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EXPLOSIVE COMPOSITION

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This invention pertains to an improved explosive charge of high density.

The varied uses of explosive compositions frequently include applications in places where the temperature and pressure are excessive. For example, in oil well shooting, particularly in the deeper wells, it is common to find temperatures and pressures far exceeding those occurring under atmospheric conditions. In such cases, the use of known explosives, although perhaps generally satisfactory, presents certain difficulties. Thus, nitroglycerin, though very attractive from the standpoint of strength and high water resistance, involves more hazard than is desirable. Not only is it rather hazardous to transport and handle in general, but in addition there exists the possibility of premature detonation due to friction of the containers with the bore of the well when the material is loaded. Although instances where there is failure of initiation of the nitroglycerin are few, such failure, when it does occur, may result in damage to the drilling equipment if explosion results on the resumption of drilling.

Attempts have been made to overcome the disadvantages of liquid nitroglycerin by resorting to various modifications of blasting gelatin. These permit obviation of some of the difficulties prevailing when ungelatinized nitroglycerin is used, but are not entirely satisfactory because there is the possibility that, due to the high pressures and temperatures occurring in wells, the gelatins will attain a density beyond that at which they will propagate the detonation wave. In such cases, there remains in the bore of the well a potential source of hazard, so that once again resumption of drilling of the well involves possible damage to the equipment.

The object of the present invention is an improved explosive charge of high density. Another object is an explosive charge which will not become insensitive at elevated temperatures and pressures. A further object is a blasting charge adapted for the blasting of oil wells and the like because not only does it remain capable of initiation and propagation at high pressures and temperatures, but in addition, in the event that it remains uninitiated, it does not prevent the normal operations characterizing the drilling of oil wells. A still further object is an explosive charge which has the ability to detonate and propagate throughout a column of great length, even though the column of explosive be in the presence of oil, water, mud, or sand. Other objects will become apparent as the invention is described more fully hereinafter.

I have found that the foregoing objects are accomplished by employing as the explosive charge, under suitable conditions of confinement, explosive compositions of the nature of those disclosed in copending U. S. application Serial No. 289,187, which was filed August 9, 1939, now Patent Number 2,220,891. In this application an ammonium nitrate explosive composition was disclosed containing at least 50% by weight of ammonium nitrate, a sensitizer preferably of the nitro-aromatic hydrocarbon class, such as trinitrotoluene, and the reaction product of ammonia with an inorganic nitrate other than those of the alkali metals. I have discovered that these compositions can be subjected to very elevated pressures and temperatures without exceeding their critical density, that is to say, they are capable of initiation even though they be compressed to a density which approximates their true specific gravity. This is particularly surprising when it is borne in mind that solid explosives, which are rather insensitive, are apt to become incapable of initiation if they are subjected to pressure.

Because of this fact, it is possible to compress the present compositions to any desired form or shape, while using pressures comparable to those prevailing in oil wells, without destroying the composition's capacity to be initiated and to propagate the detonation wave once it has been initiated. Moreover, since they are insensitive to shock and friction, it follows that any failure of detonation of the explosive does not necessitate the extreme measures required heretofore for recovery of explosive charges. Thus, if they be employed in oil wells and for any reason fail to detonate, drilling of the well may be resumed without danger of causing their detonation.

Since explosive compositions of this type are affected by water, it is essential that they be enclosed in containers which are substantially watertight if they are loaded in places where water is present. This may be accomplished very readily, because it is a relatively simple matter to compress the explosives to such size and shape that they may be so charged into containers that there is a minimum of free space therein. Since these compositions have already been subjected to a pressure at least as high as that to which they will be subjected at their place of use, it follows that, provided the explosive has been suitably charged into the container, the pressures prevailing can cause no substantial distortion of said container, even though said container is incapable in itself of withstanding said prevailing pressures. The impracticability of employing a container of such construction that its walls are capable of withstanding elevated pressure is believed apparent. Likewise, materials which will be compressed further after their introduction to the place of application cannot be employed satisfactorily because the compression of the materials removes them as supports for the container. Such compression not only tends to desensitize the explosive charge by causing it to exceed its

critical density, but in addition may cause collapse of the container in which it was enclosed, thus exposing said charge to the action of oil, water, and the like, with the result that the possibility of detonation is rendered almost negligible.

In order to illustrate the characteristics of my explosive charges, reference is made to the following example:

Example 1

	Parts
Ammonium nitrate	69.0
Trinitrotoluene	20.0
Dicyandiamide	1.5
$Ca(NO_3)_2$—xNH_3 (calcium nitrate-ammonia compound)	7.5
Sawdust	2.0

The foregoing ingredients were formed into pellets 2⅛'' in length and 2'' in diameter by compressing with a hydraulic press under a pressure of 5,000 lbs. per square inch. The resulting pellets had an average density of 1.62 and exhibited no tendency to "spring" or expand after pressure had been released. The true specific gravity of the foregoing composition is approximately 1.69 so that substantially no free space remained within the pellets. These pellets, when loaded snugly into tin cans and initiated in unconfined condition by means of a 50-gram 1¼ x 1½'' TNT primer, gave an average velocity of 5,000 meters per second.

It will be understood that in many cases it will be desirable to employ with my basic composition comprising ammonium nitrate, a sensitizer, and a reaction product of ammonia with an inorganic nitrate other than those of the alkali metals, solid compounds which are well known explosives in themselves, such as pentaerythritol tetranitrate, tetryl, nitromannitol, erythritol tetranitrate, trimethylene trinitramine, and other compounds having comparable behavior with respect to pressure, friction, impact, and the like. Thus, solid explosive compounds which are very susceptible to initiation by means of static, friction, etc., are not within the purview of the invention. Materials such as pentaerythritol tetranitrate and tetryl have a sensitiveness somewhat greater than that of the basic explosive charge herein contemplated and consequently may be regarded as factors ensuring performance on the part of the explosive when it is used under the most extremely adverse conditions. A composition involving the use of such materials is illustrated in the following example:

Example 2

	Parts
Ammonium nitrate	62.1
Trinitrotoluene	18.0
Dicyandiamide	1.4
Sawdust	1.8
$Ca(NO_3)_2$—xNH_3 (calcium nitrate-ammonia compound)	6.7
Pentaerythritol tetranitrate	10.0

This composition was compressed into pellets of the same size as those recited in Example 1, compression being effected at the same pressure, i. e., 5,000 lbs. per square inch. These pellets had a density of 1.57, as compared to a true specific gravity of about 1.68, so that here too, the free space within the pellets was almost negligible. These pellets were packed in tin cans 6 inches in length and having an internal diameter slightly exceeding 2 inches, each of the cans being sealed after enclosure of the explosive pellets. When initiated by means of a 30-gram 1¼ x 1½'' TNT primer, the average unconfined velocity through a column of 10 cans was 5,900 meters per second. Moreover, one can filled with the explosive charge upon initiation was capable of detonating a second can of the explosive, even though it was removed a distance of 20''.

It will be understood that, in addition to the other essential properties of explosives, those for use under the most severe temperature and pressure conditions should possess not only stability but also the ability to detonate and propagate under these conditions. Thus, in oil well shooting they must be capable of initiation and propagation of the detonation wave through long columns over oil, water, mud, or sand-filled gaps of a maximum of about 6''. This is necessary because, in loading a column of explosive charges in containers, very often the containers are separated from each other by several inches, this space being filled with mud, water, sand, and the like. In order to achieve blasting which is efficient, the explosive must be capable of propagating its detonation wave from one container to another through these gaps. The ability of the present compositions to accomplish this result is illustrated in the following example:

Example 3

The identical composition disclosed in Example 2 was formed into pellets of the same size as those described in said example, the formation of said pellets being effected under exactly the same conditions as set forth therein. After they were loaded in the cans, said cans were charged into a long pipe having an internal diameter of 2½'' and the free space in the pipe was filled with oil, water, or heavy mud. Tests were then carried out whereby two of the cans were initiated by means of one stick of 60% straight dynamite 1¼'' in diameter by 8'' in length, and a third can of the material was placed some distance from the first two in order to determine the gap over which the explosive composition would propagate the detonation. Numerous tests gave the following average results:

Material in the gap	Distance of propagation
	Inches
Oil	6
Water	7
Heavy mud	3

The foregoing results indicate that, although the gap over which the explosive will propagate is reduced when said gap is filled with oil, water, or mud, yet even with these materials present, failures of propagation should be at a minimum under the conditions normally prevailing in wells. Moreover, since the sensitiveness of these explosive compositions increases materially the increase in diameter, it follows that larger diameters are accompanied by even better propagation.

Since the present compositions are desensitized by substantial exposure of water, consideration has been given to the effect produced by water in those cases where the container might not be completely waterproof. In this connec-

tion, cartridges having small holes were immersed in water under a pressure of 2000 lbs. per square inch. Due to the fact that the free space within the container is very small, it was found that these cartridges actually permitted the entrance of less than 2% water. When similar tests were conducted in the presence of oil, only about 1½% of oil entered the composition. In neither case was the quantity of liquid sufficient to cause desensitization of the explosive composition.

Although the foregoing description refers specifically to pellets having a diameter of about 2", this has been done merely to show the results obtained when the explosive is pelleted in those sizes, which would be more apt to disclose any deficiency of the material. The use of pellets substantially greater in diameter than 2" is therefore contemplated. Moreover, it is not essential that the explosive within each container be composed of two or more charges, but instead it may be made of a single pellet designed to fit the maximum space within any given container.

It will be understood that, for many uses, it is not essential that the explosive pellets be subjected to a pressure capable of compressing them to approximately the true specific gravity of the ingredients of which they are composed. Instead, there need be employed only a pressure equal to that which will be encountered where the explosive is used. However, I prefer to compress the composition to a density of at least 1.50, because at this density the material is capable of relatively slight compression and hence is satisfactory for use in most applications, even though such applications involve exceedingly high pressures.

The discovery that explosive compositions of this type can be compressed to substantially their true specific gravity without becoming desensitized makes available to the art explosives which have broad application, particularly in those cases where it is disadvantageous to employ more sensitive compositions, such as those containing nitroglycerin, and where it is desirable to obtain a high bulk strength. Consequently, although I have described their use in conjunction with oil wells, I do not intend to be limited to such use since other applications will be apparent to those skilled in the explosives art. I wish, therefore, to be bound only in accordance with the following claims.

I claim:

1. A blasting unit comprising a substantially water-tight and pressure-resistant container and a pelleted charge within said container having a density of at least 1.50 and comprising at least 50% by weight of ammonium nitrate, the reaction product of ammonia with an inorganic nitrate other than those of the alkali metals, and pentaerythritol tetranitrate.

2. A blasting unit comprising a substantially water-tight and pressure-resistant container and a pelleted charge within said container having a density of at least 1.50 and comprising at least 50% by weight of ammonium nitrate, the reaction product of ammonia with an inorganic nitrate other than those of the alkali metals, and tetryl.

3. A blasting unit comprising a substantially water-tight and pressure-resistant container and a pelleted charge within said container having a density of at least 1.50 and comprising at least 50% by weight of ammonium nitrate, the reaction product of ammonia with an inorganic nitrate other than those of the alkali metals, and trimethylene trinitramine.

4. A blasting unit comprising a substantially water-tight and pressure-resistant container and a pelleted explosive charge within said container, said charge comprising between 60 and 70 parts of ammonium nitrate, the reaction product of ammonia with an inorganic nitrate other than those of the alkali metals, and a high explosive, normally solid, organic sensitizer and being incapable of substantial compression by the application of pressure.

5. A blasting unit comprising a substantially water-tight and pressure-resistant container and within said container a hard, coherent pellet having a density of at least 1.50, said pellet comprising 60 to 70 parts of ammonium nitrate, trinitrotoluene, the reaction product of calcium nitrate and ammonia, and pentaerythritol tetranitrate, said ingredients being distributed substantially uniformly throughout the pellet.

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