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EXPLOSIVES AND METHOD OF BLASTING

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The invention relates to an improvement in explosives and more particularly relates to improved light metal-containing explosive compositions wherein the light metal component and explosive component are volumetrically coextensive, and to a method of blasting therewith.

This application is a continuation-in-part of my copending application Serial No. 836,879 now abandoned filed August 31, 1959.

In preparing and using a slurry similar to the light metal-containing ammoniated ammonium nitrate compositions described in a copending application Serial No. 784,895 filed January 5, 1959, now Patent No. 3,094,443 issued June 18, 1963, a problem arises that if the slurry is formulated from substantially equiaxed particulated light metal in the particle size range passing from about a No. 20 sieve (U.S. Sieve Series) to about a No. 200 sieve, the so-formulated slurry does not remain homogeneous on standing. The metal particles tend to settle rapidly.

It is accordingly the principal object of the present invention to provide a light metal-containing ammonium nitrate explosive composition which retains substantially uniform distribution of said light metal throughout the explosive composition on standing.

It is a further object of the present invention to provide an improved metal-containing ammonium nitrate explosive composition which is readily mixed at the blast site.

Another object of the present invention is to provide an improved light metal-containing ammonium nitrate explosive composition which is readily prepared from inexpensive particulated forms of light metal.

Another object of the present invention is to provide an improved light metal-containing ammonium nitrate explosive composition which exhibits enhanced work potential on detonation yet is not unduly shock sensitive.

Still a further object of the invention is to provide an improved method of blasting with a light metal-containing ammonium nitrate explosive composition.

These and other objects and advantages of the invention will be better understood on becoming familiar with the following specification and claims.

The invention is predicated on the discovery that upon admixing a particulated light metal of low bulk density with a bulk explosive, for example a liquid solution containing at least 60 weight percent of ammonium nitrate dissolved in liquid ammonia, water, or mixtures thereof, the metal and the solution phases being substantially volumetrically coextensive, and the metal being selected from the group consisting of magnesium, magnesium-base alloys, aluminum, aluminum-base alloys, magnesium-aluminum alloys and mixtures thereof, an explosive composition is obtained having a good work potential on detonation but only moderate sensitivity to detonation as by shock. Upon suitably loading a bore hole with the explosive composition of the invention, and providing the requisite initiation therefor, improved blasting results are obtained.

The particulated light metal used in the composition of the invention is conveniently selected from machine chips, flakes or band saw filings obtained as scrap from conventional cutting, cleaning and machining operations, or shredded or sheared foil may be used if desired. In any event, the particulated metal should have an effective bulk

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density (pour or light tap) in the range of from about 0.03 to about 1.0 gram per cubic centimeter in the composition, the most preferred bulk density varying directly with the percent metal employed. The metal particles preferably are nonequiaxed as in the case of foil pieces, or curved or elongated as in the case of shavings whereby close packing of the particles does not readily occur. In utilizing the said embodiment of the instant invention, normally in the confinement of a bore hole, or a suitable container, as in testing, for example, a quantity of Divers liquid is admixed with a suitable proportion of the particulated light metal to form a volumetrically coextensive mixture.

Divers liquid is a substantially saturated solution of ammonium nitrate in anhydrous liquid ammonia. A saturated solution of ammonium nitrate in ammonia under conditions of atmospheric pressure and ambient temperature will generally contain from about 15 to about 30 percent by weight of ammonia but more generally from about 20 to about 25 percent by weight of ammonia.

In selecting the form of particulated metal for use in preparing the composition, it is advantageous from the standpoint of efficient power production on detonation to use metal particles which in bulk have just about the requisite void space to contain a predetermined amount of ammonium nitrate solution and thus to obtain a relatively uniform distribution of metal and liquid phases on commingling the two. However, a small head of liquid solution above the solid metal does not adversely affect detonation velocity or power. While the exposure of a small amount of metal is likewise not particularly harmful, it is generally desirable to at least cover the metal phase to obtain the maximum benefits from the metal. It will then be appreciated that in order to maintain volumetrically coextensive the liquid and metal phases, a particulated metal having a low bulk density is to be employed in mixtures of low metal content and, on the other hand, particulated metal of relatively high bulk density is to be employed in mixtures of high metal content.

To illustrate the improved method of blasting according to the instant invention, a composition of a light metal and ammoniacal ammonium nitrate solution wherein the metal and the solution are volumetrically coextensive is prepared and charged at the blast site in one of several ways. If the bore hole is readily accessible or if a confining container is used, since in any case confinement of the explosive charge is conducive to obtaining a complete and powerful detonation, it may be preferred to transfer a predetermined amount of the ammonium nitrate solution to the bore hole or container and then to add the requisite amount of particulated light metal to make the solid and solution phases practically coextensive. If an anhydrous ammoniacal solution is used, it may be preferred to put the metal in place first before the cold anhydrous ammoniacal solution collects atmospheric moisture, and to add the said solution to the metal until the metal is just covered. In loading inaccessible bore holes, it may then be preferred to admix the metal and nitrate solution in a suitable container, such as a bucket or plastic bag or other open container, adjust the relative amounts of solid and liquid phases, and pour or otherwise transfer the composition into the bore hole. A primary detonator, such as a No. 8 electric blasting cap alone, or a length of 50 grains per foot high velocity fuse cord, such as Primacord armed with an electric blasting cap, or other more powerful detonators such as a pentolite booster, shaped charge or tetyl booster is then lowered or inserted into the mix preferably near the bottom thereof. Lead wires or a fuse are then run from the initiator to a suitable firing mechanism. Tamp or stemming material, such as sand or gravel, as conventionally used provides adequate confinement of the load in the bore hole. Upon activating the

firing mechanism and firing the detonator, the ammonium nitrate explosive composition detonates with an excellent blasting power comparable or even greater than that obtained for ammonium nitrate mixtures containing appreciable amounts of a conventional explosive, such as gelatin dynamite.

As examples of the composition and practice of the invention, a number of explosive mixtures were prepared in glass bottles having a volume of 120 cubic centimeters and detonated. In each case, the particulated metal was placed in the bottle and caused to occupy a volume of about a total of 100 cubic centimeters in this bottle. Divers liquid was poured over the metal thereby forming substantially volumetrically coextensive phases of the metal and the liquid. The remainder of the bottle was then filled with sand stemming. Some of the mixtures were detonated by two inch lengths of 50 grains per foot Primacord (a high velocity fuse cord containing pentaerythritol tetranitrate) inserted into the mixture and armed with a No. 8 electric blasting cap. Other mixtures were detonated by a No. 8 electric blasting cap alone. Bottles were stoppered after arming. Observations of each detonation were made visually as well as by means of a barographic recorder which responded to the maximum pressure of the impulse of the detonation. The mixtures tested and the test results are listed in the following table.

Also listed in the table are the results of experiments carried out as comparison or blank tests. In these experiments, variously, detonations of initiators in the presence and absence of Divers liquid were recorded.

length of 50 grain per foot Primacord was inserted into the mixture, armed with a No. 8 electric blasting cap, and the bottle stoppered. Upon initiating the blasting cap, the explosive mixture was detonated. There was a loud report and the barographic recorder indicated a maximum impulse of 14.8 millimeters.

As a further example of the instant invention, about 50 pounds of a 50-50 weight percent mixture of coarse magnesium and aluminum chips and 45 pounds of an aqueous ammoniacal solution of ammonium nitrate consisting of about 4-6 percent water, 25-35 percent ammonia, balance ammonium nitrate, were placed in a plastic container wherein they occupied a volume of about 1.0 cubic foot. In this container, the metal and fluid were substantially volumetrically coextensive and the effective bulk density of the metal in the composition was about 0.8 gram per cubic centimeter. The container was inserted into a bore hole about six feet deep, armed with a shaped charge initiator, the hole stemmed and the load then detonated. A blast of very good efficiency resulted.

Among the advantages of the invention are the simple loading techniques required and the safety with which the separate components of the composition may be transported to the blast site.

Various modifications can be made in the present invention without departing from the spirit or scope thereof for it is understood that I limit myself only as defined in the appended claims.

Test No.	Composition, percent by wt. ¹		Metal or alloy	Source and form of metal	Effective bulk density of metal in container, grams/cc.	Detonator	Barographic impulse, mm. pressure rise	Visual and audio observations
	Divers liquid	Particulated metal						
1	97	3	cell Mg	MC	0.018	Primacord	3.4	Slightly louder report than blank 1.
2	95	5	do	MC	0.03	do	10.8	Good report, smoke, trace of fire.
3	90	10	do	MC	0.06	do	10.5	Very good report, flash, smoke.
4	85	15	do	MC	0.09	do	9.5	Do.
5	80	20	do	MC	0.12	do	11.6	Sharp fast report, flash, smoke.
6	80	20	ZK61	RF	0.12	do	11.5	Do.
7	80	20	AZ31	BD	0.12	do	15.3	Do.
8	80	20	AZ31	BD	0.12	do	16.8	Good report, large flash.
9	90	10	AZ31	BD	0.06	No. 8 E.B.C.	7.2	Do.
10	97	3	Al	FC	0.018	Primacord	13.3	Good report, no flash.
11	95	5	Al	FC	0.03	do	14.1	Excellent report, no flash.
12	90	10	Al	FC	0.06	do	16.6	Very heavy detonation, flash.
13	85	15	Al	FC	0.09	do	16.7	Do.
14	80	20	Al	FC	0.12	do	17.2	Very heavy detonation, fire.
15	90	10	Al	FC	0.06	No. 8 E.B.C.	14.1	Very heavy detonation, flash.
16	80	20	Al	FC	0.12	No. 8 E.B.C.	20.6	Very heavy detonation, fire.
17	85	15	cell Mg	GC	0.09	Primacord	6.6	Good report, flash.
18	80	20	do	GC	0.12	do	6.4	Very good report, flash.
19	90	10	do	GC	0.06	do	6.1	Good report, no flash.
20	80	20	do	GC	0.12	do	9.8	Very good report, flash.
Blank 1	100					do	3.7	Weak report, little smoke.
Blank 2	100					No. 8 E.B.C.	(ave. of 3) 1.3	Very weak report.
Blank 3						Primacord	2.4	Do.
Blank 4						No. 8 E.B.C.	2.0	Do.

¹ Total Explosive load—60 grams.

Cell Mg=magnesium of purity grade as obtained from electrolytic cells.

ZK61=magnesium-base alloy having as nominal composition 6 percent Zn, 1 percent Zr, balance Mg.

AZ31=magnesium-base alloy having as nominal composition 3 percent Al, 1 percent Zn, 0.2 percent Mn, balance Mg.

MC=machine chips, generally of spiral shape, bulk density (light tap) about 0.035 to 0.1, surface area about 39 sq. in. per gram.

RF=rotary filings, bulk density about 0.2 gram per cubic centimeter.

BD=bandsaw dust, bulk density about 0.2 gram per cubic centimeter.

FC=foil chips prepared by cutting 0.0008 inch thick household foil wrap into pieces about 0.25 inch by 1 inch, surface area about 66 sq. in. per gram.

GC=Grignard chips, pharmaceutical grade, chip size about 0.010 by 0.125 by 0.5 inch, bulk density about 0.23 gram per cubic centimeter.

No. 8 E.B.C.=No. 8 electric blasting cap.

By way of an additional example of the practice of the invention, 6 grams of aluminum foil chips prepared by cutting commercial aluminum foil wrap having a thickness of about 0.0008 inch into pieces about 0.25 inch by 1 inch were placed in a similar 120 cubic centimeter glass bottle. These occupied a volume of about 100 cubic centimeters and were covered by 54 grams of a saturated water solution of ammonium nitrate. The effective bulk density of the metal in the composition was about 0.06 gram per cubic centimeter. A 2 inch

I claim:

1. A metallized ammonium nitrate explosive composition comprising particulated, non-equiaxed, light metal chips selected from the group consisting of magnesium, magnesium-base alloys, aluminum, aluminum-base alloys and mixtures thereof and a liquid ammonium nitrate based component, said ammonium nitrate component comprising a mixture containing at least about 60 weight percent ammonium nitrate in combination with a solvent for said ammonium nitrate, said solvent being selected

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from a group consisting of liquid ammonia, water and mixtures thereof, said light metal chips and said liquid ammonium nitrate based component being substantially volumetrically coextensive and said metal having an effective bulk density in said composition of between about 0.03 and about 1.0 gram per cubic centimeter.

2. The improved metallized ammonium nitrate explosive composition comprising a solution of ammonium nitrate in a solvent selected from the group consisting of liquid ammonia, water and mixtures thereof, said solution containing at least 60 weight percent of ammonium nitrate, and particulated non-equiaxed light metal chips selected from the group consisting of magnesium, magnesium-base alloys, aluminum, aluminum-base alloys and mixtures thereof, whereby close packing of said particulated light metal does not readily occur, said particles of said light metal having an effective bulk density in said composition of from about 0.1 to about 0.8 gram per cubic centimeter and said solution and said particulated light metal being substantially volumetrically coextensive.

3. The improved method of blasting which comprises commingling in a bore hole about equal volumes of a mixture of a coarse non-equiaxed aluminum and magnesium chips and a solution of ammonium nitrate, said mixture of chips being composed of about 50 weight percent of

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aluminum and magnesium and said solution containing from about 4 to about 6 percent water, 25 to about 35 percent ammonia, balance ammonium nitrate, said mixture of chips having an effective bulk density in the composition ranging from about 0.10 to about 0.80 gram per cubic centimeter and said mixture of chips and said solution being substantially volumetrically coextensive, arming the commingled solution and chip mixture with a detonator therefor, stemming said commingled solution and particulated light metal and initiating said detonator.

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