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EXPLOSIVE

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This invention relates to explosive compositions modified from the standard types of nitroglycerin explosives and more particularly to such explosives that have a relatively low degree of sensitiveness.

Most of the commercial dynamites in general use at the present time contain nitroglycerin as the principal explosive ingredient. In some of these explosives, the nitroglycerin content has been replaced in part by ammonium nitrate. This exchange gives an economic advantage without sacrificing explosive strength, since the ammonium nitrate is sensitized by the amount of nitroglycerin present, and therefore develops satisfactory strength.

In another type of explosives in common use, the gelatin dynamites, the nitroglycerin has been gelatinized by the solution in it of a small amount of nitrocellulose. In this way a plastic explosive is obtained which has many advantages over the ungelatinized explosive, particularly with respect to increased density and improved water resistance. In these gelatin dynamites, as in the non-gelatinous explosives, a portion of the nitroglycerin may be replaced by ammonium nitrate, if desired, in which case ammonia gelatins are obtained.

The explosives described in the foregoing, as containing nitroglycerin as the explosive ingredient and no ammonium nitrate, are commonly termed straight dynamites. Similarly those explosives, in which a portion of the nitroglycerin has been replaced by ammonium nitrate, are termed ammonia dynamites. The gelatin dynamites are classified in the same way as straight gelatins and ammonia gelatins.

All the foregoing types of dynamites are in general use in large quantities, and their properties are well understood and standardized. Such explosives have proved very satisfactory in practical use, and are commonly brought to explosion by means of the usual blasting caps, that is by No. 6 or No. 8 caps. These two grades of standard caps are defined in Bulletin 59 of the United States Bureau of Mines which specifies that No. 6 and No. 8 caps shall contain the equivalents of one and two grams of mercury fulminate or fulminate composition respectively. As a matter of fact, if the standard explosives in common use are not sensitive to the ordinary blasting caps, and capable of being consistently detonated thereby, they are considered altogether unsatisfactory for use in blasting operations, since misfires and failures bring increased hazards in removing the unexploded charge.

An object of our invention is to provide explosives so modified from the standard types of nitroglycerin explosives that they have a greatly reduced degree of sensitiveness. A further object is to provide explosives which are incapable of

detonation by ordinary means, but may be detonated by an adequate booster, thereby providing greatly increased safety in the manufacture and use of blasting explosives. A still further object of our invention is to bring about the above decreased sensitiveness by a replacement of a portion of the nitroglycerin in the explosive by less sensitive and less expensive ingredients. Further objects will appear as the description of our invention proceeds.

We have found that these objects may be accomplished by a replacement of a substantial portion of the nitroglycerin present in the explosive by an amount of a relatively insensitive organic compound, soluble in the nitroglycerin, and preferably a nitrocompound of the aromatic series, sufficient to render the finished explosive incapable of detonation by ordinary means, such as mechanical shock, friction, and in fact by the strongest commercial detonator. The explosive must, however, be sufficiently sensitive so that it is capable of detonation by means of a proper amount of a high explosive booster charge. We have found that this degree of insensitiveness can be obtained without detracting from the practical value of such explosives provided the detonation of the explosive is brought about by means of an adequate booster charge of other high explosives. In other words, we have found that nitroglycerin explosives, desensitized, as above described, will detonate and propagate with full efficiency provided the detonation is initiated with an adequate booster.

The fact that such an explosive can not be detonated by means of commercial blasting caps would ordinarily be considered a disadvantage. It is apparent upon further consideration, however, that the less sensitive an explosive can be, and yet be satisfactory for use, the greater are the resulting advantages, particularly with respect to safety in handling. Many additional advantages in favor of low sensitiveness will be readily apparent to those skilled in the art of explosives and their manufacture.

In producing compositions according to our invention, we may start with explosives similar to the usual commercial dynamites. If a straight dynamite is chosen and a sufficient amount of an aromatic nitrocompound, for example mononitrotoluene, is introduced into the composition, while at the same time a portion of the nitroglycerin content is replaced, an explosive is obtained which is sufficiently insensitive that, while it will not detonate by a force equivalent to that of a No. 8 cap, it can be made to do so by means of an adequate booster. Since the straight dynamites are initially very sensitive, a relatively insensitive nitrocompound must be used, since we have found that the desensitizing effects of such compounds are in inverse ratio to their nitrogen

contents. If desired, other agents having a greater desensitizing power may be included with the nitrocompound, for example, a paraffin hydrocarbon such as petroleum jelly. Under these conditions the choice of the nitrocompound is not so limited with respect to the nitrogen content.

In a similar manner, the usual ammonia dynamite formulas can be brought to a low degree of sensitiveness by the replacement of a portion of the nitroglycerin by the proper amount of a nitrocompound of the aromatic series. Since the ammonia dynamites are in general less sensitive than the straight dynamites, a lesser amount of nitrocompound is sufficient to desensitize the compositions to the point where the explosive requires a booster charge for its detonation. While we have indicated above the addition of mononitrotoluene, in the case of straight dynamites, the more highly nitrated derivatives may be used as well, for example, dinitrotoluene and trinitrotoluene. Commercial trinitrotoluene, however, has in general very little desensitizing effect, because of its more highly nitrated condition, and for this reason would be satisfactory only in explosives with relatively low initial sensitiveness, or in combination with other compounds of lower degree of sensitiveness, or having a tendency to liquefy the trinitrotoluene.

The sensitiveness of both straight and ammonia gelatins may be likewise reduced by a replacement of a substantial portion of their nitroglycerin content by a nitrocompound of the aromatic series, and we find the application of our invention particularly advantageous in the case of the ammonia gelatins.

As representative examples of explosive compositions that may be used as the starting point in the preparation of explosives according to our invention, the following are given as illustrative:

	20% straight dynamite	40% ammonia dynamite	40% straight gelatin	40% ammonia gelatin
	Percent	Percent	Percent	Percent
Nitroglycerin.....	20.0	13.0	32.0	25.0
Nitrocotton.....			1.0	0.6
Ammonium nitrate.....		37.0		9.0
Sodium nitrate.....	62.0	38.0	53.0	52.0
Carbonaceous combustible material.....	15.0	10.0	13.0	12.4
Calcium carbonate.....	3.0	2.0	1.0	1.0

If it is desired, for example, to produce a modified 40.0% ammonia dynamite by the replacement of a portion of the nitroglycerin by a suitable nitrocompound, it will be found that the amount of replacement necessary to yield an explosive insensitive to commercial blasting caps will depend on the nitrocompound used, and particularly on its sensitiveness. With trinitrotoluene, for example, practically a 90% replacement is necessary to give the desired results. With dinitrotoluene on the other hand, a replacement of approximately 75% will give the same result. With mononitrotoluene and nitrobenzene, the replacements necessary will be approximately 50.0% and 55% respectively.

When explosives, on the other hand, are produced on a modified formula for 40% ammonia gelatin, by replacement of a portion of the nitroglycerin by a nitrocompound, it is found that, when trinitrotoluene is used, even 100% replacement of the nitroglycerin does not desensitize the explosive to the point where a booster charge is required. Furthermore, the limited solubility of trinitrotoluene in nitroglycerin renders it not well

adapted for this purpose except as other nitrocompounds are combined with it, to give a substantially liquid product, when combined with the small amount of residual nitroglycerin in the explosive. Solid nitrocompounds of the aromatic series when used alone are not well adapted for replacing the nitroglycerin in our new explosives of the nitroglycerin type, as will be shown later. In the case of dinitrotoluene, approximately a 55% replacement gives the sensitiveness desired, while with mononitrotoluene and nitrobenzene, a replacement of an amount of nitroglycerin slightly less than 50% of that present is sufficient to give the desired result.

While various compositions of explosives are satisfactory according to our invention, the following may be given as further illustrating specific embodiments thereof:

	Modified 40% ammonia dynamite	Modified 40% ammonia gelatin	Modified 60% ammonia gelatin
	Percent	Percent	Percent
Nitroglycerin.....	6.5	11.25	5.0
Mononitrotoluene.....	6.5		24.0
Dinitrotoluene (liquid).....		13.75	
Nitrobenzene.....		0.5	0.7
Nitrocotton.....		20.0	41.6
Ammonium nitrate.....	41.4	54.2	28.7
Sodium nitrate.....	36.2		
Carbonaceous combustible.....	2.4		
Sulphur.....	6.0	0.3	
Chalk.....	1.0		

The so-called straight dynamites and gelatins may be altered to reduce their initial sensitiveness to the desired degree in a substantially similar manner.

The amount of nitrocompound that should be used to give the most advantageous results is dependent on several factors, for example the type of dynamite in which the replacement of the nitroglycerin is made, the density of the dynamite, and the desensitizing power of the nitrocompound. In the examples given it will be understood that the density is that normal to the standard nitroglycerin explosives.

Many different nitrocompounds of the aromatic series are available for use according to our invention, the choice of compound depending largely on the type of dynamite in which the nitrocompound is to be substituted and on the degree of sensitiveness of the original explosive.

As we have indicated in the foregoing, the desensitizing effect of the nitrocompound is in general inversely proportional to the number of nitrogroups present and to the nitrogen content. As examples of mono-nitrocompounds may be mentioned the mono-nitro derivatives of benzene, toluene, xylene, naphthalene, phenol, and the like. Similarly, the corresponding di-nitrocompounds may be used with relatively less desensitizing effect than in the case of the mono-nitrocompounds. Furthermore, certain of the corresponding trinitro derivatives may be employed, particularly those of toluene, xylene, and naphthalene. With such nitrated materials, however, the desensitizing effect is slight and it may be desirable to employ simultaneously a stronger desensitizing compound, such as a paraffin hydrocarbon or a nitrocompound of low sensitiveness, such for example as nitrobenzene, or mononitrotoluene.

We are aware that nitrocompounds of the aromatic series have been used heretofore with nitroglycerin as freezing point depressants, in

which case there has doubtless been a slight decrease in the sensitiveness of the explosive. Such explosives, however, containing nitrocompounds such as nitrotoluenes, nitroxyls, and the like, have always had a nitroglycerin replacement so small that the explosive remained readily sensitive to the influence of the ordinary commercial blasting caps. According to our invention, however, the proportion of nitrocompound and nitroglycerin will in general be such that the amount of nitrocompound will at least be equal to that of the nitroglycerin.

Heretofore, in the replacement of nitroglycerin by nitrocompounds, it has been immaterial whether such nitrocompounds were liquid or solid, since a relatively small amount was used, which was readily soluble in the nitroglycerin. According to our invention, however, in the replacement of nitroglycerin in the gelatin type of dynamite, it is important that the kind and amount of nitrocompound be such that the combination of nitroglycerin and nitrocompound be substantially liquid at ordinary room temperatures, in order that satisfactory plasticity and gelatinization may result with the nitrocotton. Whereas in explosive compositions according to the prior art, the nitrocompound has been employed to depress the freezing point of the nitroglycerin, the replacement of nitroglycerin, according to our invention, is such that the nitroglycerin substantially depresses the freezing point of the nitrocompound.

Since it is important, in the case of gelatinous explosives, that the combination of nitroglycerin and nitrocompound be substantially liquid at ordinary room temperatures, the nitrocompound for use, or the mixtures of nitrocompounds, should be so chosen that a liquid combination results. For example, nitroglycerin and liquid mono-nitrocompounds of the aromatic series are miscible in all proportions and give liquid combinations. Likewise, nitroglycerin gives liquid combinations in practically all proportions with the so-called liquid dinitrotoluene, which is a product obtained in the refining of the mixed isomers of dinitrotoluene, which result from the direct nitration of toluene. If solid dinitrotoluene and trinitrotoluene are employed with nitroglycerin, sufficient of the mono-nitrocompound may be desirable to ensure a liquid product.

Whereas we have described our invention as particularly applicable to compounds having incorporated therein nitroaromatic compounds, other organic compounds which are substantially soluble in nitroglycerin may be similarly used, such as ketones, ethers, primary alcohols, polyhydric alcohols, amino compounds, acetic esters, and the like. These may be employed either alone or combined with the nitroaromatic compounds. Some of the organic liquids suitable for our purpose find particular value in facilitating the production of a nitroglycerin-nitroaromatic combination that will be liquid even at very low temperatures, such as prevail in winter through their mutual solvent action on both the nitroglycerin and nitroaromatic compounds.

We are aware that nitrocompounds of the aromatic series have been used heretofore in explosives containing substantial amounts of chlorates and perchlorates, in the presence of relatively small amounts of nitroglycerin. Such explosives are beyond the scope of our invention, however, since they are relatively sensitive by reason of the chlorate or perchlorate content, and are readily detonated by the ordinary com-

mercial blasting caps and are fired in this manner.

The explosive compositions in accordance with the present invention are not adapted for use in blasting operations except in columns or masses having a diameter equal to or greater than that of a two-inch circle, or a cross-sectional area of approximately three square inches, and employed in combination with a booster charge of high explosive, all as described in the co-pending application of Kirst, McCoy and Woodbury, Serial No. 599,592, filed March 17, 1932. We have found that such compositions are not sufficiently sensitive when used in masses having dimensions less than those specified in the foregoing to propagate satisfactorily and with certainty.

The method of blasting to be used with these explosives involves the use of main charges of explosives having a degree of insensitiveness within definite limits. These limits state that the explosive, when unconfined, shall be incapable of detonation by means of a commercial No. 8 blasting cap, but capable of detonation and propagation when primed with 1000 grams of trinitrotoluene or the equivalent thereof, 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 commercial grades of nitroglycerine or nitrostarch dynamites. In order that the proper sensitiveness may be obtained, the explosive must not be too insensitive. In the case of the compositions cited heretofore, the replacement of the nitroglycerine by nitrocompounds of the aromatic series must not be carried to a point where the compositions can not be detonated by means of 1000 grams of trinitrotoluene.

The sensitiveness of the explosives according to our invention may be determined by the following test, in which a single paper-wrapped $4\frac{1}{2} \times 8$ " cartridge of the explosive to be tested is placed vertically on a cylindrical lead test block, $2\frac{1}{4}$ " 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 $4\frac{1}{2}$ ", 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 lead test block. The compression of the lead block will vary widely, 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 1000 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.

Our insensitive explosives are particularly desirable for use in quarry blasting where large quantities of explosives are consumed in a single

blast and where the number of men engaged in the operations is usually very great.

While we have described our explosives as comprising dynamite compositions in which a portion of the nitroglycerin has been replaced by nitrocompounds of the aromatic series, we wish to include not only nitroglycerin itself but liquid nitric esters generally, and particularly those compounds which have been used heretofore as dissolved freezing point depressants of the nitroglycerin, namely ethylene glycol dinitrate, nitrochlorhydrins, nitrated polymerized glycerin, ethyl nitrate, and the like.

While we have described many specific embodiments of our invention in the foregoing, it is to be understood that we intend to be limited in our invention only as indicated in the following patent claims.

We claim:

1. An explosive comprising a liquid nitric ester and at least one nitrocompound of the aromatic series, the relative amounts of said ingredients being so proportioned that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

2. An explosive comprising a nitroglycerin dynamite in which a portion of the nitroglycerin has been replaced by at least one nitrocompound of the aromatic series, the relative amounts of said ingredients being so proportioned that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

3. An explosive of the straight dynamite type in which a portion of the nitroglycerin has been replaced by at least one nitrocompound of the aromatic series, the relative amounts of said ingredients being so proportioned that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

4. An explosive of the ammonia dynamite type in which a portion of the nitroglycerin has been replaced by at least one nitrocompound of the aromatic series, the relative amounts of said ingredients being so proportioned that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

5. An explosive of the gelatin dynamite type in which a portion of the nitroglycerin has been replaced by at least one nitrocompound of the aromatic series, the relative amounts of said ingredients being so proportioned that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

6. A gelatin dynamite comprising nitroglycerin, nitrocotton, ammonium nitrate and at least one nitrocompound of the aromatic series, said nitrocompound being present with the nitroglycerin in such proportions that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that

from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

7. A gelatin dynamite comprising nitroglycerin, nitrocotton, ammonium nitrate and at least one nitrocompound of the aromatic series, the relative amounts of said nitrocompound and nitroglycerin being so proportioned that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

8. An explosive of the gelatin dynamite type in which a portion of the nitroglycerin has been replaced by a nitrotoluene, the relative amounts of nitrotoluene and nitroglycerin being so proportioned that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

9. A gelatin dynamite comprising nitroglycerin, nitrocotton, ammonium nitrate and a dinitrotoluene, said dinitrotoluene being present with the nitroglycerin in such proportions that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

10. A gelatin dynamite comprising nitroglycerin, nitrocotton, ammonium nitrate and a dinitrotoluene, the relative amounts of the dinitrotoluene and the nitroglycerin being so proportioned that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

11. A gelatin dynamite comprising between 3 and 10 per cent. nitroglycerin, nitrocotton, ammonium nitrate and at least one nitrocompound of the aromatic series, said nitrocompound being present with the nitroglycerin in such proportions that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

12. A gelatin dynamite comprising between 3 and 10 per cent. nitroglycerin, nitrocotton, ammonium nitrate and at least one nitrocompound of the aromatic series, the relative amounts of said nitrocompound and nitroglycerin being so proportioned that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

13. An explosive comprising a liquid nitric ester, at least one nitrocompound of the aromatic series, and a liquid organic desensitizing agent, substantially soluble in said nitric ester and functioning as a liquefying agent for the combination of nitric ester and nitrocompound, the relative amounts of nitroglycerin and desensitizing ingredients being so proportioned that the detonation of the explosive and its propagation when unconfined requires a detonating impulse greater than that from a No. 8 cap, said explosive having a cross-sectional area of at least about 3 square inches.

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