

1

3,212,944

AMMONIUM NITRATE COMPOSITIONS CONTAINING HYDRATABLE METAL SALTS AND METHODS FOR PRODUCING THE SAME

John E. Lyon, Florissant, John R. Parks, University City, and Joseph G. Stites, Jr., Des Peres, Mo., assignors to Monsanto Company, a corporation of Delaware
No Drawing. Filed May 10, 1961, Ser. No. 109,011
16 Claims. (Cl. 149—21)

The present application is a continuation-in-part of U.S. application Serial No. 55,155, now abandoned, filed September 12, 1960.

This invention relates to ammonium nitrate materials especially suitable for use in the field of explosives and to methods for preparing such materials. More particularly, the invention relates to high density ammonium nitrate materials useful for the provision of explosives of improved efficiency.

Ammonium nitrate based explosives are now widely employed and, for example, are employed in strip mining operations where it is necessary to remove a sedimentary rock overlayer to expose the desired mineral values. Explosives of this type, when used for such operations, have the advantage that they are inexpensive and the advantage that they can be "field mixed," but this does not mean that such explosives are ideal in all respects. To the contrary, ammonium nitrate based explosives, as commonly employed, have two pronounced disadvantages. The first of these disadvantages is that the detonation velocity of presently available ammonium nitrate explosives is considerably below the speed of sound in hard rock so that high efficiency is not obtained. The second such disadvantage is that the explosive compositions normally have such low densities that they will not sink when introduced into a water filled bore hole.

Explosives based primarily upon ammonium nitrate in admixture with a suitable fuel are not at the present time widely employed in underground mining operations. There are a number of reasons for this but two of primary importance are that this class of explosives usually has such a large "critical diameter" that they cannot be employed in small diameter bore holes and the detonation velocity of such explosives has not been high enough to give the desired results. As contrasted to the 8 to 10 inch diameter bore holes usually employed in strip mining, the bore holes used in underground mining are usually between 1 and 2 inches in diameter and this is below the minimum satisfactory size usable with conventional ammonium nitrate-fuel mixtures.

Ammonium nitrate based explosives generally comprise ammonium nitrate granules, pellets or globules mixed with an amount of a suitable combustible fuel approximately sufficient to be oxidized by the decomposition of the ammonium nitrate, the most widely employed combustible fuels being liquid hydrocarbon mixtures, such as No. 2 fuel oil. Globules formed by solidification of suspended droplets are known in the art as "prills" and low density prilled ammonium nitrate is generally considered the best available form of ammonium nitrate for preparing explosives of the above type because the low density prills contain minute voids which permit the liquid hydrocarbon fuel to penetrate and become intimately associated with the ammonium nitrate. The minute voids also provide numerous compression centers which are believed to aid in the propagation of the explosion through adiabatic compression of the gases contained in the voids to temperatures in excess of the ignition temperature of the ammonium nitrate-fuel mixture. In recent years there has been introduced into the agricultural fertilizer trade high density ammonium nitrate prills but these have been found to be not suitable for use in making explosive mix-

2

tures apparently because with such prills it is impossible to obtain an intimate admixture of a combustible fuel and ammonium nitrate and because of the substantial absence of minute compression centers as above described.

In accordance with this invention, there is provided a microprilled product which can have an appreciably higher bulk density than that of the high density fertilizer material mentioned above and, where desired, can have a density appreciably above that of water. It has been found that if microprills of proper sizes are selected, penetration of a fuel, such as hydrocarbon oil, to the interior portions of the prills is not necessary for an efficient explosion and that the voids existing between the minute prills apparently serve as compression centers similarly to the internal voids of low density prills. By proper selection of prill size it has also been found that a microprilled product in accordance with this invention can be employed for producing an explosive which gives excellent results in bore holes of a diameter conventionally employed in underground mining operations. Further, an explosive composition properly prepared from the microprilled product has a detonation velocity substantially above that of previously available hydrocarbon-ammonium nitrate mixtures and above the speed of sound in hard rock.

The ammonium nitrate particles in compositions according to this invention must comprise prills and cannot suitably consist of particles formed by grinding or the like. If high density fertilizer ammonium nitrate prills are ground, the resulting product is a relatively low density material which cannot readily be compressed to give a bulk density comparable to that of the fertilizer grade material from which it was formed. Further, if the low density ground material is used to form an explosive mixture, the resulting mixture is characterized by a relatively low detonation velocity. It has, however, been found that ammonium nitrate cannot be microprilled by the techniques employed in the production of the above-mentioned high density fertilizer prilled material for the reason that if one attempts to produce a product containing extremely small prills, the prills cohere so tenaciously as to make the product unsuitable for its intended use, and if one attempts to avoid this by the use of a parting agent, such large quantities of the agent are required to prevent prill cohesion that the utility of the resulting product in the explosives field is materially reduced if not destroyed.

In accordance with the process of this invention, high density microprills of ammonium nitrate are produced by forming a molten mixture of ammonium nitrate and a hydratable inorganic material, the amount of hydratable material being insufficient to detract from the efficient use of the finished product in compounding explosives. The amount of water in the mixture is then reduced, if such is necessary, below that capable of being taken up as water of hydration of the hydratable material and the thus dehydrated mixture is subjected to a prilling operation. It has been found that exceedingly small prills can readily be formed from such a mixture without any tendency for the prills to adhere to each other in an objectionable manner. Apparently free water is necessary for objectionable prill cohesion and is not present as a result of the hydratable material effectively binding substantially all of the free water in the mixture. In accordance with a preferred embodiment of the invention, a hydratable material is selected which imparts to the prills dimensional stability through variations in temperature normally encountered in storage so that disintegration of the prills in storage is substantially eliminated.

The hydratable inorganic material which is mixed with ammonium nitrate in accordance with this invention can constitute any material which, at least in anhydrous form,

3

is thermally stable at prilling temperatures and which readily forms a hydrate at lower temperatures. This does not mean that the hydrated or partially hydrated material cannot be thermally stable at prilling temperatures or that the anhydrous material could not suitably be capable of forming a hydrate at prilling or higher temperatures but only that the inorganic material must be capable of forming a hydrate with any free water in the ammonium nitrate mixture prior to the time that the prills would normally cohere in an objectionable manner. In particular, it is important that the hydratable material retain the prills substantially free of unbound water at temperatures within the range of 0° C. to 45° C. which are usually encountered in storage. Simple hygroscopic inorganic salts as a class are suitable for use in accordance with this invention but the preferred hydratable materials are water soluble inorganic salts which form a hydrate in saturated air at a temperature of about 85° C. or higher. Illustrative examples of suitable materials are magnesium nitrate, aluminum nitrate, iron nitrate, calcium nitrate, zinc nitrate, magnesium sulfate, magnesium oxide and magnesium carbonate. Of course, it will be understood with reference to oxides and carbonates that they are largely transformed to nitrates when added to molten ammonium nitrate.

In accordance with a preferred embodiment of the invention, as previously mentioned, a hydratable material is employed which imparts dimensional stability to the ammonium nitrate prills through a temperature range normally encountered by the prills in storage. Ammonium nitrate is capable of existing in several crystalline forms and normally undergoes a phase change at a temperature of about 32° C. This phase change is accompanied by a volume change which causes compacted forms of ammonium nitrate such as prills to crack or crumble internally and to eventually break down to a fine powder. This is very undesirable for a number of well known reasons, and it is a distinct advantage that one can produce a product in accordance with this invention which has, in addition to the advantages mentioned above, the desirable characteristic of being dimensionally stable at usual storage temperatures. Illustrative examples of salts that can be employed to impart dimensional stability are calcium nitrate and magnesium nitrate.

The amount of the hydratable material employed must be at least sufficient to chemically bind as water of hydration substantially all of the water in the ammonium nitrate mixture so that theoretically substantially no free water is present in the prilled material. Since it is almost impossible to retain the water in the ammonium nitrate mixture at a negligible level, one should normally employ, under even favorable conditions, at least about 0.02 percent by weight, and preferably at least about 0.1 percent by weight, of the hydratable material. At the other extreme one should not normally employ more than about 3 to 6% by weight of the hydratable material because the presence of more than this amount of explosively inert material detracts from the usefulness of the ammonium nitrate composition in the formulation of explosives, explosively inert material being defined to mean a material which neither decomposes to release oxygen nor is oxidizable to release energy under conditions of explosion. Preferably the amount of the hydratable material is retained below about 1% by weight of the mixture.

In view of the above discussion, it will be seen that the amount of water present in the ammonium nitrate mixture at the time of prilling should not only be below the amount capable of being bound as water of hydration by the hydratable material in the mixture but should also be below the amount which would result in excessive explosively inert material, as above defined, being present in the mixture. This means that the water content, including water of hydration, at the time of prilling should be below about 5% by weight of the mixture and should preferably be below about 1% by weight of the mixture.

4

If one desires prills which are dimensionally stable, the water content of the mixture at the time of prilling should be even lower and should in all such instances be below about 2% by weight and preferably below about 0.5% by weight of the mixture.

The hydratable material can be introduced into the ammonium nitrate mixture by any desired procedure. For example, solidified substantially anhydrous ammonium nitrate can be mixed with the hydratable material while it is in a dehydrated condition and contains less than the normal amount of water of hydration, and the resulting mixture thereafter heated to a molten state and prilled. This procedure has the disadvantage that the hydratable materials suitable for use in this invention are frequently not available in a dehydrated form and the further disadvantage that the materials must be handled at all times under controlled humidity conditions. A procedure which is usually more satisfactory comprises preparing a relatively dilute solution of ammonium nitrate and adding the hydratable material in hydrated form to the ammonium nitrate solution. The resulting aqueous mixture can, in most instances, then be dehydrated by conventional procedures to a satisfactory water content. In some instances hydratable materials are advantageously employed which so tenaciously hold their water of hydration that special measures must be taken to reduce the water content of the ammonium nitrate mixture to a satisfactory level. The problem is further complicated by the fact that ammonium nitrate cannot be readily handled at temperatures normally necessary to result in the dehydration of many hydratable materials which otherwise have desirable characteristics for use in this invention. It has been found, however, that the presence of molten ammonium nitrate apparently facilitates the removal of water from such difficultly dehydratable hydrates and that dehydration can be effected under proper conditions at temperatures below the upper limit at which ammonium nitrate can be readily handled. For example, by the use of temperatures in the range of 170 to 210° C. and pressures below about 0.3 atmosphere, an ammonium nitrate composition containing calcium nitrate, magnesium nitrate or a mixture of the two can readily be dehydrated to a water content of less than 0.5%. The terminal dehydration step can be carried out in any conventional manner but is advantageously carried out by evaporation from thin films of the molten mixture using a tubular or wiper film evaporator.

The prilling operation can be generally conventional and conventional apparatus can suitably be employed, but a few variations from normal equipment and procedure are advantageous. One such variation is that a spray nozzle is advantageously employed which produces microprills within a size range to be subsequently described. Spray nozzles of this type are commercially available and the selection of a suitable nozzle normally presents no difficulties. If a spray head is selected under which the conditions employed provides prills having a proper range of particle sizes, no screening of the product will be required, although the particle size range of the product being produced should be checked at intervals. A further advantageous variation from the usual procedure comprises neutralizing the ammonium nitrate to remove any free acid present therein before prilling since the presence of free acid in the prills makes them more hygroscopic and sensitive to temperature changes. One consideration specific to the process of this invention is that the product must be cooled before appreciable caking has occurred to a temperature below that at which the hydratable material in the ammonium nitrate tends to form a hydrate so that the free water content of the prills is held at substantially zero level. This, however, need not necessitate a change in conventional prilling procedures because salts are readily available which tend to form hydrates at temperatures above those at which prills are conventionally removed from prilling towers.

Practice of the present invention does not preclude one from employing conventional coating or parting agents, although it is a distinct advantage of the invention that such agents are not required. Typical examples of materials which can be applied to or coated upon the ammonium nitrate prills include talc, diatomaceous earth, surface active agents and the like. It should be emphasized, however, that if the coating or parting agent is an explosively inert material, as above defined, the amount employed should be limited such that the total amount of inert materials in and on the ammonium nitrate prills is below about 6% by weight.

In order for the product to have the desired characteristics, at least about 80% by weight of the prills must be of a size less than about 20 mesh. Preferably not more than about 5 to 10% of the prills should be larger than about 20 mesh because it has been determined that high density, impervious prills of a size larger than about 20 mesh do not perform efficiently in explosive compositions, and that the presence of prills in excess of this size detracts from the usefulness of the prilled composition in explosive mixtures. The further removed the oversize prills are from 20 mesh the greater is the reduction in explosive efficiency so that not only should the percentage by weight of oversize prills be held to a minimum but the degree to which the prills exceeds 20 mesh in size should also be minimized.

When the prills are intended for manufacture of explosives for use in holes of greater than about 3 inches in diameter, not more than about 5 to 15% by weight of the prills should be below about 140 mesh in size because the presence of a large percentage of prills smaller than 140 mesh results in a reduction in bulk density, increased caking tendencies and reduced flowability. It is normally an advantage of ammonium nitrate based explosives that they are relatively insensitive to detonation, but a product according to this invention containing greater than about 5 to 15% particles smaller than 140 mesh can, under favorable conditions, be readily detonated by a single primer cap. The presence of an excessive percentage of undersized particles also aggravates caking and reduces flowability. For best results the prills should cover a substantial portion of the size range of from about 20 to 140 mesh. This is because a prilled product in which the prills vary in size over an appreciable range is more dense than a product formed from prills of uniform size. As a general rule the prill density and the range in prill size should be such that the product has a bulk density of at least about 60 or 62 and preferably of from about 68 to 75 pounds per cubic foot. The density of the individual prills is of no greater importance except as it relates to bulk density, but because of this relationship the prills should have as near the theoretical maximum of 107 pounds per cubic foot as possible and should have a density of at least about 90 pounds per cubic foot. This is not difficult to achieve in accordance with the present invention, and, in fact, particle densities in excess of about 100 pounds per cubic foot can be routinely obtained.

For a prilled product with most desirable properties for use in holes of greater than about 3 inches in diameter, not only should the prill size extend over a substantial range but specific percentages of the prills preferably should be within various segments of the range of prill sizes. Best results with respect to the detonation velocity, sensitivity and density of explosive mixtures prepared therefrom have been achieved with prilled ammonium nitrate compositions in which the prill sizes were as follows: 5 to 30% of the prills in the range of 20 to 40 mesh, 25 to 55% of the prills in the range of 40 to 60 mesh, 15 to 60% of the prills within the range of 60 to 100 mesh, 4 to 15% of the prills in the range of 100 to 140 mesh and 1 to 5% of the prills smaller than 140 mesh. These are, however, only presently preferred ranges and excellent results can be obtained even though material departures are made from these percentage ranges.

For a prilled product intended for the manufacture of explosives to be used in holes of less than about 2 or 3 inches in diameter, a product composed of particles predominantly less than about 140 mesh in size is generally advantageous in spite of the previously mentioned disadvantages of such a product. If great care is exercised to retain the product in a completely dry state, a product in accordance with this invention is satisfactory even when a major portion of the prills are so small that they cannot be classified by conventional screening techniques, or, in other words, less than about 325 mesh. Normally, however, best results are obtained with a product in which at least 50 to 80% of the prills are less than about 140 mesh with about 10 to 40% of the prills being smaller in size than 325 mesh. A wide range of particle sizes does not appear to be of primary importance with a product formed from such prills because other factors, such as a tendency to agglomerate, appear to have more effect upon bulk density than does particle size distribution.

To convert the ammonium nitrate prills to an explosive it is necessary that the prills be mixed with a suitable fuel. Materials such as carbon black, sawdust and oat hulls can be employed, but a liquid fuel such as a hydrocarbon oil permits a more intimate mixture and is much to be preferred. The fuel may be mixed with the ammonium nitrate prills using any suitable equipment as illustrated by a rotatory mixer.

The amount of fuel mixed with ammonium nitrate prills to form an explosive is preferably an amount sufficient to exactly utilize the oxygen liberated by the decomposition of the nitrate. With the usual hydrocarbon oils this is about 6% by weight. If an amount of fuel either appreciably above or below the theoretically optimum amount is employed, the explosion efficiency of the composition is reduced and an efficient explosion is not normally obtained if one employs less than about 3% or more than about 15% of a combustible fuel based on the weight of ammonium nitrate.

An explosive composition prepared in accordance with this invention can be conventionally employed. Normally the mixture of fuel and ammonium nitrate is simply poured into a borehole, primed, fused and stemmed in the usual manner. If used in wet or water filled boreholes, the ammonium nitrate mixture is preferably packed in waterproof containers or the like to prevent moisture adsorption. Waterproof containers of a high density product prepared in accordance with this invention normally sink when placed in a water filled borehole and, as previously mentioned, this is a distinct advantage.

The invention will now be further illustrated by the following specific examples.

EXAMPLE I

One hundred pounds of anhydrous ammonia are reacted with 675 pounds of 55% aqueous nitric acid to give 555 pounds of 85% aqueous ammonium nitrate solution. This solution is then concentrated to a 95% solution by evaporating water therefrom at a temperature of about 140° C. and pressure less than about one-half atmosphere. Independently of the foregoing, 2.4 pounds of magnesium oxide are dissolved in 13.8 pounds of 55% nitric acid to form a solution of magnesium nitrate. This latter solution is filtered to remove any insoluble impurities and is then added to the aforementioned 95% ammonium nitrate solution to give about 512 pounds of ammonium nitrate solution containing 1.75% magnesium nitrate and about 6% water. This solution is passed rapidly through small diameter (e.g., 1 inch) tubes maintained at about 190° C., and is then allowed to flash into a chamber maintained at about 0.13 atmosphere pressure wherein water is vaporized from the composition to reduce the water content of the ammonium nitrate melt to about 0.3% H₂O. The thus concentrated ammonium nitrate is then prilled at a spray temperature of about 197° C.

using a spray pressure and spray head such as to give prills of a size less than about 20 mesh but only about 5% of which are smaller than 140 mesh.

Prills prepared in the above manner were mixed with 6% by weight of light fuel oil using a conventional concrete mixer to effect thorough mixing. One hundred fifty pounds of the oiled material were then loaded into each of several nine inch diameter holes drilled in a shale and limestone overlayer at an open pit mine. The holes were primed, stemmed and detonated in a conventional manner. The detonation velocity was 17,000 to 18,000 feet per second which compares to a detonation velocity of 12,000 to 13,000 feet per second using a comparable product prepared from commercially available low density, prilled ammonium nitrate.

EXAMPLE II

A concentrated molten ammonium nitrate mixture is prepared as in Example I and is atomized into a prilling tower to produce a product composed of prills of the following sizes:

Mesh:	Percent
20 to 40 -----	1
40 to 60 -----	3
60 to 100 -----	5
100 to 140 -----	17
140 to 270 -----	37
270 to 325 -----	11
—325 -----	26

The prills were then mixed with 6% by weight light fuel oil using a concrete mixer to achieve thorough mixing. For comparative purposes a similar product was made except there was employed conventional light density prilled ammonium nitrate instead of the micropilled product of this invention. The results of comparative tests are given in the following table:

Table 1.—Explosive properties of AN/FO mixtures in black iron pipe

Mixture	Critical Diameter, inches		Detonation velocity, Ft. per Second		Density, gms./cc.
	Con-fined	Uncon-fined ¹			
Conventional prills...	1½	4	1" dia... 2" dia...	Failed 10,000	0.83 0.83
Dense micropills...	1	1½	1" dia... 2" dia...	12,900 15,000	0.97 0.97

¹ In cardboard tubes.

It will be seen from the above table that a product according to this invention is useful in holes down to 1" in diameter and has a critical unconfined diameter of only 1½ inches. The product was further tested in actual mining operations with 1½ inches diameter bore holes in dolomitic limestone and was found to give excellent results.

The procedure when employing other hydratable materials and other types of fuel is generally the same as illustrated above.

While a prilled product prepared in accordance with this invention is especially useful in the field of explosives, it can also be employed to advantage in other instances. For example, it has been found that a dense free-flowing, prilled ammonium nitrate product prepared in accordance with this invention can be employed to advantage as a source of oxygen in rocket propellant compositions. Likewise, a prilled product in accordance with this invention can be advantageously employed in the fertilizer field for the reason that the free-flowing, small diameter prills can be readily and evenly distributed in the soil to be fertilized, or can be mixed with other fertilizer materials of similar particle size so that segregation is minimized.

Having thus described our invention and several embodiments thereof, what we desire to claim and secure by Letters Patent is:

1. A method for producing free-flowing ammonium nitrate prills having a bulk density of at least 62 pounds per cubic foot and especially suitable for use in the field of explosive which comprises forming a molten mixture of ammonium nitrate and between about 0.02% and about 6% of a hydratable inorganic material selected from the group consisting of magnesium nitrate, aluminum nitrate, iron nitrate, calcium nitrate, zinc nitrate, magnesium sulfate, magnesium oxide and magnesium carbonate, the total water content of said mixture being below that capable of being held as water of hydration by said hydratable inorganic material, prilling said molten mixture, and recovering a prilled product, at least about 80% by weight of which is prills of a size less than about 20 mesh.

2. A method according to claim 1 wherein a prilled product is recovered, at least about 90% of which is prills within the size range of 20 to 140 mesh and not more than 5% of which is prills larger than about 20 mesh.

3. A method according to claim 1 wherein a prilled product is recovered which is composed of at least about 50% by weight of prills of a size less than 140 mesh and 10 to 40% of said product is prills of a size less than about 325 mesh.

4. A method for producing free-flowing ammonium nitrate prills having a bulk density of at least 62 pounds per cubic foot and especially suitable for use in the field of explosives which comprises forming a molten mixture containing at least about 94% by weight of ammonium nitrate, between about 0.02% and about 6% of a hydratable inorganic salt selected from the group consisting of magnesium nitrate, aluminum nitrate, iron nitrate, calcium nitrate, zinc nitrate, magnesium sulfate, magnesium oxide and magnesium carbonate, and not more than about 5% of water, the total water content of said mixture being below that capable of being held as water of hydration by said hydratable salt at temperatures below about 85° C., and the combined percentage of water and hydratable inorganic salt present in said mixture constituting not more than 6% by weight, prilling said molten mixture and recovering a prilled product at least about 95% by weight of which is prills of a size less than about 20 mesh.

5. A method in accordance with claim 4 wherein said inorganic salt is a material suitable for imparting improved dimensional stability to said prills, and the water content of said molten mixture is below about 2% by weight.

6. A method in accordance with claim 5 wherein the particle size distribution of said prills is such that said prilled product has an uncompressed bulk density of at least about 60 pounds per cubic foot.

7. A method in accordance with claim 6 wherein said inorganic salt is magnesium nitrate.

8. A method in accordance with claim 6 wherein said inorganic salt is calcium nitrate.

9. A method for producing free-flowing ammonium nitrate prills especially suitable for use in the field of explosives which comprises forming a molten mixture containing at least about 98% by weight of ammonium nitrate, between about 0.02% and about 1% by weight of a hydratable inorganic salt selected from the group consisting of magnesium nitrate, aluminum nitrate, iron nitrate, calcium nitrate, zinc nitrate, magnesium sulfate, magnesium oxide and magnesium carbonate, not more than about 1% by weight of water, the total water content of said mixture being below that capable of being held as water of hydration by said hydratable salt at temperatures below about 85° C., prilling said molten mixture and recovering a prilled product at least about 90% by weight of which is prills of a size less than about 20 mesh, the prill size distribution of said prilled product being such that said product has an uncompressed bulk density of at least about 60 pounds per cubic foot.

pressed bulk density of at least about 60 pounds per cubic foot.

10. A method in accordance with claim 9 wherein said inorganic salt is a magnesium nitrate.

11. A free-flowing composition especially suitable for use in the field of explosives comprising prilled ammonium nitrate, at least about 80% by weight of which is present as prills of a size less than about 20 mesh, said prills having a bulk density of at least 62 pounds per cubic foot and containing between about 0.02% and about 5% by weight, calculated on an anhydrous basis, of a hydratable inorganic material selected from the group consisting of magnesium nitrate, aluminum nitrate, iron nitrate, calcium nitrate, zinc nitrate, magnesium sulfate, magnesium oxide and magnesium carbonate and an amount of water less than that required for the complete hydration of said inorganic material, the total amount of explosively inert material in said composition being below about 6% by weight.

12. A composition according to claim 11 wherein at least about 90% of the ammonium nitrate is present as prills within the size range of from 20 to 140 mesh.

13. A composition according to claim 11 wherein at least about 50% of the ammonium nitrate is present as prills of a size less than 140 mesh and 10 to 40% of the ammonium nitrate is present as prills of a size less than 325 mesh.

14. A free-flowing ammonium nitrate prilled composition comprising at least about 80% by weight of prills in the size range of about 20 to 140 mesh, said prills having a mean density of at least about 90 pounds per cubic foot and being composed of at least about 94% by weight of ammonium nitrate, and between about 0.02% and about 5% by weight, calculated on an anhydrous basis, of a hydratable inorganic salt selected from the group consisting of magnesium nitrate, aluminum nitrate, iron nitrate, calcium nitrate, zinc nitrate, magnesium sulfate, magnesium oxide and magnesium carbonate, an amount of water not greater than 5% by weight, bound as water of hydration by said hydratable salt, the total amount of explosively inert material in

said composition being below about 6% by weight and size distribution of said prills within said range being such that said composition has an uncompacted bulk density of at least about 62 pounds per cubic foot.

15. A composition as in claim 14 wherein said inorganic salt is one which imparts improved dimensional stability to said prills and the water content of said prills is below about 2% by weight.

16. A free-flowing composition especially suitable for use in the field of explosives comprising ammonium nitrate, at least about 90% by weight of which is present as prills of a size less than about 20 mesh, said prills containing between about 0.02% and about 1% by weight, calculated on an anhydrous basis, of a hydratable inorganic salt selected from the group consisting of magnesium nitrate, aluminum nitrate, iron nitrate, calcium nitrate, zinc nitrate, magnesium sulfate, magnesium oxide and magnesium carbonate and water not in excess of about 1% by weight of water bound as water of hydration by said hydratable salt, said prills having a mean prill density and a size distribution such that said composition has an uncompacted bulk density of at least about 60 pounds per cubic foot, the total amount of explosively inert materials in said composition being below about 6% by weight.

References Cited by the Examiner

UNITED STATES PATENTS

1,720,459	7/29	Wylar	149—46
2,773,753	12/56	Stengel	23—103
2,830,875	4/58	Shurter	23—103
2,852,340	9/58	Kippe	23—103
2,988,437	6/61	Stanley et al.	149—46
3,007,773	11/61	Marti	23—103
3,030,179	4/62	McFarlin et al.	23—103
3,034,858	5/62	Vives	23—103

CARL D. QUARFORTH, *Primary Examiner.*

LEON D. ROSDOL, *Examiner.*