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3,732,129

EXPLOSIVE CHARGES INITIATED BY EXPLODING WIRES

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No Drawing. Filed Nov. 29, 1968, Ser. No. 780,202
Claims priority, application Germany, Dec. 22, 1967,
P 16 46 348.2

Int. Cl. C06b 19/00

U.S. Cl. 149—2

11 Claims

ABSTRACT OF THE DISCLOSURE

Explosive materials of the group brisant explosives and priming powders, which normally have densities such that they are not well suited for use with exploding wires used for initiation. Such materials are treated to provide them in a form of reduced density, whereby use therein of exploding wires is accommodated. The explosive material in the form of small particles is molded to form a body thereof, with the aid of a binder, to provide the material with a density of about 30–65% of the average crystal density of the explosive material. The exploding wire is embedded in the molded body, and, the ignition energy of the exploding wire is about 0.1–120 joules.

BACKGROUND OF THE INVENTION

The present invention relates to a method for the preparation of molded bodies of brisant and very safe-to-handle explosives or of priming powders which can be initiated by exploding wires.

It is in the prior art to initiate explosive compositions by means of initial detonating agents. This, however, involves the danger of accidental initiation by mechanical stress, by stray electric currents, by stray electromagnetic fields, or by electrostatic charges, among other things. These hazards are avoided by performing the initiation of explosives with exploding wires, without using initial detonating agents. This method has acquired considerable importance in recent years for reasons of safety, because exploding wires initiate the explosive in which they are embedded only when the applied voltage has a certain value which is specific for a wire of a certain material having a defined length and a given diameter; furthermore, initiation by exploding wires depends to a great extent on the shortness of the duration and on the intensity of the pulse of electric current.

Wire ignition is used advantageously in rocketry and space technology, where there is a special need for igniting devices of great safety, which are not subject to the factors involved in ignition by initiating agents, as described above. For example, the separation of rocket stages or the destruction of off-course rocket stages, and other ignition processes in rockets are performed by means of the wire-detonation of brisant explosives. Another advantage of the ignition of rocket fuel charges by exploding wires consists in the fact that the ignition lag can in this manner be considerably shortened and can be kept substantially constant, thus achieving a more rapid pressure rise in the rocket.

Initiation by exploding wires makes it possible both in the case of explosives and in the case of initial detonating agents to progress beyond point initiation to linear, areal or three-dimensional initiation by means of linear, annular, areal or three-dimensional arrangements of the ignition chain and thus to obtain certain particular detonation fronts or areas of ignition. Ignition chains of this sort consist of alternate pieces of a thick wire and a thin wire of the same or different length.

If an electrical impulse of high voltage is passed through such a chain, the thin pieces of wire undergo an

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explosive reaction. The high-temperature plasma of the wire metal that expands from the point of explosion, accompanied by a shock wave, serves for the initiation of the explosive surrounding the wire or for the ignition of the priming composition. The make-up of the chain, as described above, assures simultaneous and uniform initiation of the explosive or of the priming composition over the entire length of the chain.

For the practical application of point igniters or chain igniters made of exploding wires in explosives or in priming powders, it is necessary that:

(1) The wire or chain be completely enveloped by the explosive or priming powder, and

(2) The enveloping explosive or priming powder have as good mechanical strength as possible;

(3) The density of a molded body made from the explosive or from the priming powder and containing the point primer or chain primer be considerably lower than the crystal density of the explosive or priming powder. For example, PETN [pentaerythritol tetranitrate], whose crystal density is 1.7 g./cm.³, can be initiated by an exploding wire, at the low electrical energies which are justifiable in practice (about 0.1 to 120 joules), only at densities lower than 1.1 g./cm.³. (Conference reports, "Exploding Wires," Plenum Press, New York, 1962 and 1964).

THE INVENTION

Now, the problem existed of enveloping a point primer or chain primer with a molded body of a brisant explosive in such a manner that the molded body, in spite of the high crystal density of the brisant explosive, has a density amounting to 30 to 65%, preferably 35 to 55%, of the average crystal density of the brisant explosive or of the priming powder, but at the same time has a good mechanical strength and can be initiated by ignition energies of 0.1 to 120 joules.¹

It has already been proposed to reduce the density of an explosive while at the same time preserving its resistance to mechanical stress by the simple addition of glue or cold-setting plastics. However, this procedure has the disadvantage that the addition of these inert substances to brisant explosives reduces greatly the responsiveness of these explosives to ignition by exploding wires; hence, a considerably higher energy is needed for the ignition of such explosive compositions than would be necessary without the addition of these inert substances. In many cases, such explosive mixtures cannot be initiated at all.

The present invention, therefore, has to do with a method for the preparation of molded bodies of brisant explosives or priming powders having point primers or chain primers embedded in them, the said bodies being suitable for wire ignition at an ignition energy of 0.1 to 120 joules, and having a density amounting to 30 to 65%, preferably 35–55%, of the average crystal density of the brisant explosive or priming powder. These molded bodies do not exhibit the above-mentioned disadvantages when they are manufactured according to the invention by heating in a mold wire igniter embedded in a mixture of brisant explosive or priming powder and 0.2 to 12% by weight of the exploding material plus binder, of a fusible binding agent that is solid at room temperature and whose melting or softening temperature is below the melting or decomposition temperature of the brisant explosive or priming powder, so as to raise it to a temperature below the melting or decomposition temperature of the explosive or priming powder, and above the melting point or softening range of the binding agent, and then cooling it.

¹ Under average crystal density we understand the arithmetical average value of the crystal densities of components of the employed high explosives or of the priming powders.

Thus, the invention provides an explosive article consisting essentially of an explosive material of the group of brisant explosives and priming powders, in the form of small particles, and a binder bonding said particles together to form a body thereof. A point or chain exploding wire igniter is embedded in the body of explosive material. The molded body has a density of about 30–65% of the average crystal density of the explosive material. The amount of binder is about 0.2–12 weight percent of the explosive material plus binder, and the binder is a fusible, normally solid material having an activation temperature for the binding of the particles of explosive material together (the softening or melting temperature of the binder) below the deformation temperature of the explosives (the melting or decomposition temperature of the explosive material). The ignition energy of the igniter is about 0.1–120 joules.

By brisant explosives according to the invention is meant those explosives whose detonation speed is greater than 5,000 meters per second, and which are not initial detonating compositions; examples are: PETN (pentaerythritol tetranitrate) hexogen, octogen (cyclotetramethylene tetranitramine) (HDX), nitromannitol. Priming powders according to the invention are lightly compressed, fast-burning, non-exploding mixtures of (1) oxygen-yielding inorganic salts or oxides, preferably nitrates (e.g. ammonium, nitrate, sodium nitrite, ammonium oxalate or dichromate potassium nitrate), (2) combustible substances, preferably wood charcoal, carbon black or wood flour, and optionally (3) metal powder, preferably powder of aluminum, magnesium or boron, which are used preferably for the ignition of rocket fuels and to which inert substances can be added if desired.

Binding agents can be aromatic nitro compounds, and aromatic, heterocyclic and aliphatic nitramines, which are solid at room temperature, fusible, and capable of detonative reaction, and whose melting point is lower than the melting point or decomposition temperature of the brisant explosive or of the priming powder, and which do not decompose at their melting temperature.

An example is trinitrotoluene.

However, a diphenyl urea substituted by one or more alkyl or aryl radicals, e.g. diethyl or dimethyl diphenyl urea, can also be used as a binding agent, providing the melting point or the softening temperature of these compounds is lower than the melting or decomposition temperature of the brisant explosive or of the priming powder.

Bodies of any desired shape can be made, according to the shape of the mold in which the mixtures are heated, the point igniter or chain igniter serving for the initiation being simultaneously incorporated therein.

The density of the molded body depends on the quantity of binder added, the temperature and the time for which the temperature is maintained, and also in some cases the pressure that is exerted on a plunger by which the mold is stoppered.

The amount of binding agent added can amount, according to the invention, to from 0.2 to 12%, and is preferably 0.5 to 10% of the weight of the molded body. The greater the amount added is, the greater becomes the density of the molded body on which, in turn, the amount of igniting energy depends and which influences the speed of detonation, or deflagration, as the case may be. The density can amount to up to 1.1 g./cm.³, but if possible it should not exceed 0.85 g./cm.³, since otherwise the igniting energies become too high.

The duration of the heating within the temperature range according to the invention can vary widely. In many cases the desired temperature needs to be maintained only until all parts of the body have this temperature, but it can also be maintained for hours.

The plunger pressure on the mold can be adjusted so as to amount to between 0.1 and 1.5, and preferably between 0.5 and 1.0 kp./cm.². To achieve bodies of uniform volume and uniform density, the movement of the com-

pression plunger can be restricted while the quantity of composition weighed in remains the same.

In accordance with the present invention, it is possible to prepare porous rods, rings or the like, in which the deflagration proceeds from the embedded source of ignition uniformly throughout the length. Hollow balls consisting of condensation products of phenol and formaldehyde, or of pre-expanded polystyrene foam, are then also added to the mixture that is to be heated.

Furthermore, it is possible to make the brisance of the molded bodies according to the invention increase with the distance from the point igniter or chain igniter, so that the molded bodies will also be able to detonate explosives that are difficult to initiate (e.g., cast TNT). For this purpose the molded bodies are given a density that increases from the point igniter or chain igniter out. This density increase can be continuous or in steps.

EXAMPLES 1–7

TABLE 1

| | PETN:TNT composition in percent by wt. | Density, g./cm. ³ | Detona- tion speed in m./s. | Ignition energy, in joules |
|--------|--|---------------------------------|--------------------------------------|----------------------------------|
| 1..... | 99.5:0.5 | 0.630 | 4,200 | 4 |
| 2..... | 99:1 | 0.651 | 4,290 | 4 |
| 3..... | 98:2 | 0.738 | 4,450 | 6 |
| 4..... | 96:4 | 0.767 | 4,600 | 12 |
| 5..... | 9:64 | 0.797 | 4,730 | 16 |
| 6..... | 92:8 | 0.826 | 5,100 | 16 |
| 7..... | 90:10 | 0.850 | 5,300 | 20 |

Examples 1 to 7 listed in Table 1 were prepared as follows:

Pentaerythritol tetranitrate (PETN) and trinitrotoluene (TNT) were mixed in the stated quantity ratios by known methods; ignition wires of gold having a diameter of 0.05 to 0.1 mm. and a length of 1.5 to 5 mm. were installed and the whole was heated in a mold at 85° C. Instead of ignition wires of gold, wires made of silver, platinum, nickeline or other materials known in the exploding wire art can also be used. After three hours of heating at this temperature the mold was cooled. The molded bodies obtained were all mechanically solid bodies, had the detonation speeds and densities listed in the table, and could be initiated by exploding-wire ignition using the stated ignition energies.

Round and square sticks having a length of 170 mm. were also prepared from the mixtures named in the examples, and they were ignited by the igniter chain having as many as 30 exploding sections. By means of X-ray flash photographs it was proven that the igniter chains were initiated uniformly and simultaneously over the entire length; the same is also true in the case of an areal or three-dimensional arrangement of such ignition chains in the molded bodies according to the invention.

EXAMPLES 8–10

TABLE 2

| | Composition, PENT:diethyl diphenyl- urea in per- cent by weight | Plunger pressure in kp./cm. ² | Density in g./cm. ³ | Detona- tion speed in m./s. | Ignition energy joules |
|---------|---|---|--------------------------------------|--------------------------------------|------------------------------|
| 8..... | 98:3 | (a) 0.2..... (b) 0.3..... | 0.58 0.76 | 4,000 4,600 | 12 12 |
| 9..... | 95:5 | (a) 0.2..... (b) 0.3..... | 0.62 0.84 | 4,300 4,950 | 24 25 |
| 10..... | 90:10 | (a) 0.2..... (b) 0.3..... | 0.76 0.84 | 4,000 5,250 | 100 110 |

Examples 8–10 in Table 2 were prepared in the same manner as Examples 1–7, except that the different pressures were exerted on the plunger on the mold. These examples show that, as the percentage of binder by weight increases, the density of the molded body increases, and that this is simultaneously accompanied by an increase in the required ignition energy.

EXAMPLE 11

Round and square sticks 170 mm. long and having a diameter or thickness of 20 mm. were prepared analo-

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gously to Examples 1-7, and equipped with ignition wires consisting of a chain of 30 firing sections. The composition of the sticks was as follows (in percent by weight):

| | Percent | |
|--|---------|---|
| KNO ₃ ----- | 68.0 | 5 |
| Wood charcoal ----- | 17.5 | |
| Hollow balls of a phenol-formaldehyde resin ---- | 5.0 | |
| Trinitrotoluene ----- | 9.5 | |

The ignition energy for such sticks amounted to 50 joules, and the ignition time was 19 ms. (1 ms.=10⁻³ sec.).

It can be proven by motion pictures made with a high-frequency motion picture camera ("Fastax") that the sticks deflagrate simultaneously and uniformly throughout the entire length.

EXAMPLE 12

A body was molded analogously to Example 11 from the same components, but the following percentage composition (in percent by weight):

| | Percent | |
|--|---------|----|
| KNO ₃ ----- | 66.5 | |
| Wood charcoal ----- | 16.3 | 25 |
| Trinitrotoluene ----- | 7.2 | |
| Hollow balls of a phenol-formaldehyde resin ---- | 10.0 | |

The sticks prepared had the same shape as those of Example 11, and the ignition energy required by the chain of 30 firing sections also mounted to 50 joules and the ignition time of the stick was 18 ms. The stick deflagrated uniformly through its entire length.

What is claimed is:

1. A molded explosive article consisting essentially of:
 - (a) an explosive material selected from the group consisting of brisant explosives which are nitrated polyvalent alcohols or nitrated amines, and priming powders which are a mixture of an oxygen-yielding inorganic salt or oxide and a carbonaceous fuel, in the form of small particles,
 - (b) a binder bonding said particles together to form a body thereof,
 - (c) a point or chain exploding wire igniter embedded in said body,
 - (d) the molded body having a density of about 30-65% of the average crystal density of the explosive material,
 - (e) the amount of said binder being about 0.2-12 wt. percent of the explosive article,
 - (f) said binder being a fusible, normally solid material for the binding of the particles of explosive material together, having an activation temperature below the deformation temperature of the explosive,
 - (g) the ignition energy of the igniter being about 0.1-120 joules.
2. Explosive article according to claim 1, said density being about 35-55% of average crystal density of the explosive material.
3. Explosive article according to claim 1, the binder being a detonatable aromatic nitro compound or a detonatable aromatic, aliphatic, or heterocyclic nitramine, or an alkyl or aryl substituted diphenyl urea or a mixture thereof.
4. Explosive article according to claim 1, the binder being an alkyl or aryl substituted diphenylurea or a mixture thereof.

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5. Explosive article according to claim 1, the explosive material consisting essentially of:

pentaerythritol tetranitrate
hexogen
octogen

nitro mannitol or
a mixture thereof,

and the binder consists essentially of
trinitrotoluene
diethyldiphenyl urea or
a mixture thereof.

6. Explosive article according to claim 1, wherein the explosive material consisting essentially of an inorganic nitrate salt and carbon, and the binder consists essentially of

trinitrotoluene
diethyldiphenyl urea or
a mixture thereof.

7. Explosive article according to claim 1 and containing voids.

8. Process of producing a molded body of an explosive material selected from the group consisting of brisant explosives which are nitrated polyvalent alcohols or nitrated amines, and priming powders which are a mixture of an oxygen-yielding inorganic salt or oxide and a carbonaceous fuel, having a point or chain exploding wire igniter embedded therein, according to claim 1 which comprises:

assembling a mixture of the explosive material, the binding agent, and the igniter whereby the igniter is embedded in the binder and explosive material, molding the mixture of the explosive material and the binding agent to the desired shape, said mixture having the igniter embedded therein,

said binder being normally solid and having an activation temperature below the deformation temperature of the explosive,
heating the mixture to activate the binder without deformation of the explosive,

and thereafter cooling to solidify the binder, the molded body having a density of 30-65% of the average crystal density of the explosive, and the ignition energy of the igniter being about 0.1-120 joules.

9. Process according to claim 8, wherein the molding is performed under a pressure of about 0.1-1.5 kp./cm.².

10. Process according to claim 8, wherein the molding is performed under a pressure of about 0.5-1.0 kp./cm.².

11. Explosive article according to claim 1 wherein the explosive material consists essentially of potassium nitrate, sodium nitrate, ammonium nitrate of a mixture thereof and the binder consists essentially of trinitrotoluene, diethyldiphenyl urea or a mixture thereof.

References Cited

UNITED STATES PATENTS

| | | | |
|-----------|---------|----------------------|----------|
| 2,988,994 | 6/1961 | Fleischer Jr. et al. | 102-28 X |
| 3,040,660 | 6/1962 | Johnston | 102-28 |
| 3,135,636 | 6/1964 | McGirr | 149-18 |
| 3,156,186 | 11/1964 | Picciano et al. | 102-28 |
| 3,181,463 | 5/1965 | Morgan et al. | 102-28 |

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U.S. Cl. X.R.

102-28; 149-20, 47, 55, 56, 57, 62, 69, 92, 105, 108; 264-3 R