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C1D D7A
F3A AC1A2 AC1A3 A1B1

(56) Documents Cited

GB 2176848 A	**GB 1106396 A**
GB 0652542 A	**GB 0625672 A**
GB 0544252 A	**US 4369688 A**
US 3574800 A	

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(54) Abstract Title
Production of energetic materials

(57) A method of producing an elongate body of enegetic material which comprises extruding a first energetic material to form a core and extruding around the core a second energetic material or moderator to form a composite in which the first and second materials are bonded together. The said materials may be gun or rocket propellants and may be extruded simultaneously.

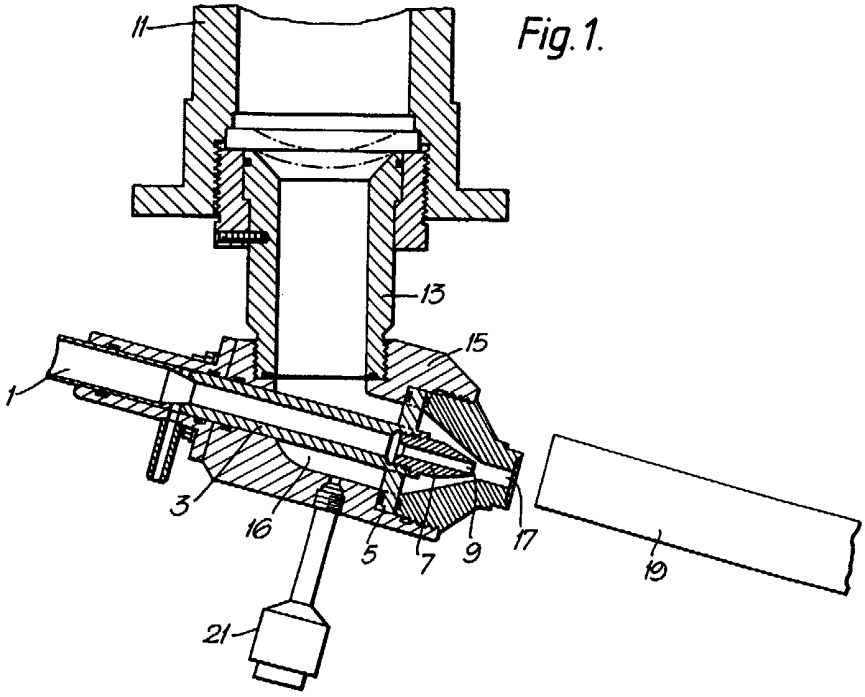

Fig. 1.

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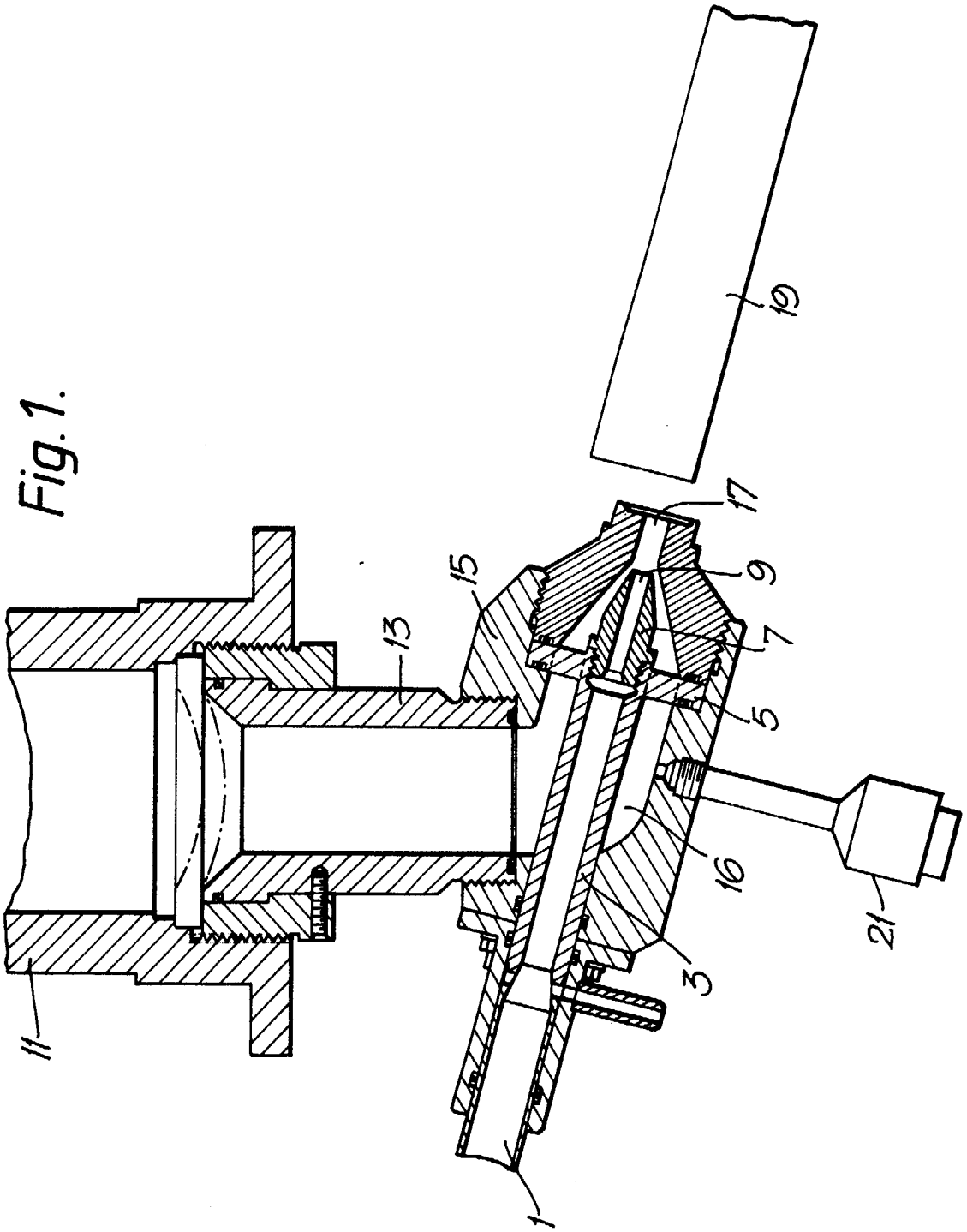
Fig. 1.



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PRODUCTION OF ENERGETIC MATERIALS

The present invention relates to the production of energetic materials.

According to the present invention a method of producing an elongate body of energetic material comprises extruding a first material which comprises a viscous intimate mixture of an energetic material and a polymeric binder together with a moving body of a second material to form a composite in which the first and second materials are bonded together.

The first material may for example be a coating material and the second material may be a core material embedded within the coating material. The core material may conveniently be a cord which has emerged from an inner die by drawing or extrusion. Thus, the output cord (forming the core material) from a first die may form the inner feed to a second die, the second outer feed to which is an extrudable coating material.

The second material may be a ductile solid such as a metallic wire which may for example be drawn through a die through which the polymer bonded energetic material is extruded thereby to coat the wire. Preferably, the ductile solid is drawn at the same rate as that at which the extrusion is carried out.

Alternatively, the second material may be a polymeric or a polymer-bonded material which is co-extruded together with the first material. Preferably the extrusion of both materials is carried out at the same rate. In this case, composite

polymer-bonded energetic materials may be formed in which different formulations are brought together as different adhered layers of a composite body.

The viscosity of the first material and, where co-extruded, the second material is preferably in the inclusive range 0.1KPa sec to 100 KPa sec.

Preferably the Figure of Insensitiveness of the energetic material is above 100, desirably greater than 150.

The extruded material may be or contain a solventless polymer. Alternatively, the extruded material may include a solvent to facilitate processibility. Simple organic solvents such as ethanol or diethyl ether are suitable as processing solvents for energetic materials.

The temperature of extrusion depends on the particular material involved, but in general elevated temperatures are preferred to soften the material being extruded. Typically, although not essentially, the temperature is in the inclusive range $50^{o}C$ to $100^{o}C$.

In order to maintain safety in handling energetic material, the method according to the invention is preferably carried out by an apparatus which is housed in a safe building or structure remote from human operators. Preferably, processing parameters such as rate of extrusion, temperature, pressure and solvent content are continuously monitored.

Automatic closed loop control may be provided so that for instance an increase in detected pressure is followed by a decrease in extrusion rate or in the event of detecting an incident such as fire an automatic flooding of the apparatus with water is triggered.

The extruders used to extrude energetic materials in the process of the present invention may be selected from any

suitable known extruders, eg. press extruders, ram extruders or co-rotating twin screw extruders.

Examples of various kinds of energetic products which may be produced by the method according to the present invention are as follows:

(1) Gun Propellants

Such propellants are known in the prior art in the form of pellets, tubes, multitubes, slotted tubes, sticks or strands or combinations of these forms produced by mixing the relevant ingredients and pressing them together and optionally coating the pressed mixtures by dipping eg. with a burning rate moderator. By forming the propellant by the method according to the present invention, different ingredients, eg. basic propellant composition and moderator or propellant compositions of different burning rate, may be combined together in a single composite structure in a highly controlled fashion thereby allowing the product to be kept closely within quality specifications and to allowing waste to be reduced. The form of the product obtained by selection of one or more suitable extrusion dies may otherwise be the same as the prior art.

The required length is obtained by chopping the co-extrudate at suitable intervals. This is preferably carried out as close as possible to the extrusion.

Gun propellant formulations suitable for processing by the method of the present invention include so-called single, double, triple and multiple-base compositions all of which are based on nitrocellulose as energetic polymer and, where required nitroglycerine as energetic plasticiser. Other gun propellant formulations such as so-called "lova" materials which are highly energetic materials which contain no or little nitroglycerine may also be used. Such materials are generally based upon compositions containing as highly energetic filler nitramines such

as RDX or HMX, together with a polymeric binder such as polyurethane, polyester or poly(ethylene-vinyl acetate) and optionally an inert or energetic plasticiser other than nitrogylcerine.

According to a preferred feature of the present invention a gun propellant element formed by the method according to the present invention comprises a body formed of an inner region comprising a first propellant composition having a first burning rate the inner region having on its surface a uniformly thick coating of a second propellant composition having a second burning rate substantially lower than the first burning rate. The said element may be any of the gun solid propellant shapes known in the prior art, eg. a cylindrical pellet, stick or length. The cross-sectional shape of the element may be solid circular. Alternatively, the element may be tubular, multi-tubular or slotted tubular. The said element may comprise a stick having a slotted tubular form, the second propellant composition forming a coating on both the outside and inside surfaces of the inner region, the inner region being a slotted tubular core. We have found that unexpectedly the propellant element according to this feature of the present invention beneficially provides a propellant burning pressure v time curve which is broader than that obtained individually with either the first or second propellant compositions. Such a curve provides an increase in propellant force without the incidental increases in flame temperature and pressure peak normally associated with such a force increase. Increased flame temperature and pressure peak normally lead to an enhancement of gun barrel erosion. The relative amount of the first and second propellant compositions present in the said element depend on the respective individual burning rate, pressure v time curves and geometrical dimension of the inner and other regions. However, it will be evident to

those skilled in the art that from these properties of the individual propellant regions various pressure-time curves can be obtained as desired by known numerical analytical and modelling techniques.

2. Rocket Propellant Grains

Rocket propellants may be produced by casting solid grains together with a casting liquid eg. as in the method described in UK Patent No. 1,179,415. The grains employed in this type of process, known as the base grain process, may be produced by co-extrusion by the method according to the present invention where it is desired to provide the grains in a form in which they are coated more richly with one ingredient of their composition.

3. Plastic bonded explosives

These generally comprise high explosive solid fillers such as nitramines bonded by a flexible polymeric binder, eg. based upon polyurethane, polytetrafluroethylene or poly(ethylene-vinyl acetate). The materials may be required to be produced in special shapes for particular applications, eg. cutting charges. Different ingredients of the plastic bonded explosive or different plastic bonded explosive compositions may be co-extruded by the method according to the present invention to give a single blend of properties. Alternatively, a plastic bonded explosive composition may be co-extruded with an inert polymer based material. For example, linear cutting charges of the form described in UK Patent No. GB 2176878B sold by the present applicants under the trade mark EXPLOSIVE CUTTING TAPE comprise an explosive strip incorporating a substantially V-shaped hollow groove lined with a metal filled polymeric material. The explosive strip and its liner may conveniently be co-extruded by the method according to the invention thereby simplifying the process of production of the charge.

4. Initiatory cords

These known products comprise an easily ignitable metal, eg. comprising fine wire containing magnesium, incorporated within a cord body comprising an explosive material.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view of an apparatus for carrying out the process according to the invention.

Figure 1 shows an apparatus suitable for the production of co-extruded gun propellant cords. A first propellant constituent is charged in a dough form in a feed tube 1 and is fed be a screw driven piston (not shown) into a narrower tube 3 having fitted at its end a mandrel 5 and a guide bush 7 forming a die 9 through which the first propellant constituent may be extruded as a cord. A second propellant constituent is charged in dough form in a conventional vertically arranged press cylinder 11 from which it is pressed by a conventional press screw (not shown) through an adaptor 13 fitted on the lower end of the cylinder 11 which communicates with a barrel 15 fitted around the tube 3. The barrel 15 has a cavity 16 including a bend which allows the direction of travel of the second propellant ingredient to join that of the first propellant ingredient. The barrel 15 has a tapering internal diameter leading to an extrusion die 17. The axis of the die 17 is co-incident with that of the die 9 and the extruded cord produced as an output from the die 9 is fed along the axis of the die 17 where it is coated with the second propellant ingredient. The extruded output from the die 17 is thereby cord of the first propellant ingredient embedded within a coating of the second propellant ingredient. The coated cord travels down a collection chute 19 and may be cut to a desired length in a known way by a cutter (not shown).

The pressure inside the barrel 15 may be monitored by a conventional pressure transducer 21 and the feeding actions may be stopped when the pressure rises above a pre-determined safe limit. Air may be withdrawn from the feed tube 1 via a vacuum adaptor 23 and outlet tube 25 fitted thereto.

CLAIMS

1. A method of producing an elongate body of energetic material which comprises extruding a first material which comprises a viscous intimate mixture of an energetic material and a polymeric binder together with a moving body of a second material to form a composite in which the first and second materials are bonded together.

2. A method as claimed in claim 1 and wherein the first material is a coating material and the second material is a core material embedded within the coating material.

3. A method as claimed in claim 2 and wherein the core material is a cord which has emerged from an inner die by drawing or extrusion, the output cord comprising the core material from a first die forming the inner feed to a second die, the second outer feed to which is an extrudable coating material.

4. A method as claimed in any one of the preceding claims and wherein the second material is a ductile solid which is drawn through a die through which the polymer bonded energetic material is extruded thereby to coat the wire.

5. A method as claimed in any one of claims 1 to 3 and wherein the second material is a polymeric or a polymer-bonded material which is co-extruded together with the first material.

6. A method as claimed in claim 5 and wherein composite polymer-bonded energetic material is formed in which different formulations are brought together as different adhered layers of a composite body.

7. A method as claimed in claim 1 and wherein the viscosity of the first material and, where co-extruded, the second material is in the inclusive range 0.1KPa sec to 100 KPa sec.

8. A method as claimed in any one of the preceding claims and wherein the energetic material comprises a gun propellant.

9. A method as claimed in any one of claims 1 to 7 and wherein the

energetic material comprises a grain for the production of a rocket propellant.

10. A method as claimed in any one of claims 1 to 7 and wherein the energetic material comprises a linear cutting charge.

11. A method as claimed in any one of claims 1 to 7 and wherein the energetic material is an iniatory material.

Amendments to the claims have been filed as follows

1. A method of producing an elongate body of energetic material by extruding a first material comprising a first propellant composition said first material forming a core, and extruding around said core, a second material comprising a second propellant composition or a moderator, to form a composite in which the first and second materials are bonded together.

2. A method according to claim 1 wherein the second material is a propellant composition having a lower burning rate than that of the first propellant composition.

3. A method according to claim 1 or claim 2 wherein the first propellant composition is a gun propellant.

4. A method according to claim 3 wherein the said core is of slotted tubular form and the second material forms a coating on both the inner and outer surfaces thereof.

5. A method according to claim 1 or claim 2 wherein the first propellant material is a rocket propellant.

6. A method according to any one preceding claim wherein the viscosity of the first material and of the second material is in the inclusive range 0.1KPa sec took 100KPa sec.

7. A method according to claim 1 and substantially as hereinbefore described.

8. A composite element of a propellant charge being an elongate body formed by a method according to any one preceding claim.

INVESTOR IN PEOPLE

Application No:	GB 8908707.6	**Examiner:**	R C Kennell
Claims searched:	1 at least	**Date of search:**	16 October 1989
		additional search	30 October 1992

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X	1,5,6,10	GB 2176878A	ROYAL ORDNANCE
X	1,2,3,11	GB 1106396	DU PONT
X	1,5,11	US 4369688	YUNAN
X	1-4,8,9	US 3574800	PIERCE
X	1 at least	*GB 0652542	I.C.I
X	1 at least	*GB 0625672	LAVORAZIONE
X	1 at least	*GB 0544252	I.C.I
		*from additional search made on 30 October 1992	

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[ᵛ]:

B5A, *C1D, *F3A

Worldwide search of patent documents classified in the following areas of the IPC[ᵛ].

C06B

The following online and other databases have been used in the preparation of this search report:

Online:WPI