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C. O. DAVIS ET AL
BLASTING AGENT

3,053,707

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2 Sheets-Sheet 1

Fig. 1

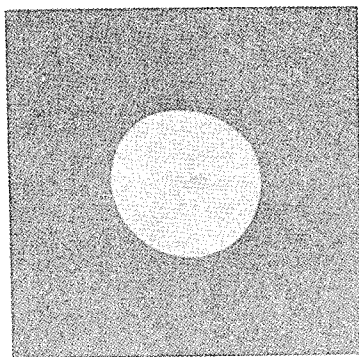
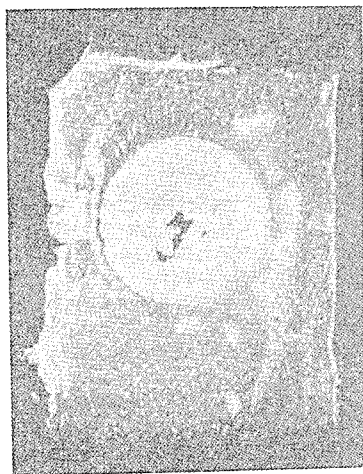


Fig. 2



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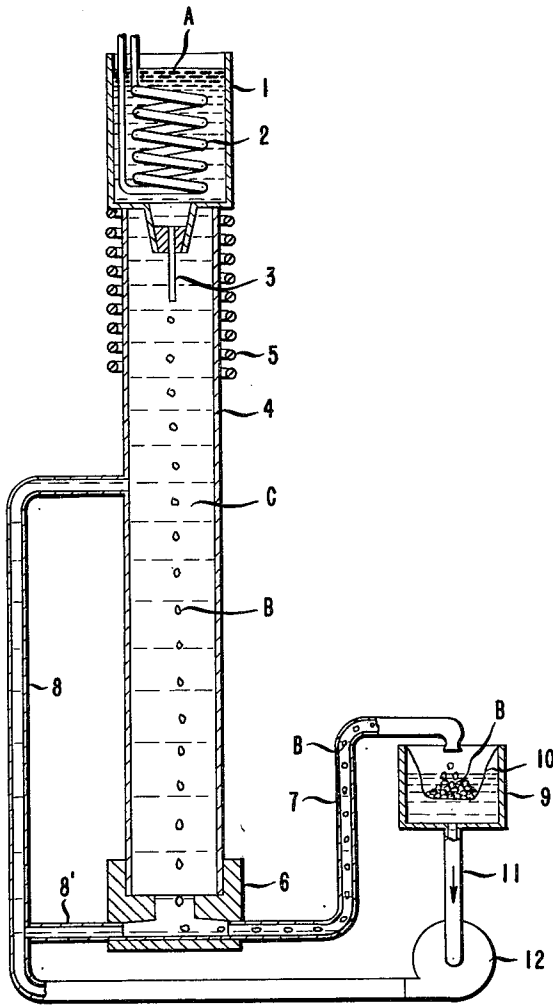
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Fig. 3



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BLASTING AGENT

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The present invention relates to a novel blasting agent and to a method for the preparation of such agent.

In large scale blasting operations, the use of blasting agents free from high explosive ingredients has gained wide acceptance because of their substantially lower cost and greater safety during storage and handling. The blasting agents most widely used are those based on ammonium nitrate and a non-explosive fuel, such as carbonaceous materials. These compositions, however, have essentially no water resistance, and, until recently, were used exclusively packaged in rigid, water-impervious containers. The containers, usually of metal, represent a substantial proportion of the ingredient cost of the assembled package and sealing the composition in the container represents an added cost in manufacture. Of considerable importance also is the fact that rigid containers will occupy considerably less than the available volume of a borehole. The great majority of boreholes have very irregular walls due to varying hardness of the strata through which they are drilled, crevices in the strata, and the normal perambulations of the drill. Since the diameter of the container loaded into the borehole cannot be greater than the diameter of the narrowest portion of the borehole, much space within the hole will be unoccupied by the composition in the container.

The use of water-insoluble high explosives, particularly TNT, in free-running form to fill such annular space in a borehole has gained wide acceptance, despite the relatively high cost of the explosive, because of the considerably higher loading density, and, accordingly, of available energy for blasting thus obtained.

The use of ammonium nitrate-fuel compositions packaged in flexible bags of polymeric materials is also known. Such bags will permit the enclosed compositions to substantially fill a borehole, provided the bag material is sufficiently thin for adequate expansion of the contents. Unfortunately, however, such bags are easily cut or torn by the rough walls of the borehole, so that little, if any, water protection is afforded to the contents after loading. For this reason, the use of flexible bag packaged compositions has been completely restricted to essentially dry boreholes.

The loading of granular or prilled ammonium nitrate in admixture with a fuel directly into a borehole has also been practiced to some extent. The mixtures, however, are not satisfactorily free-flowing, and tend to bridge in the hole, thus preventing full loading. Further, the loose mixture will not pack to a density over about 0.8 gram per cubic centimeter. The likelihood of segregation of fuel from the ammonium nitrate, particularly if any moisture is present, increases the probability that only a portion of the energy available will actually be obtained.

Accordingly, an object of the present invention is to provide a blasting agent wherein the foregoing disadvantages are overcome. A further object is to provide a method for preparing such blasting agent. Additional objects will become apparent as this invention is more fully described.

The foregoing objects may be attained when we provide as a blasting agent a plurality of geodes of a blend of ammonium nitrate and sodium nitrate having a melting point below about 128° C., the interior and the surface of the said geode containing a carbonaceous fuel liquid

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at a temperature below the melting point of the said blend. The geodes in accordance with this invention are prepared by introducing the blend of ammonium nitrate and sodium nitrate in molten form dropwise below the surface of a column of the carbonaceous fuel, the temperature of the fuel being above the melting point of the blend at the portion of the column at which the drops enter and below the melting point of the blend but above the melting point of the fuel below this portion. The droplets of blend assume a substantially spherical form while in the portion of the fuel column at a temperature above the melting point of the blend. As the drops descend, solidification occurs when the drops are in the portion of the fuel column at a temperature below the melting point of the blend. The outer surface of the drop crystallizes first, and crystallization proceeds inwardly as the heat flows from the drop to the fuel. Because the crystals of sodium nitrate and ammonium nitrate are of higher density than the blend in molten form, shrinkage occurs, thus producing a typical geode. The shell of the geode is sufficiently porous so that the liquid fuel is drawn into the cavity in the center of the geode. When the geodes thus formed are strained to remove excess liquid, a light coating of the fuel remains on the surface of the geode. This combination of surface coating and core of fuel provides an essentially unseparable combination of oxidizing agent and fuel and the spherical form permits attainments of a relatively high bulk density.

The term "geode" is widely used in crystallography to describe a more or less spherical shell of crystalline material having a central cavity. The inner surface of a geode may be covered with projecting crystals so that the cavity is not clearly defined, but represents a portion of considerably less density than the shell. This formation is frequently found in nature with material such as quartz and calcite, and is, therefore, more frequently associated with mineral aggregates. However, the structure of the ammonium nitrate-sodium nitrate crystals produced by the described method so closely resembles the mineral geodes that the application of the term to the present particles is appropriate.

In order to more fully illustrate the method by which the geodes of the present invention are prepared, reference is now made to the accompanying figures. FIGURE 1 is an enlarged photograph of a center section of a geode prepared in accordance with the present invention; FIGURE 2 is an enlarged photograph of a slice through the center of a geode prepared in accordance with this invention, and FIGURE 3 is a schematic drawing of an apparatus for preparing the described geodes.

Referring now to the figures in greater detail, in FIGURES 1 and 2 the cavity in the central portion of the spherical mass of crystalline material is clearly evident. In the slice shown in FIGURE 2, a fragment near the cavity has broken loose from the walls, but the general configuration of the geode is evident. The geodes pictured had an actual diameter of about 6 millimeters.

In FIGURE 3, 1 represents a melt tank containing a heating coil 2 and a dropping tip 3. The melt tank 1 is mounted over a column 4 which has a heating element 5 about its upper portion. At the bottom of column 4 is a distributor 6 and connected thereto are flow tubes 7 and 8. Tube 8' is connected to the liquid return tube 8. Flow tube 7 leads to the top of a receiver 9 which contains a strainer element 10 and a fluid discharge tube 11. The tube 11 is connected to the exhaust opening of pump 12. A represents molten ammonium nitrate-sodium nitrate blend, B represents solidified blend in final form, and C represents liquid fuel.

The operation is as follows: The blend A is melted and maintained in molten form in melt tank 1 by means

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of heat from coils 2, which may contain steam under pressure. The molten blend B flows through dropping tip 3, leaving there in the form of separated drops. The liquid fuel C surrounding tip 3 is maintained at a temperature higher than the melting point of blend A by means of heating coils 5, so that no solidification of blend A can occur in either the dropping tip 3 or for a short interval after the drop frees itself from tip 3. As the drop descends in the fuel C in column 4, it reaches a zone where the temperature of fuel C is below the freezing point of the blend A, and solidifies to form geode B. When geode B enters the distributor 6, the flow of fuel C carries it through tube 7 to the receiver 9. The geode B is held on the strainer 10 while excess fuel C continues on to circulating pump 12 and back to the column 4 through tube 8. This circulation of the fuel C in the lower portion of column 4 helps maintain a lower temperature in the cooling portion of column 4.

The method of the present invention is further illustrated by the following examples. All parts given are by weight.

EXAMPLE I

Using an apparatus arrangement similar to that described in the drawing, geodes were prepared as follows: a mixture of 80 parts ammonium nitrate and 20 parts sodium nitrate was introduced into the melting pot and heated to a temperature of 150° C. In this proportion, the blend formed a eutectic which had a melting point of 120° C., so that at 150° C. the blend was easily flowable. The molten blend passed through a dropping tip having an internal diameter of 3.175 millimeters into a column of kerosene. At the portion of the column surrounding the dropping tip, the temperature of the kerosene was 130° C. and at the bottom of the column about 7 feet from the dropping tip, the temperature of the kerosene was 40° C.

The pellets produced were spherical and had an outside diameter of from 4 to 6 millimeters. When they were broken, the presence of a central cavity was readily observable. The pellets, after straining, contained about 4% by weight of kerosene entrapped in the core and on the surface of the pellet. The pellets were free-flowing, had a ballistic mortar strength of 11.1, and a bulk density of about 1.0 gram per cubic centimeter.

EXAMPLE II

In a run identical with that described in Example I, except that dinitrotoluene was used in the column instead of kerosene, pellets of essentially identical size and form were obtained, but in this case contained from 4 to 7% by weight of dinitrotoluene in their cores and on their surfaces. These pellets were also free-flowing and had a ballistic mortar strength of 9.5. Their bulk density was about 1.0 gram per cubic centimeter.

EXAMPLE III

The procedure of Example I was repeated, except that the mixture consisted of 72 parts of ammonium nitrate, 18 parts of sodium nitrate and 10 parts of urea. The melting point of the ternary eutectic thus formed is about 100° C., therefore the blend was heated to about 135° C., and the kerosene in the portion of the column surrounding the dropping tip was heated to about 110° C. The pellets were of essentially the same size and form as obtained in Example I, and contained about the same proportion of kerosene.

EXAMPLE IV

A mixture of 66 parts of ammonium nitrate, 14 parts of sodium nitrate and 20 parts of potassium nitrate (melting point —121° C.) was heated to about 135° C. and fed dropwise through a dropping tip having an internal diameter of 3.175 millimeters into a column of kerosene. The temperature at the top of the column was about 130° C. The geodes obtained had a diameter of

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from 4 to 6 millimeters and a bulk density of 1.03 grams per cubic centimeter. The geodes, when initiated by a primer, detonated at a velocity of 1440 meters per second. The kerosene content was between 4 and 5% by weight.

EXAMPLE V

A mixture of 50 parts of ammonium nitrate, 33 parts of sodium nitrate, 10 parts of urea, and 7 parts of potassium nitrate (melting point 57° C.) was heated to 90° C. and fed dropwise through a dropping tube having an inner diameter of 3.75 millimeters into a column of dinitrotoluene at 110° C. at the top and 25° C. at the bottom. The geodes formed had a diameter of about 6 millimeters, a bulk density of 1.02 grams per cubic centimeter, and a DNT content of about 7% by weight. The geodes detonated at a velocity of 2310 meters per second.

EXAMPLE VI

The procedure of Example III was followed, except that dinitrotoluene was used in the column and the dropping tip had an inner diameter at the dropping end of 6.35 millimeters, geodes having an average diameter of about 9 millimeters were obtained. The geodes had a bulk density of slightly under 1.0 gram per cubic centimeter, a dinitrotoluene content of about 6% by weight, and detonated at a velocity of 2000 meters per second. The geodes were shot in a 6-inch diameter borehole in a quarry and gave excellent blasting action.

Geodes prepared in accordance with the present invention may be coated with various materials to increase their water resistance or retard setting. The geodes may also be coated with combustible materials to increase the quantity of fuel adhering to the geode. The geodes are free-flowing and will not bridge when poured into a borehole, provided they have a diameter of at least 4 millimeters. Smaller particles also do not have an internal cavity of sufficient size to hold the desired amount of fuel within the geode itself. Geodes having a diameter of more than 12 millimeters are unsatisfactorily fragile. Accordingly, we prefer that the geodes have a diameter between about 4 and 12 millimeters. The diameter of the geode is primarily dependent upon the diameter of the opening of the dropping tube, the density of the fuel in the zone in which the geode composition is liquid, and the density of the molten geode composition. To a lesser degree, geode size is also effected by the viscosity of the fuel, the pressure on the molten composition such as produced by the depth of the melt, and the configuration of the dropping tip. The temperature of both the melt and the fuel influences their density, the flowability of the melt, and the viscosity of the fuel.

We have found that a dropping tip having an opening of smaller diameter than about 1.4 millimeters will not permit sufficiently rapid flow of the melt for satisfactory operation, and the pellets produced are undesirably small with respect to diameter. On the other hand, when the diameter of the dropping tube opening is greater than about 7.0 millimeters, the melt has a tendency to flow as a continuous column rather than in the form of droplets. Even if droplets are formed, they are of such large diameter that the geodes formed lack the structural strength to withstand packing and loading into a borehole.

Obviously, the density of the fuel used as a coolant for the ammonium nitrate-sodium nitrate melt must be lower than that of the melt, or the droplet would not flow downward from the dropping tip. The largest geodes for a specific dropping tube are obtained when the densities of the melt and of the fuel are not very far apart. The following table shows the effect of fuel density on geode diameter. The melt composition consisted of 80 parts of ammonium nitrate and 20 parts of sodium nitrate, which at a temperature of 135° C. had a density of 1.83 grams per cubic centimeter. The

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dropping tube had a diameter of 0.318 millimeter. The fuel at the dropping tube was at a temperature of 130° C.

Table I

Fuel	Density (g./cc.)	Geode Diameter (mm.)
No. 10 motor oil.....	0.88	4.95
Castor Oil.....	0.95	5.21
Dinitrotoluene.....	1.52	6.23

The density of the fuel can obviously be controlled by selection of the fuel, and the density of the melt can be regulated by variation in the composition. For example, as previously indicated, an 80/20 ammonium nitrate/sodium nitrate melt has a density of 1.83 grams per cubic centimeter. The density of 72/18/10-ammonium nitrate/sodium nitrate/urea melt is 1.79 grams per cubic centimeter. The density of 72/20/8-ammonium nitrate/sodium nitrate/potassium nitrate melt is 1.87 grams per cubic centimeter.

A feature of the present invention which is critical is the use of a mixture of ammonium nitrate and sodium nitrate which forms a eutectic having a melting point below 128° C. At temperatures higher than about 140° C., the temperature required to maintain a material melting at 128° C. in a pourable, fluid state, the operating difficulties increase drastically and the number of fuels which can be used is greatly reduced. Further, at temperatures over 140° C., spontaneous reaction of the oxidizing agent and the fuel are likely to occur. The fuel obviously must be liquid at the temperature at which the ammonium nitrate-sodium nitrate mixture is fluid and also a temperature at which the mixture is sufficiently solidified to permit removal of the geodes from the fuel.

The aliphatic and aromatic hydrocarbons, both substituted and unsubstituted, which are liquid at the desired temperature ranges are suitable fuels. For reasons of economy, low cost materials such as motor oils, kerosene, dinitrotoluene, and the like are preferred.

As shown in the examples, the melting point of the ammonium nitrate-sodium nitrate composition can be lowered by the addition of melting point depressants such as urea. The presence of a combustible melting point depressant is additionally advantageous in that the fuel content of the geode is thereby increased. The inclusion of potassium nitrate is advantageous because of the stabilizing effect of the potassium nitrate on the crystal density of ammonium nitrate due to temperature changes. However, both the melting point depressants and the potassium nitrate represent ingredients whose cost is greater than that of the basic ingredients needed to produce a blasting agent in accordance with this invention,

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and, in some cases, the additional cost may offset the advantages resulting from their inclusion. Accordingly, this inclusion represents a preferred embodiment rather than a critical feature of this invention.

The geodes produced in accordance with the present invention may be used in all types of blasting. For example, they may be used to supplement packaged explosives in a borehole or they may be used as the main blasting charge. They are particularly advantageous, however, when used in boreholes which contain standing water. The term "standing water" is used to refer to the presence of a collected body of water in a borehole as distinguished from wet walls and muck in the bottom of the borehole. The geodes of the present invention, because of their high absolute density, 1.6 to 1.72 grams per cubic centimeter, sink rapidly to the bottom of the borehole. As geodes on the bottom dissolve, the geodes above them settle, thus preventing the fuel released from segregating. When the hole is initiated, the blasting energy of all of the oxidizing agent-fuel combination is thus available.

The present invention has been described in detail in the foregoing. Many modifications and variations will occur to those skilled in the art, and we intend, therefore, to be limited only by the following claims.

We claim:

1. A blasting agent comprising a plurality of geodes having a diameter between 4 and 12 millimeters and consisting essentially of a blend of ammonium nitrate and sodium nitrate having a melting point below 128° C., the interior and the surface of said geode containing from 4 to 7% by weight of a carbonaceous fuel selected from the group consisting of dinitrotoluene, kerosene and castor oil.

2. A blasting agent as claimed in claim 1, wherein urea is incorporated into said blend as a melting point depressant.

3. A blasting agent as claimed in claim 1, wherein said carbonaceous fuel is dinitrotoluene.

4. A blasting agent as claimed in claim 1, wherein said blend includes potassium nitrate.

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