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( 16 of 23 )

**United States Patent**  
**Canterberry**

**5,062,365**  
**November 5, 1991**

Rapid burning propellant charge for automobile air bag inflators, rocket motors, and igniters therefor

**Abstract**

A rapid burning propellant charge for applications including igniters, launch eject motors, and gas generators for automobile air bags. The propellant charge comprises a reticulated substrate having a quantity of interconnected ligaments and a coating of solid propellant material on the ligaments. In order to provide a large amount of surface area for a fast burn time, interstices are between coated ligaments to define propellant surface area for combustion. In applications where minimum smoke is desired, the reticulated substrate is preferably composed of carbon, graphite, or a non-combustible material, and the solid propellant material is preferably a minimum smoke type.

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**Related U.S. Patent Documents**

<u>Application Number</u>	<u>Filing Date</u>	<u>Patent Number</u>	<u>Issue Date</u>
158829	Feb., 1988	5024160	
908763	Sep., 1986	4798142	

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**Current International Class:** C06B 45/00 (20060101); C06B 21/00 (20060101); C06D 5/00 (20060101); B60R 21/26 (20060101); F42B 5/00 (20060101); F42B 5/16 (20060101); F42B 3/04 (20060101); F42B 3/00 (20060101); F42B 003/00 (); F42B 015/10 ()



<a href="#">4418622</a>	December 1983	Foster et al.
<a href="#">4547342</a>	October 1985	Adams et al.
<a href="#">4574700</a>	March 1986	Lewis
<a href="#">4793955</a>	December 1988	Poulter et al.

#### Foreign Patent Documents

45-20199	Jul., 1970	JP
660789	Nov., 1951	GB
885409	Dec., 1961	GB
972724	Aug., 1965	GB
1172221	Mar., 1972	GB

#### Other References

Brochure, "Duocel, a New Basic Design Material", by Energy Research and Generation, Inc.

Technical Report AFRPL-TR-68-232, Dec. 1968, "Foamed Aluminum Propellant Study." .

Brochure, "Duocel Foam Metal, a New Basic Design Material for Energy Absorption and Structural Applications", by Energy Research and Generation, Inc. .

Brochure, "Duocel Foam Metal, a New Basic Design Material, Passive Omnidirectional Borehole Deformation Gauge", by Energy Research and Generation, Inc. .

Brochure, "ERG Evolutionary Basic Design Materials", by Energy Research and Generation, Inc. .

Brochure, "Reticulated Vitreous Carbon", by Energy Research and Generation, Inc. .

"Scott, Chemotronics Get Reticulation Patents", C&EN, Jun. 7, 1965, p. 42..

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#### *Parent Case Text*

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This is a divisional of application Ser. No. 158,829, filed on Feb. 11, 1988, and now U.S. Pat. No. 5,024,160, which is a divisional of application Ser. No. 908,763, filed Sept. 18, 1986, now U.S. Pat. No. 4,798,142.

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#### *Claims*

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What is claimed is:

1. An igniter comprises a gas generant charge including a reticulated substrate having a network of interconnected ligaments and a coating of solid gas generant composition on said ligaments, said solid gas generant composition being interconnected in the form of a network, said coating has a thickness such that interstices are between coated ligaments which interstices define open gas generant surface area for supporting combustion, said interconnected ligaments defining voids which are open to each other so that the gas generant may constitute a single mass.



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The present invention relates to solid propellant charges. Uses of the propellant charges of the present invention include, but are not limited to, igniters and launch eject motors where it is desired that the propellant charges burn rapidly for rapid development of heat or thrust. Other uses of the propellant charges of the present invention are as gas generators for automobile air bag inflators as well as other apparatus where it is desired to produce inflating gas rapidly. Therefore, for the purposes of this application and the claims, a "propellant charge" is meant to include gas generators for air bag inflation systems and other inflation systems. However, it should be understood that this invention is not limited to just these uses, but may find uses, for example, as main propulsion propellant charges for rocket motors.

A typical solid propellant charge includes a fuel such as aluminum particles and an oxidizer such as ammonium perchlorate which are usually bound together by a binder such as hydroxy terminated polybutadiene. The binder may also act as a fuel. Where the fuel and oxidizer are separate materials which are mixed together to form the propellant, the propellant is known as a "composite propellant".

A composite propellant is usually manufactured by blending the ingredients into a thick and viscous but still pourable mixture which is then added to the rocket motor chamber where the mixture is cast and cured into a solid mass of propellant material in position for use. For some applications such as igniters and air bag inflators, the propellant mixture may be extruded into a desired geometric shape such as, for example, pellets for an air bag inflator, as illustrated at 62 in U.S. Pat. No. 4,547,342 to Adams et al.

In a solid propellant charge, burning proceeds in a direction perpendicular to the surface at all times. Thus, in a type of rocket motor known as an end burner wherein the propellant grain is a solid mass of propellant without a perforation therein, burning is initiated at the nozzle end and proceeds in a direction toward the head end of the rocket. The burning time for an end burner type of propellant grain is relatively slow compared to those propellant grains which are perforated longitudinally usually along their longitudinal center lines. In this type of grain, burning may be initiated along the entire length of the propellant grain so that the burning proceeds from the perforation radially outwardly toward the rocket motor case. The burning time for a propellant charge is also determined by the shape of the internal perforation, the shape known as a "tube shape" or "center perforate" being relatively slower burning, for example, than the shape known as the "internal star shape" of propellant grain.

Tactical weapons such as canister fired missiles may use launch eject motors containing solid propellant charges for ejecting missiles out of their canisters before their main motors ignite. It is desirable that the propellant grain for the launch eject motor as well as the propellant charge for the igniter for the flight motor thereof be of the smokeless or minimum smoke type since large quantities of smoke or exhaust including any toxic gas therein may be injurious to the operators thereof, and the smoke or exhaust may undesirably hinder visibility of the target which visibility must be maintained after launch for control of the missile. However, smokeless or minimum smoke propellants do not usually burn as fast as is normally desired. Further, this type of propellant tends to become soft in the high temperatures typically encountered or which may be encountered in areas of the world where such tactical weapons may be used. If the propellant becomes too soft and its physical state is as a result altered such as during acceleration as the missile is ejected from the canister, the burning properties of the propellant are accordingly altered resulting possibly in an inadequate burning rate or possible explosion of the launch eject motor.

It has been suggested in U.S. Pat. No. 3,191,535 to Mulloy to prepare a solid propellant which consists essentially of a cellular fuel element having uniform interconnecting spherical voids of a metal or metal







material 54 such that interstices are between the coated ligaments for increased surface area as will be described more fully hereinafter. As shown in FIG. 4 wherein reticulated carbon is illustrated, the reticulated structure 50 is composed of a multitude of such ligaments 52 which are of generally uniform dimension and interconnected with each other to form voids 55 which are open to each other. For the purposes of this specification and the claims, a "reticulated structure" or "reticulated substrate" is meant to refer to a structure or substrate which is composed of a multitude of ligaments which are interconnected with each other to form voids which are open to each other and includes such a structure as described in the Walz patents.

In order to prevent or reduce the production of smoke from burning of the reticulated structure 50 in accordance with an aspect of the present invention, the reticulated structures 50 for both the launch motor grain 28 and the igniter 40 as well as other applications where a minimum smoke propellant is required are each composed of a non-combustible material, i.e., a material which does not burn at the temperatures and conditions under which the coated propellant is burned, or a minimum smoke material. Although carbon and graphite may be combustible under some conditions such as if the propellant mass is oxygen rich, carbon and graphite produce non-smoke producing carbon dioxide when they burn and are thus minimum smoke materials.

Other applications of the coated reticulated structure of the present invention may not require that the propellant charge be smokeless or of a minimum or reduced smoke type in which case it may be preferable that the reticulated structure 50 be composed of combustible material such as, for example, aluminum, boron, beryllium, or copper so that it will also burn as the propellant material burns to provide increased energy. Thus, it should be understood that the reticulated structure 50 of the present invention is not limited to a minimum smoke or non-combustible material.

The ligaments 52 may be sized such that the reticulated structure 50 only occupies between about 1 1/2 and 6% of the volume of a propellant charge. The coating 54 may be applied to the ligaments 52 by any suitable means commonly known to those of ordinary skill in the art to which this invention pertains such as by dip coating or by spraying onto the ligaments a propellant lacquer prepared by dissolving a propellant material in a suitable solvent such as acetone and then allowing the material to dry on the ligaments. The thickness, illustrated at 56 in FIG. 5, of the coating 54 is determined by applying engineering principles of common knowledge to those of ordinary skill in the art to which this invention pertains in order to achieve desired impulse and other performance requirements. However, in accordance with the present invention, the thickness 56 of the coating 54 is such that interstices, illustrated at 58, are between the interconnected coated ligaments to define propellant surface area 60 for combustion. It may be necessary to repeat the process of dip coating or spraying and then drying several times to allow a build-up of propellant material to the thickness 56 desired. The thickness may be such that the interstices 58 are so small as to be hardly noticeable to the eye so that, taking into consideration the volume taken up by the reticulated structure 50, a very high percentage of perhaps 90 to 97 1/2% of the available volume of a propellant charge is occupied by propellant material but yet the surface area 60 for rapid burning may be increased by perhaps on the order of 500 percent or more.

Referring to FIG. 6, there is shown generally at 70 a gas generator or inflator assembly according to the present invention for the generation of gas to inflate a vehicle inflatable crash protection bag. Inflator 70 has a generally cylindrical external outline and includes a housing construction 72 comprising two structural components. The two structural components comprise an upper shell or diffuser 74 and a lower shell or base 76 which are joined by three concentric inertia welds shown at 78, 80, and 82 to form the housing construction 72 of the inflator assembly 70. The three inertia welds are performed simultaneously in a single inertia welding operation.

The diffuser 74 may be formed by forging with three concentric cylinders 84, 86, and 88, each of which





7.87 2 0.0822 0.6565 6.211 3 0.0895 0.7568 5.84 4 0.0796 0.6095 13.69

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A typical burn time at 1000 psi for the tested propellant material in a conventional solid form without interstices therebetween is between about 0.2 and 0.4 in. per sec. Thus, the test results show that a burn time several times greater than the typical burn time of a propellant material may be achieved by a propellant charge which is composed of the propellant material and which embodies the present invention. Samples of the tested propellant charge were prepared and burned in a window bomb wherein large amounts of subsurface combustion (i.e., combustion in the interior of the coated reticulated structure) were observed.

If the reticulated structure 50 is non-combustible, the remaining structure after combustion may serve as a combustion stabilizer by the damping of pressure or sound waves and may also serve as a means for disrupting gas flow vortex formation. In addition, a carbon reticulated structure may be grounded to the motor case to prevent the hazards of static discharge.

Since the total surface area available for burning in a coated reticulated structure embodying the present invention is so large, such a coated reticulated structure is provided to achieve a fast burn time no matter what the burn rate of the propellant material coated thereon.

It is to be understood that the invention is by no means limited to the specific embodiments which have been illustrated and described herein, and that various modifications thereof may indeed be made which come within the scope of the present invention as defined by the appended claims.

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