.5
	100.0	100.0

The foregoing analyses may be summarized as follows:

	Percent coarse	Percent fine
Held on 35-mesh screen	87.9	1.6
Passed 35, held on 65-mesh screen	8.0	19.4
Passed 65-mesh screen	4.1	79.0
	100.0	100.0

It is to be understood that these are merely examples of ammonium nitrate of two commercial finenesses. Furthermore, other selected

coarse grains and selected fine grains may be blended. For example, coarse grains passing a 20-mesh screen and held on a 40-mesh screen may be blended with fine grains passing a 150-mesh screen. It will now be apparent from the detailed description of our invention that many other types of grains are available and their use will merely necessitate determining the optimum proportions suitable for obtaining high densities.

The foregoing compositions, when subjected to the same degree of hand tamping showed the following density and velocity characteristics:

	1	2	3	4
Ctgs./50 lbs.—2 x 8"	56	48	50	56
Ctgs./50 lbs.—4½" x 16"	5.31	4.39	4.59	5.30
Density of explosive	1.02	1.23	1.16	1.02
Velocity—m./sec. (2-inch diam.)	2170	3090	3640	3550

From the foregoing tabulation, the improvement resulting with respect to density, and consequently with respect to bulk strength, is apparent. This is particularly the case with Formula 2 for 4½ x 16" cartridges, where there is approximately a 20% increase in density and volume strength.

It is noteworthy that, even though an ammonium nitrate blend contains approximately 50% of coarse particles, the velocity of the composition is not lowered from that where all fine nitrate was used. We believe that this is due to the increase of density which tends to counterbalance the normal effects of coarse nitrate ammonia on velocity. The blending of powders of different degrees of fineness, therefore, can be applied to give the desired increase in density, without sacrifice of velocity, a property of explosives which is considered as fundamental.

An oxidizable ingredient is preferably included in order to utilize a portion of the excess oxygen in the ammonium nitrate and serve at least as a partial sensitizer of the ammonium nitrate.

The compositions to which our invention is applicable include all explosives comprised substantially of ammonium nitrate to which has been added oxidizable substances for the purpose of utilizing the excess oxygen in the ammonium nitrate and to so sensitize the mixture that it will propagate the detonation wave when once it is initiated. Carbon carriers, such as pulverized coal, engine oil, paraffin, high density meals, cornstarch, and like materials, in the proportions of 1 to 10%, may be used for the foregoing purposes. An additional sensitizing ingredient, which may be taken from the class of nitrated organic compounds, or from the powdered metals, may also be and preferably is included. As such a sensitizer we prefer to use a nitro-aromatic compound, such as nitrotoluene, or an aliphatic nitric ester such as nitroglycerin, and we find it satisfactory to use from 1 to 10% of such ingredient.

Since only a low percentage of liquid explosive ingredient is used in any case, the oxidizable substance need not be an absorbent material of low density, as is the case with the present nitroglycerin dynamites. In fact our invention contemplates the use of substantially non-absorbent and non-compressible combustibles of relatively high density, since a high density explosive is the desideratum.

We may, for example, apply our invention to compositions such as the following to produce products having superior properties and giving improved performance.

A	Percent	B	Percent
Nitroglycerin	5 to 10	Nitroglycerin	5.0
Ammonium nitrate	80 to 90	Ammonium nitrate	91.5
Coal, starch, etc	10 to 5	Petrol. oil, etc	3
		Chalk	0.5
C		D	
Dinitrotoluene	4.0	Dinitrotoluene	4.0
Ammonium nitrate	92.0	Ammonium nitrate	92.0
Coal	4.0	Paraffin	4.0

The dinitrotoluene-coal and the dinitrotoluene-paraffin compositions C and D may be compressed to densities of 1.1 to 1.3, using relatively high pressures, or such densities may be obtained by using lower pressures and the proper blends of coarse and fine grains of nitrate of ammonia. In either case we have found that, in large diameter cartridges, such explosives at relatively high densities give surprisingly high blasting efficiencies. With a density about 1.15 we have obtained blasting efficiencies equal to 60% gelatin dynamite, and with a density of 1.25 we have obtained blasting efficiencies equal to 75% gelatin dynamite. The foregoing compositions C and D will in general be insufficiently sensitive to be detonated by means of a blasting cap alone but will be sufficiently sensitive to propagate the explosion throughout a 4-inch column, for example, when such explosion has once been initiated by a satisfactory booster charge. One of the advantages of our invention lies in the fact that with a 50—50 blend of coarse and fine particles a density of 1.15 can be obtained with the use of a packing pressure of 130 pounds per square inch against a pressure of 640 pounds, necessary when only fine ammonium nitrate is used. This means not only increased safety in operations but also the ability to adapt present equipment to packing, rather than necessitating the design of new and larger presses for this purpose.

Compositions similar to A are cap-sensitive and composition B is on the border line between sensitiveness and insensitiveness to detonation by a commercial blasting cap. Whereas these explosives are hazardous to compress to high densities, yet they can be readily raised to densities of 1.2 to 1.3 by using blends of coarse and fine nitrate of ammonia and employing the ordinary safe methods of cartridging. At such densities these explosives have volumetric strength far exceeding that of low-nitroglycerin, high-ammonium nitrate explosives of the prior art.

It will be apparent to those skilled in the art that a great advantage results from the use of our high ammonium nitrate, high density explosive. Our invention finds wide application in cartridges of large diameters, that is at least 2 inches, and particularly in such operations as quarry blasting. We have found that these new high density explosives will give wholly unexpected blasting execution in operations where, as far as it is known to us, it has always been considered necessary to use high strength explosives of relatively high nitroglycerin contents. We are able, therefore, by means of our invention to replace, with compositions containing 85% or more of ammonium nitrate, such explosives as 60% straight or ammonia dynamites, and straight or ammonia gelatins up to and including 75% strength, a per-

formance which we believe has heretofore been impossible. The replacement of the formerly-used explosives is desirable not only from the economic point of view but also because of increased safety in handling, as well as improved performance. While the use of explosives high in ammonium nitrate might, under certain conditions, be undesirable because of their low water resistance, this disadvantage can be obviated by making use of suitable waterproof containers, or by protecting the compositions in other ways.

While our present invention is of particular value in the case of explosives containing the maximum of ammonium nitrate, the principle involved in using blends of ammonium nitrate to facilitate high density is broadly applicable to all explosives containing any appreciable proportion of ammonium nitrate. The higher the percentage of ammonium nitrate, the greater the effect on density produced by blending the different sized grains. There are numerous prior art explosives containing from 40 to 75% of ammonium nitrate and sensitized by such materials as nitroglycerin, nitrostarch, and trinitrotoluene, etc., in varying amounts. The use of blends of different sized grains of ammonium nitrate in these explosives for the purpose of producing explosive of relatively higher density or for the purpose of facilitating the attainment of good density of loading comes within the scope of our invention.

Though this invention is particularly applicable to explosives of large diameter, it will now be appreciated from the foregoing that the principles involved in the use of blends of coarse and fine ammonium nitrate are of value not solely to large diameter cartridges but is also applicable to the smaller diameters, such for example as the 1", 1⅛", 1¼", etc., size, where the composition is readily detonatable by a commercial blasting cap.

While we have indicated in the foregoing that certain of the objects of our invention can be accomplished by utilizing the ammonium nitrate in the forms of a blend of coarse and fine particles, our invention is not limited to compositions containing such blends. Our invention is applicable equally well to all high-strength, high density ammonium nitrate explosives, and preferably above 1.10 and not sufficiently high but that the propagation of the detonation throughout the length and breadth of the column is possible, unaided by other explosive means, when the detonation has once been initiated.

While we have also indicated in the foregoing that nitroglycerin is a desirable sensitizer for our high ammonium nitrate explosives, other aliphatic nitric esters are suitable for this purpose, such for example, as ethylene glycol-dinitrate, nitrostarch, pentaerythritol tetranitrate, and like compounds. Various aromatic nitrocompounds may also be used for like purposes. Where nitroglycerin is mentioned as sensitizing ingredient, this term is intended to include not only the compound of this name but also solutions in it of various freezing point depressants, such as ethylene glycol dinitrate, tetranitrate diglycerin, nitrated sugars, and others.

It will therefore be seen that among other things we have found that utilizing large diameters permits of blasting with explosives of lower sensitiveness than heretofore used or believed to be practical, and that these large diameters permit the use of higher density ammonium nitrate explosives which according to past practice either do not propagate detonation, or propagate only with low efficiency. We have also found that these relatively high density explosives have unusual blasting value, and that even with substantial amounts of coarse ammonium nitrate at the high density of 1.25 we can obtain unexpected high velocity and improved blasting strength. This is contrary to the teachings of the prior art that high density ammonium nitrate explosives are deficient in blasting strength. So far as we are aware, no relatively high density explosive comprised substantially of ammonium nitrate has ever been devised that on a volumetric basis will show equal blasting efficiency against 60% to 75% gelatin dynamite.

While we have disclosed various specific embodiments of our invention in the foregoing specification, it is to be understood that these are illustrative merely, and not as limitations.

We claim:

1. An ammonium nitrate blasting explosive charge characterized by high blasting strength and relatively high density, comprising a blend of relatively coarse and relatively fine particles of ammonium nitrate and a sensitizing agent, said fine particles filling a substantial proportion of the voids caused by the coarse particles.

2. An ammonium nitrate blasting explosive charge characterized by high blasting strength and relatively high density, and having a low degree of sensitiveness comprising a blend of relatively coarse and relatively fine particles of ammonium nitrate in which the fine particles substantially occupy the interstices between the coarser particles, and a sensitizer, said explosive charge having a cross-sectional area of not less than approximately three square inches.

3. A blasting explosive charge characterized by relatively high density and comprising a sensitizing ingredient and at least 85% of a blend of relatively coarse and relatively fine particles of ammonium nitrate, said fine particles filling a substantial proportion of the voids caused by the coarse particles.

4. An ammonium nitrate blasting explosive charge having an apparent density not lower than 1.10 and comprising at least 85% of relatively coarse and relatively fine particles of ammonium nitrate, said fine particles filling a substantial proportion of the voids caused by the coarse particles, 1 to 10% of an oxidizable ingredient, and 1 to 10% of an additional sensitizing ingredient.

5. The explosive of claim 4, in which the sensitizing ingredient comprises an aliphatic nitric ester.

6. The explosive of claim 4, in which the sensitizing ingredient comprises nitroglycerin.

7. The explosive of claim 4, in which the oxidizable ingredient comprises a relatively non-absorbent and non-compressible material.

8. The explosive of claim 4, in which the oxidizable ingredient comprises coal in finely divided condition.

9. The explosive of claim 4, in which the ammonium nitrate comprises a blend of particles sufficiently coarse to be held on a 40-mesh screen and of particles sufficiently fine to pass a 60-mesh screen, the coarse and the fine particles being present in the proportions of 80 to 20 parts and 20 to 80 parts respectively.

10. The explosive of claim 4, in which the cross-sectional area of the explosive is not less than approximately three square inches.

11. A blasting explosive charge comprising approximately 88% ammonium nitrate, 7% ground coal, and 5% nitroglycerin, the ammonium nitrate being present as a blend of particles sufficiently coarse to be held on a 40-mesh screen and of particles sufficiently fine to pass a 60-mesh screen, the coarse and the fine particles being in the proportion of 80 to 20 parts and 20 to 80 parts respectively, said explosive having an apparent density not lower than 1.10.

12. An ammonium nitrate blasting explosive charge characterized by high blasting strength, relatively high density, and a low degree of sensitiveness, said explosive charge comprising at least 85% of a blend of relatively coarse and relatively fine particles of ammonium nitrate, said fine particles filling a substantial proportion of the voids caused by the coarse particles, 1 to 10% of an oxidizable ingredient, and 1 to 10% of an additional sensitizing ingredient, said charge having a cross-sectional area of at least 3 square inches, a density not lower than 1.10, and a sensitiveness sufficient to propagate an explosion wave when once initiated, but insufficient to be initiated by means of a commercial blasting cap.

13. The composition of claim 12, in which said oxidizable ingredient comprises paraffin and said sensitizing ingredient comprises dinitrotoluene.

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