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AMMONIUM NITRATE EXPLOSIVE

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This invention relates to ammonium nitrate explosives and more particularly to such compositions having relatively low degrees of sensitiveness.

Commercial dynamites as manufactured heretofore have been compounded so as to have a sensitiveness such that they can be readily detonated by means of the usual blasting caps, and the common practice in blasting is to initiate the explosion of dynamites either by means of a No. 6 or a No. 8 blasting cap or by a length of Cordeau fuse.

These dynamites have, in general, proved very satisfactory in practical use. Their relatively high degree of sensitiveness, however, which makes it possible to detonate them readily, carries with it some definite disadvantages. Such dynamites have, for example, a decided sensitiveness to shock and friction and certain ones are very inflammable, so that a definite and recognized hazard is involved in their manufacture, transportation and use. Explosives sufficiently insensitive so that they are not capable of detonation by the ordinary means would have the advantage of increased safety in handling. This advantage would be of great practical value, particularly in quarry blasting, where large quantities of explosives are used in a single blast and where the number of men involved is considerable.

In the copending application of W. E. Kirst, J. W. McCoy, and C. A. Woodbury, Serial No. 599,592, filed March 17, 1932, a new method of blasting is described, involving the use of explosives capable of detonation by means of powerful booster charges but so insensitive that they cannot be detonated by ordinary means. It has been found that very insensitive explosives, especially in large diameters, can be made to propagate detonation with full efficiency under the condition of confinement afforded by the bore hole, provided an adequate booster charge is used for initiating the explosive and that the degree of insensitiveness of the main explosive is regulated within definite limits.

The object of our invention is to provide explosives of increased safety because of their greatly reduced degree of sensitiveness. A further object is such an explosive, containing ammonium nitrate as the principal ingredient. A still further object is to provide explosives of the kind described that cannot be exploded by the ordinary blasting caps, but that can be used satisfactorily in many blasting operations when primed with an adequate booster charge of explosive.

According to our invention, the foregoing objects are accomplished by the use of ammonium nitrate as the principal explosive ingredient. While ammonium nitrate by itself might be entirely satisfactory as a blasting explosive, from the point of view of potential strength and execution, it is too insensitive for use. Under such circumstances it would be difficult to initiate, and, in the diameters used in blasting work, would not propagate the explosion throughout the length of the column, even if initiation were started. It is necessary, therefore, to employ one or more properly chosen sensitizing agents with the ammonium nitrate.

We find various compounds available and satisfactory for use as such sensitizing materials, and we find it desirable to use a material capable of utilizing the excess oxygen of the ammonium nitrate, with the simultaneous generation of heat thereby adding to the explosive effect. As such agents we may use oxidizable inorganic elements or compounds, for example aluminum, magnesium, selenium, sulphur, and inorganic sulphides, carbides, ferro-silicon or other silicides, and the like. We prefer, however, to employ organic fuels as sensitizing agent. In such capacity, we may use fuels containing oxygen, for example, various alcohols such as amyl alcohol, ethylene glycol, glycerin and the like, aldehydes, ketones and carbohydrates, of which sugars, starch and cellulose are examples. We may use also fuels containing no oxygen, and consisting of carbon or compounds of carbon and hydrogen. As examples of satisfactory fuels of this class, we may cite various forms of carbon, hydrocarbons, and the like. We prefer, however, to use coal as a fuel with ammonium nitrate. We find a satisfactory composition to result when the relative proportions are selected of 92–95% ammonium nitrate and 5–8 parts of coal. For such use, the ingredients of this mixture should be thoroughly incorporated so that there is intimate contact between the particles of the two ingredients.

An additional class of compounds that give the desired results with ammonium nitrate is the one comprising the various nitro derivatives of the aromatic series. Many such nitrocompounds are available, having varying degrees of sensitiveness and sensitizing effects. In general, it may be said that the greater the number of nitro groups and the higher the nitrogen content in such compounds, the greater is the sensitizing

value. As examples of desirable mononitro compounds, we may cite the derivatives of benzene, toluene, xylene, naphthalene, phenol, and the like. Similarly, the dinitro derivatives of the same compounds may be used, and these will generally show a correspondingly greater sensitizing value than the mononitro derivatives. The trinitrocompounds of the same materials have an even greater sensitizing effect, and under certain conditions these may impart to the explosive composition containing ammonium nitrate a sensitiveness greater than is desired. It may be so great, in fact, that the explosive will be rendered sufficiently sensitive to detonate under the influence of an ordinary commercial blasting cap, in which case the composition is outside the scope of our invention.

While any of the above mentioned nitrocompounds, and others which are not named, are suitable for use, having varying contents of nitrogen, we find the nitrotoluenes the most generally satisfactory, and preferably use mononitrotoluene.

While desirable results are obtained by the use of compositions containing a nitrocompound of the aromatic series as the sensitizer for ammonium nitrate, we find the best results to be obtained by the use, with the nitrocompound, of an additional sensitizer consisting of a fuel or a material capable of utilizing the excess oxygen of the ammonium nitrate, with generation of heat. While various fuels may be chosen from those listed heretofore as satisfactory for use with ammonium nitrate, we prefer to employ an organic hydrocarbon, of which class the various aliphatic members of the paraffin and the olefin series are represented as well as the aromatic hydrocarbons. Preferably, we use the solid compound known as paraffin, since this has the desired requisites of chemical and physical form and properties, and is economically available.

The employment of the ingredients described in the preceding makes it possible to control the sensitiveness to the desired degree by various adjustments. The sensitiveness may be varied by the use of one or more different nitrocompounds of varying degrees of nitration. It may be controlled, also, by varying the proportions of nitrocompound or compounds and paraffin hydrocarbon, since the hydrocarbon has a smaller sensitizing effect than even a mononitrocompound.

A further very effective means of adjusting the sensitiveness of our explosive comprises the control of the fineness of the grains of ammonium nitrate employed. For example, if ammonium nitrate is used having a fineness such that over 50% will pass a 40-mesh screen, with at least 25% passing a 100-mesh screen, the sensitiveness of the finished explosive, other things being equal, will be greater than if the finess is such that the greater part of the material is held on a 40-mesh screen. Using the finer grade ammonium nitrate just described, a less sensitive nitrocompound, or a relatively greater proportion of hydrocarbon to the amount of nitrocompound, may be used than when the coarser grade is employed, while still obtaining the same sensitiveness in the finished explosive. In a similar way, if the finer ammonium nitrate is used, a higher density explosive is possible with the same degree of sensitiveness for the finished explosive. Wider variations in fineness than those just cited have a still greater effect on sensitiveness, and on the proportions and kinds of sensitizers necessary.

The strength of the explosive may be decreased, if desired, and the oxygen balance varied, by substitution for a portion of the ammonium nitrate of sodium nitrate or other non-explosive oxidizing agent.

While the fineness of the ammonium nitrate has an important effect on the sensitiveness of the explosive composition, an additional controlling factor is the fineness of the sensitizing agent and the thoroughness of the incorporation of the oxidizing and reducing ingredients. This is particularly true in the case of compositions containing ammonium nitrate and solid organic fuels, such as coal or other similar carbon compounds.

While various compositions may be used with satisfacory results for our explosives, we find the following formulas satisfactory:

	I	II	III
	Per cent	*Per cent*	*Per cent*
Ammonium nitrate	92.0	91.3	70.0
Sodium nitrate			20.0
Dinitrotoluene	4.0		
Nitrobenzene		6.5	6.5
Paraffin	4.0		3.5
Fuel oil		2.2	

The foregoing compositions have different properties, depending on the several possible variables. Using a formula such as I, we prefer to pack it to a density of 1.15. Likewise, while various grades of ammonium nitrate may be used with respect to fineness, we preferably employ ammonium nitrate having a fineness such that not more than 20% will be held on a 40-mesh screen, while not less than 25% will pass a 100-mesh screen. Under such conditions, when the explosive is properly primed and shot unconfined in cartridges, 5 inches in diameter and 16 inches in length, it will have a velocity approximating 5,000 meters per second. Its sensitiveness should be such that, when unconfined, it is incapable of detonation by a No. 8 blasting cap, but is capable of detonation by means of 1,000 grams of trinitrotoluene at a density of 0.95, or by various commercial explosives of high velocity in general use. As a matter of fact our explosive compositions will fail to detonate with several No. 8 caps fired simultaneously, or even a No. 9 or a No. 10 cap. It is apparent, therefore, that the sensitiveness of the composition is far below that necessary to detonate consistently with a single commercial blasting cap of maximum strength. Such an explosive is entirely satisfactory, therefore, for use in commercial blasting operations, when primed by a suitable booster charge of high explosive.

It is known that the density of ammonium nitrate explosives has a considerable effect on the sensitiveness. For example, Marshall in his book on "Explosives", v. I, p. 389, gives data showing this fact for an explosive comprising 90% ammonium nitrate and 10% mononitronaphthalene. Whereas such an explosive at a density of 0.9 can be detonated by 0.4 grams of mercury fulminate, the same explosive at a density of 1.2 requires a charge of 5 grams of fulminate for its detonation. Our invention, however, does not comprise the control of the sensitiveness of the explosive by variation of the density. We select the density desired for the explosive, depending on the bulk strength necessary, and bring about the proper degree of sensitiveness by adjustment of variables other than the density. Our explosive, for example, will be incapable of detonation even by a No. 8 cap at densities of 1.0, at which density the explosive cited by Marshall explodes with a charge of 1 gram of mercury

fulminate, which is the amount contained in the ordinary No. 6 blasting cap.

The density of the majority of ammonium nitrate explosives rarely exceeds 1.0, except as the explosive is subjected to considerable pressure, and compressed explosives of this type, when crushed to a loose powder, readily attain such a density. Therefore, a density of 1.0 affords a convenient standard of comparison. Furthermore, it is desirable that an explosive be difficult to detonate at the densities which might be readily encountered in use.

The compositions according to our invention will, in all cases, have ammonium nitrate as the principal ingredient, and in amounts of over 50% of the finished explosive. Preferably the ammonium nitrate content will constitute more than 85% of the composition. The amounts of nitrocompounds of the aromatic series and of paraffin hydrocarbon will vary according to the other factors involved, but will in all cases be within the ranges of 0.5 to 10.0% for each of these ingredients. If the ammonium nitrate content falls greatly below 85%, other explosive compounds may be used to make up the deficiency, for example one of the perchlorates. Such compounds, however, must not be present in amounts that will throw our explosive outside of the prescribed sensitiveness limits. Sodium nitrate may also be present under such conditions as a substitution for a portion of the ammonium nitrate, with a corresponding reduction of the strength of the explosive.

The explosive compositions described in the foregoing are not adapted for use in blasting operations, except as they are employed in combination with a booster charge of high explosive, as described in the co-pending application of Kirst, McCoy and Woodbury, indicating that the column or mass of explosive should have a cross-sectional area preferably equal to or greater than that of a two-inch circle or about 3 square inches.

This method involves the use of main charges of explosives having a degree of sensitiveness within definite limits. These limits state that the explosive, when unconfined, should be incapable of detonation by means of a commercial No. 8 blasting cap, but capable of detonation and propagation when primed with 1,000 grams of trinitrotoluene as hereinafter described.

It has been found that explosives of the above sensitiveness can be made to detonate and propagate continuously with full efficiency when loaded into drill holes and primed with one or more booster charges of a more readily detonated explosive, for example one of the higher grades of nitroglycerin or nitrostarch dynamites.

The sensitiveness of the explosives, according to our invention, may be determined according to the following test in which a single paper-wrapped 4½ x 8" cartridge of the explosive to be tested is placed vertically on a cylindrical lead test block, 2¼" in diameter and 4" long, supported on a steel plate, and brought to detonation. The primer to be used has the same diameter as the explosive under test, namely, 4½" and consists of trinitrotoluene compressed to a density of 0.95.

The specific procedure consists in determining the minimum amount of said primer, enclosed in a paper wrapper, which will cause the insensitive explosive under test to detonate and propagate consistently throughout the entire length of 8 inches and give a definite compression of the test block. The compression of the lead block will vary greatly, and will depend both on the completeness of the propagation and on the velocity of detonation of the test explosive. Using the above procedure, it is necessary that the explosive be brought to detonation and produce a definite compression by not more than 1,000 grams of trinitrotoluene, in order that it may fall within the sensitiveness limits prescribed by our invention.

The same test procedure may be employed when determining the ability to detonate by means of a No. 8 cap, with the exception that the cap is inserted directly in the explosive.

We are aware that combinations of ammonium nitrate with various sensitizing agents have been used as explosives heretofore. For example, the well known Favier explosives described in U. S. Patent 393,634 are of this type. The Favier explosives consisted of compressed cylinders of dense material, having a hollow core. The high density portion was so insensitive that it could not be made to detonate and propagate explosion with a contact primer at the end of a solid column, whatever the amount of primer. This made necessary the provision of a central core which had to be filled with a cap-sensitive explosive, so that the entire length of charge could be subjected to the influence of a powerful booster. The more sensitive explosive used by Favier for filling the hollow center and which detonated readily with an ordinary blasting cap was therefore an essential part of the whole explosive assembly, and the hazard connected with its use was determined by the sensitiveness of this more sensitive part.

The explosives covered by our invention are so regulated in sensitiveness that they do not require a sensitive primer throughout the entire length of the main explosive charge, and therefore they constitute a definite improvement with respect to safety.

Various so-called "safety explosives" with an ammonium nitrate base have been used in blasting, particularly in coal mining. As illustrations of such compositions may be mentioned Bellite, Ammonite, Roburite, Securite, and many others. All of these, however, can be and in practice are detonated by means of blasting caps. Because of their sensitiveness, therefore, these explosives are outside the scope of the present invention.

While we have described several embodiments in detail in the foregoing, other embodiments will now be apparent within the scope of our invention. It is, therefore, to be understood that we do not intend to be limited in our invention except as indicated in the following patent claims.

We claim:

1. A blasting explosive containing ammonium nitrate as the principal ingredient and at least one sensitizing agent, the fineness and intimacy of contact of the constituents being so controlled that the detonation of the explosive and its propagation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

2. A blasting explosive containing ammonium nitrate as the principal ingredient and at least one sensitizing material capable of utilizing the excess oxygen of the ammonium nitrate with generation of heat, the fineness and intimacy of contact of the constituents being so controlled that the detonation of the explosive and its prop-

agation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

3. A blasting explosive containing ammonium nitrate as the principal ingredient and an organic fuel as sensitizing agent, the fineness and intimacy of contact of the constituents being so controlled that the detonation of the explosive and its propagation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

4. A blasting explosive containing ammonium nitrate as the principal ingredient and finely divided coal as sensitizing agent, the fineness and intimacy of contact of said constituents being so controlled that the detonation of the explosive and its propagation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

5. A blasting explosive comprising 92 to 95% ammonium nitrate and 5 to 8% finely divided coal, the fineness and intimacy of contact of said constituents being so controlled that the detonation of the explosive and its propagation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

6. A blasting explosive containing ammonium nitrate as the principal ingredient and at least one nitrocompound of the aromatic series, the fineness and intimacy of contact of the constituents and the sensitizing power of the nitrocompound being so controlled that the detonation of the explosive and its propagation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

7. A blasting explosive containing ammonium nitrate as the principal ingredient and mononitrotoluene as a sensitizing ingredient, the fineness and intimacy of contact of the constituents being so controlled that the detonation of the explosive and its propagation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

8. A blasting explosive containing more than 50% ammonium nitrate, at least one nitrocompound of the aromatic series, and a material capable of utilizing the excess oxygen of the ammonium nitrate with generation of heat, the fineness of the ammonium nitrate and the proportion of the nitrocompound to the oxidizable material being so controlled that the detonation of the explosive and its propagation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

9. A blasting explosive containing more than 50% ammonium nitrate, at least one nitrocompound of the aromatic series, and an organic fuel, the fineness of the ammonium nitrate and the proportion of nitrocompound to the fuel being so controlled that the detonation of the explosive and its propagation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

10. A blasting explosive containing more than 50% ammonium nitrate, at least one nitrocompound of the aromatic series and a hydrocarbon, the fineness of the ammonium nitrate and the proportion of the nitrocompound to the hydrocarbon being so controlled that the detonation of the explosive and its propagation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

11. A blasting explosive containing more than 50% ammonium nitrate, at least one nitrocompound of the aromatic series, and a paraffin hydrocarbon, the fineness of the ammonium nitrate and the proportion of nitrocompound to the hydrocarbon being so controlled that the detonation of the explosive and its propagation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

12. A blasting explosive containing more than 50% ammonium nitrate, a nitrotoluene, and a paraffin hydrocarbon, the fineness of the ammonium nitrate and the proportion of nitrotoluene to hydrocarbon being so controlled that the detonation of the explosive and its propagation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

13. A blasting explosive containing more than 50% ammonium nitrate, dinitrotoluene, and a paraffin hydrocarbon, the fineness of the ammonium nitrate and the proportion of dinitrotoluene to the hydrocarbon being so controlled that the detonation of the explosive and its propagation, when unconfined and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

14. A blasting explosive containing more than 85% ammonium nitrate, 0.5 to 10.0% of at least one nitrated aromatic hydrocarbon, and 0.5 to 10.0% of a paraffin hydrocarbon, the fineness of the ammonium nitrate and the proportion of nitrated hydrocarbon to paraffin hydrocarbon being so controlled that the detonation of the explosive and its propagation, when unconfined

and at a density of 1.0, requires a detonating impulse substantially greater than that from any commercial detonator but not in excess of 1000 grams of TNT at a density of .95, said explosive having a cross-sectional area of at least about 3 square inches.

15. A blasting explosive according to claim 14, in which the ammonium nitrate used is of a fineness such that not less than 25% will pass a 100-mesh screen.

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