

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
22 January 2009 (22.01.2009)

PCT

(10) International Publication Number  
**WO 2009/011769 A1**

(51) International Patent Classification:  
**C06D 5/00** (2006.01) **B60R 21/26** (2006.01)

(74) Agents: **DRAYER, Lonnie, R.** et al.; Key Safety Systems, Inc., 5300 Allen K. Breed Highway, Lakeland, FL 33811-1130 (US).

(21) International Application Number:  
PCT/US2008/008332

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(22) International Filing Date: 7 July 2008 (07.07.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
11/778,222 16 July 2007 (16.07.2007) US

(71) Applicant (*for all designated States except US*): **KEY SAFETY SYSTEMS, INC.** [US/US]; 7000 Nineteen Mile Road, Sterling Heights, MI 48313 (US).

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL,

(72) Inventor; and

(75) Inventor/Applicant (*for US only*): **HOSEY, Edward, O.** [US/US]; 2006 Castle Court, Lakeland, FL 33813 (US).

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(54) Title: GAS GENERATING COMPOSITIONS AND AIRBAG INFLATOR

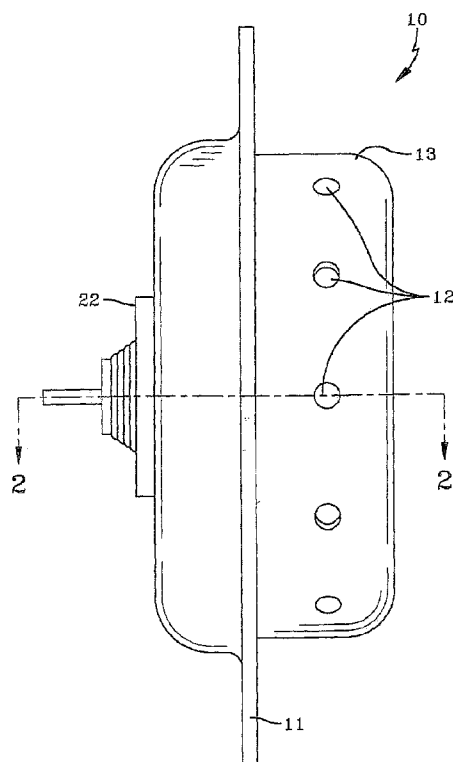


FIG-1

(57) Abstract: Airbag inflators employ gas generating compositions formed from a mixture of fuels and a mixture of oxidizers and preferably mica at levels of 1 to 5 % by weight. The gas generant composition contains a primary and secondary fuel. The primary fuel is a guanidine compound, preferably guanidine nitrate. The secondary fuel is selected from tetrazoles, triazoles and mixtures thereof at levels of 5% by weight or less of the total gas generant composition. The oxidizer system is a mixture of at least two components selected from the group consisting of transition metal oxides, alkali metal nitrates and alkaline earth metal nitrates. The novel gas generants yield inflating gases having a reduced content of undesirable gases such as nitrous oxides and carbon monoxide.

WO 2009/011769 A1



NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG,  
CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— *with international search report*

## GAS GENERATING COMPOSITIONS AND AIRBAG INFLATORS

New gas generating compositions used for inflating occupant safety restraints in motor vehicles are disclosed herein. More specifically, disclosed herein are airbag inflators employing gas generants that have increased gas conversion, lower bad gas production at lower temperatures and pressures, than the prior art gas generants. The new gas generants produce combustion products having acceptable levels of undesirable substances, such as slag. The new gas generants facilitate smaller inflators, as less generant mass is required to inflate the airbag and the lower combustion temperatures lessen damage to the airbag.

Inflatable occupant restraint devices for motor vehicles have been under development worldwide for many years. Gas generating compositions for inflating the occupant restraint devices have been under development for many years and numerous patents have been granted thereon. Because the inflating gases produced by the gas generants must meet strict toxicity requirements, most, if not all gas generants now in use, are based on alkali or alkaline earth metal azides. Sodium azides have been a preferred fuel for gas generant compositions as they react with oxidizing agents to form a relatively non-toxic gas consisting primarily of nitrogen; however there are problems with azide based generants.

A major problem associated with azide based gas generants is the extreme toxicity of the azide itself. The toxicity of the azide based generants makes their use inherently difficult and relatively expensive. In addition, the potential hazard and disposal problems of unfired inflation devices containing azide based generants must be considered.

In contrast the non-azide based gas generants (i.e., guanidine nitrate and 5-aminotetrazole) provide significant advantages over the azide based gas generants with respect to hazards during manufacture and disposal. The non-azide based gas generants heretofore known produce unacceptably high levels of noxious substances upon combustion. The most difficult undesirable gases to control are nitrous oxide and carbon monoxide.

An additional problem associated with the prior art non-azide based gas generants is the significantly higher combustion temperature relative to the azide based generants.

The relatively high levels of nitrous oxide and carbon monoxide produced by the prior art non-azide gas generants is due, in part, to the relatively high combustion temperatures typically exhibited by the non-azide gas generants. For example, the combustion temperature of a sodium azide/iron oxide composition (as the only two components) can range from about 1,200 to about 1,900 degrees Celsius (1,473 to 2,173 ° K), while the non-azide gas generants exhibit combustion temperatures as high as 2,800 degrees Celsius (3,073 ° K). Those skilled in the art understand that utilizing lower energy fuels to reduce the combustion temperature is ineffective because the lower energy fuels do not provide a sufficiently high rate of gas generation, or burn rate, for use in vehicle restraint systems. Adequate burn rate of the gas generant is required to ensure that the airbag system will operate readily and properly.

The aforementioned problems are solved by the new gas generant fuel systems that contain primary and secondary fuel components, mica and a limitation on the amount of the secondary fuel. The fuel system can be from about 40 to 70% by weight of the total gas generant. The primary fuel is selected from the group consisting of guanidine compounds. The secondary fuel is selected from tetrazole and/or triazole compounds. The new gas generant contains an oxidizer system that consists of at least one and preferably at least two components selected from the group consisting of transition metal oxides, alkali metal nitrates and alkaline earth metal nitrates. The new gas generant may contain excipients, processing aides and other compatible additives. In a most preferred embodiment the gas generant contains from 1 to about 5 % by weight of the total fuel composition is mica. The new gas generants produce inflation gases at a desired high burn rate while reducing the production of toxic and/or undesired gases.

US 5 467 715 teaches a gas generant composition comprising between about 20 and about 40 wt. % of fuel, said fuel comprising a

tetrazole and/or triazole compound at between about 50 and about 85 wt. % of said fuel and a water soluble fuel at between 15 and about 50 wt. % of said fuel. US 5 46 715 teaches that up to about 5 wt. %, typically 0.2 to 5 wt. % of a processing aid or binder is employed in the formation of pellets. This processing aid is selected from materials known to be useful for this purpose, including molybdenum disulfide, graphite, nitrocellulose, polyvinylpyrrolidone, sodium silicate, zinc stearate, talc, mica, minerals and others known to those skilled in the art.

US 5 139 588 discloses a gas generating composition comprising: (1) a non-azide fuel; (2) an oxygen containing oxidizer; (3) an alkaline metal salt of an inorganic or organic acid such as 5-aminotetrazole; and (4) a low temperature slag forming material selected from clays, talcs and silica. The nonazide gas generant uses tetrazoles or tetrazole salts as the fuel and nitrogen source. US 5 139 588 discloses the use of oxidizers and additives resulting in solid combustion products which coalesce into easily filtered slag or clinkers.

US 5 500 059 discloses gas generating compositions that contain anhydrous 5-amino tetrazole, its salts, its complexes, and mixtures thereof as the fuel. The oxidizer mixtures comprise a metal oxide or metal hydroxide, namely cupric oxide, and a supplemental oxidizer selected from the group of metal nitrates, metal nitrites, metal chlorates, metal perchlorates, metal peroxides, ammonium nitrate, ammonium perchlorate, and mixtures thereof. From the examples in this reference it is apparent that burning rates for these compositions varied greatly with the highest reported as being 2.465 cm per second (0.986 inches per second) @ 79.08 Kg per sq. cm (1117 pounds per square inch) as seen in Table 3 of this reference. Flame temperatures, listed in Table 4, were only given for a select few compositions. They ranged from 1576 to 1972°K. Gas yield (wt %) was also reported on the same select few compositions and are low ranging from only 34 to 45%.

In contrast, the new compositions disclosed herein have higher burning rates and gas yields with guanidine nitrate being the preferred

primary fuel and 5-amino tetrazole being the preferred secondary fuel. Cupric oxide is utilized as an oxidizer at between 2 to 10% by weight of the total gas generating composition, while the major oxidizer comprising a mixture of strontium and potassium nitrates. Burning rates for the new gas generants are about 2.59 cm per second (1.02 inches per second) @ 70.8 Kg per sq. cm (1000 pounds per square inch) and the combustion chamber temperature is around 2100°K. Gas conversions for the new gas generants are above 73 wt %. Gas yields are in excess of 2.85 moles/100g generant.

US 6 132 537 discloses gas generant compositions comprising a co-fuel system of guanidine nitrate and a heterocyclic organic acid, namely cyanuric acid. The oxidizer system comprises a mixture of cupric oxide, basic copper nitrate, and potassium perchlorate with at least 20% by wt. being one or more transition metal oxides. Burning rates for the compositions disclosed in US 6 132 537 were not revealed. Combustion chamber temperatures were calculated to be 1683°K. Theoretical gas yield for the compositions disclosed in US 6 132 537 using the June, 1988 version of PEP (Propellant Evaluation Program) was calculated to be only 2.34 moles/ 100g generant.

A preferred embodiment of the new gas generant has a fuel system of guanidine nitrate and 5-amino tetrazole. The preferred oxidizer system comprises at least one and preferably at least two compounds selected from the group consisting of cupric oxide, alkali metal nitrates and alkaline-earth metal nitrates. The alkali metal nitrates and alkaline-earth metal nitrates do not produce undesirable chloride salts, as does the potassium perchlorate found in the prior art compositions.

US 6 893 517 discloses gas generating compositions that comprise at least one nitrogen-containing organic fuel, namely guanidine nitrate and a further fuel, nitroguanidine. The oxidizer is potassium perchlorate and the composition incorporates a combustion moderator selected from the transition metal oxides, namely cupric oxide. Burning rates referenced in Table 2 of the patent range from 30.8 to 46.2 mm/s @ 200 bar. Using the

provided pressure exponent referenced in the same table, this translates to a burning rate of 0.82 to 1.40 in/s @ 1000 psi. Theoretical combustion temperatures for these compositions, also referenced in Table 2, range from 2377 to 2462°K. This is quite high for gas generator compositions used in airbags as such temperatures can damage the fabric of the air bag. Theoretical gas conversions are found in Table 2 and range from 78.44 to 81.32%.

US 5 756 929 discloses a gas generant composition containing at least one high nitrogen non-azide fuel selected from the group consisting of guanidine nitrate, aminoguanidine nitrate, guanidine perchlorate, and guanidine picrate; and a secondary fuel of diammonium bitetrazole.

In contrast, the new gas generant fuel system contains primary and secondary fuel components. The fuel system can be from about 40 to 70% by weight of the total gas generant. The primary fuel is selected from the group consisting of guanidine compounds. The secondary fuel is selected from tetrazole and/or triazole compounds. The new gas generant contains an oxidizer system consisting of at least one and preferably at least two components selected from the group consisting of transition metal oxides, alkali metal nitrates, alkaline earth metal nitrates. The new gas generant preferably contains excipients, processing aides and other compatible additives. The most preferred excipient is mica. The new gas generants produce inflation gases at a desired high burn rate while reducing the production of toxic and/or undesired gases.

US 5 765 866 discloses a gas generating compositions having a fuel, one or more oxidizers and mica. The mica content is greater than 5 and less than 25 wt. % of the total gas generating composition. US 5 765 866 provides a good discussion of mica and the testing procedures used for gas generating compositions. US 5 765 866 discloses the gas generant composition is incorporated into an airbag inflator.

There is disclosed herein a gas generant comprising a fuel system, in a preferred embodiment, comprising guanidine nitrate and 5-amino tetrazole. The oxidizer system, in a preferred embodiment, comprises a transition

metal oxide, namely cupric oxide in the range of 2 to 10% by weight of the oxidizer system and the balance is comprised of alkali metal nitrates and/or alkaline-earth metal nitrates. In the most preferred embodiment, the gas generant contains mica.

The alkali metal nitrates and alkaline-earth metal nitrates do not produce the undesirable chloride salts in the gas generated, as does the perchlorates of the prior art compositions. Burning rates for the new gas generants are typically about 1.02 in/s @ 1000 psi and the combustion chamber temperatures are about 2100°K. Gas conversions for the new gas generants are unexpectedly high, generally above about 73 wt. %. A primary advantage of the new gas generant compositions is that reduced levels of toxic and/or undesirable gases are produced. An airbag inflator charged with the new gas generant can be of reduced weight and size.

There is further disclosed herein an airbag inflator comprising: (a) a metal housing; and (b) a gas generant inside the metal housing, the gas generant comprising: (i) greater than 1 and less than 5 wt. % mica; (ii) a primary fuel selected from the group consisting of guanidine compounds; (iii) a secondary fuel at levels of less than 5 % by weight selected from the group consisting of tetrazoles, triazoles and mixtures thereof; (iv) an oxidizer system comprising at least two compounds selected from the group consisting of transition metal oxides, alkali metal nitrates and alkaline earth metal nitrates.

The airbag inflator may contain a gas generant that comprises guanidine nitrate as the primary fuel and at least one compound selected from the group consisting of 5-amino tetrazole, bitetrazole, 3-nitro-1, 2, 4-tiazol-5-one and mixtures thereof as the secondary fuel.

In a most preferred embodiment the new gas generant composition consists of: (a) 45 to 55 weight % guanidine nitrate; (b) 30 to 35 weight % strontium nitrate; (c) 2 to 10 weight % cupric oxide; (d) 2 to 10 weight % potassium nitrate; (e) 1 to 5 weight % 5-amino tetrazole; (f) 1 to 5 weight % boron nitride; (g) 1 to 5 weight % mica; and (h) processing aids selected from the group consisting of tetrazoles, triazoles and mixtures thereof; (iv) an

oxidizer system comprising at least two compounds selected from the group consisting of transition metal oxides, alkali metal nitrates and alkaline earth metal nitrates.

The new airbag inflator may contain a gas generant that is (a) 40-70 wt. % of said primary and secondary fuels; and (b) 30-70 wt. % of said oxidizer system. In one embodiment the primary fuel is selected from the group consisting of guanidine nitrate, nitroguanidine, aminoguanidine nitrate, diaminoguanidine nitrate, triaminoguanidine nitrate and mixtures thereof. In a preferred embodiment the primary fuel is guanidine nitrate and the secondary fuel is 5-amino tetrazole and the oxidizer system comprises potassium nitrate, copper oxide and strontium nitrate. More specifically, the potassium nitrate is 5-10 wt. % of said generant and the strontium nitrate is 40-50 wt. % of said generant. Mica is preferably present at from about 1 to about 5 wt. % of the total gas generant. The gas generant may contain processing aids known to those of skill in the art. Boron nitride is a preferred processing aid.

In one embodiment, the new gas generant composition comprises: (a) a primary and secondary fuel, said primary fuel is a guanidine compound ranging from about 40 to 60% by weight, more preferably from 45 to 55% by wt. of the total gas generant composition and said secondary fuel is a tetrazole or triazole ranging from about 2 to 15% by weight, more preferably from 2 to 10 % by wt. of the gas generant composition; (b) an oxidizer system comprising at least two components, said oxidizer system ranging from about 30 to 70% by weight of said gas generant composition, wherein said oxidizer system consists of (i) a transition-metal oxide ranging from about 2 to 15% by weight, more preferably from 2 to 10 % by wt. of the gas generant composition; and (ii) an alkali metal nitrate, an alkaline-earth metal nitrate, or mixtures thereof, wherein said alkali metal nitrate, alkaline-earth metal nitrate or mixtures thereof range from about 30 to 50% by weight of the gas generant composition; (c) from 1 to 5 wt. % mica; and d) from 0 to 5% by weight of the gas generant composition of a processing additive. In a preferred embodiment the processing aid is boron nitride, the transition-

metal oxide is cupric oxide, the alkali metal nitrate is potassium nitrate, and the alkaline-earth metal nitrate is strontium nitrate.

In yet another embodiment, the secondary fuel is selected from the group consisting of 5-amino tetrazole, bitetrazole, 3-nitro-1, 2, 4-triazol-5-one, and mixtures thereof. Most preferred is 5-amino tetrazole. The primary fuel is selected from the group consisting of guanidine nitrate, nitroguanidine, aminoguanidine nitrate, diaminoguanidine nitrate, triaminoguanidine nitrate, and mixtures thereof. The most preferred primary fuel is guanidine nitrate.

There is further disclosed a gas generant composition comprising: (a) 45 to 55 weight % guanidine nitrate; (b) 30 to 35 weight % strontium nitrate; (c) 2 to 10 weight % cupric oxide; (d) 2 to 10 weight % potassium nitrate; (e) 2 to 10 weight % 5-amino tetrazole; (f) 0 to 5 weight % boron nitride; and (g) 1 to 5 weight % mica; and (h) processing aids.

The new gas generant composition assists in the production of a gas that is low in particulate matter after filtration and toxic and/or undesirable gases. The new generant compositions and the new airbag inflators are easily prepared.

Fig. 1 is a side view of an exemplary airbag inflator useful with the new gas generant compositions.

Fig. 2 is a cross section of the airbag inflator of Fig. 1 taken along line 2-2.

Processing aids, such as silicon dioxide, may be used in the new gas generant. Those skilled in the art understand that depending upon the particular oxidizers and fuels utilized, certain processing aids have beneficial properties over others. Representative of processing aids useful in the new gas generants is silica TS-530 made by the Cabot Corporation of Tuscola, Ill., U.S.A.

The oxidizer system useful in the composition of the new gas generant consists of at least two components, ranging from 30 to 70% by weight of the total gas generant, wherein said oxidizer system consists of a transition metal oxide; and alkali metal nitrates, alkaline earth metal nitrates

and mixtures thereof. Representatives of the alkaline earth metal nitrates useful in the new gas generants include strontium nitrate. The preferred oxidizer system of the new gas generant is a mixture of strontium nitrate, potassium nitrate and cupric oxide.

Mica is useful in the new gas generant compositions. Mica is a name for a group of complex crystalline hydrous aluminum silicate minerals constructed of extremely thin cleavage flakes and characterized by near perfect basal cleavage, and a high degree of flexibility, elasticity, and toughness. The various micas, although structurally similar, vary in chemical composition. The properties of mica derive from the periodicity of weak chemical bonding alternating with strong bonding. Representative of the minerals of the mica group are muscovite, phlogopite, biotite, lepidolite and others such as fluorophlogopite. The silicon to aluminum ratio is about 3:1. Any naturally occurring mica is useful in the new gas generant composition. Those micas containing halogen atoms such as lepidolite and fluorophlogopite are not preferred. The presence of halogen atoms in certain of the mica group minerals may result in the production of combustion gases containing undesirable halogen ions. The mica useful in the composition employed with the new airbag inflators is typically ground mica having a particle size ranging from 2 to 100 microns. This ground mica is often referred to as flake mica. In the new gas generant mica with a particle size in the range of 2-25 microns is preferred.

The new gas generant composition may optionally contain up to about 3 wt. %, typically between about 1 and about 2 wt. %, of a catalyst. Those of skill in the art are aware of the catalysts that are useful in gas generant compositions.

Incorporation of the new gas generants into an airbag inflator is within the skill of the artisan. The gas generant is ignited by heat generated by a booster composition and the resulting chemical reaction generates gas which passes through a knitted wire annular filter and then through a perforated annular tube. A knitted wire cushion is used to protect the gas generant pellets.

An autoignition substance is in close proximity to the booster composition. An autoignition substance is a composition that will spontaneously ignite at a preselected temperature and thereby ignite the booster composition that will then ignite the gas generate.

#### EXAMPLE I: Preparation of Gas Generant

A one Kg batch of each of seven gas generant compositions was formulated according to Table I below. The compositions were prepared by initially mixing all the components, except for the 5-aminotetrazole (5-AT), in a batch-type vibratory grinder (Sweco) for 120 minutes. The mica used was Micro Mica 3000 (muscovite) obtained from the Charles B. Crystal Co., Inc. of New York, N.Y., U.S.A. It was finely divided mica having a bulk density of about 12.4 lbs/cubic foot and a specific gravity of about 2.8. The 5-AT was then added to the grinder and the mixture was ground for an additional 120 minutes.

TABLE I

| Formulation       | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|-------------------|----|----|----|----|----|----|----|
| Ingredient Wt. %  |    |    |    |    |    |    |    |
| Guanidine Nitrate | 40 | 45 | 47 | 47 | 52 | 52 | 52 |
| Strontium Nitrate | 34 | 34 | 34 | 32 | 31 | 32 | 32 |
| Cupric Oxide      | 9  | 7  | 6  | 6  | 5  | 4  | 3  |
| Potassium Nitrate | 6  | 6  | 6  | 6  | 6  | 6  | 6  |
| 5-Amino Tetrazole | 10 | 7  | 6  | 5  | 2  | 2  | 2  |
| Boron Nitride     | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| Mica              | 0  | 0  | 0  | 3  | 3  | 3  | 4  |

The mixture was then placed in a plough-type mixer and about 15% by wt. water was added to form agglomerate that was then passed through a granulator with an 8 mesh screen.

The granules were placed on a tray and dried at 120°C in an explosion proof oven for about 3 hours. The water content after drying was between 0.5 and 1% by weight. The dried granules were then passed through the granulator using a 20 mesh screen. The samples were then pelletized with a rotary pellet press. The pellets were about 5 mm in diameter, 1.2 mm high, weighed about 51 to 53 mg each.

About 43 gms of the formed pellets from each Formulation were then loaded into steel inflators. The assembled inflators containing the various gas generants were evaluated in a 2.83 cubic meter (100 cubic foot) test tank fitted with equipment to record the pressure and time profile of the combustion and to analyze the gases exiting the inflator. The 2.83 cubic

meter (100 cubic foot) test is designed to simulate the interior volume of the standard automobile. Gas analysis and particulate analysis is also possible using this test. The test equipment consisted of a 2.83 cubic meter (100 cubic foot) steel chamber containing a steering wheel simulator. To the chamber was attached a vacuum pump, a bubble flow meter, filters and a FT/IR gas analyzer (spectrophotometer). The inflator was attached to the simulated steering wheel assembly within the chamber, the chamber was sealed and the gas generant ignited. Gas samples were analyzed using an FTIR spectrometer at zero time and at 1, 5, 10, 15 and 20 minute intervals from ignition. Airborne particulate production can be measured using the 2.83 cubic meter (100 cubic foot) test chamber by filtering post-ignition air from the chamber through a fine filter and measuring the weight gained by the filter.

Table II sets forth the data collected for Formulations 1 through 7.

TABLE II

| Formulation                         | 1              | 2              | 3              | 4              | 5              | 6              | 7              |
|-------------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Moles gas/100gm                     | 2.81           | 2.88           | 2.92           | 2.87           | 2.93           | 2.94           | 2.94           |
| Conversion, %                       | 71.62          | 73.29          | 74.09          | 72.98          | 74.13          | 74.57          | 74.42          |
| Flame Temp.,<br>°Kelvin             | 2111           | 2095           | 2086           | 2029           | 2000           | 2016           | 2001           |
| Burn Rate in/s @<br>1100 psi (cm/s) | 1.06<br>(2.69) | 1.15<br>(2.92) | 1.13<br>(2.87) | 0.79<br>(2.01) | 0.56<br>(1.42) | 0.58<br>(1.47) | 0.55<br>(1.40) |

These results indicate that the new formulations have a much lower flame or exhaust temperature than the controls, Formulations 1 – 3. The gas analysis demonstrated a much lower production of noxious gases such as ammonia and nitrous oxide for Formulations 4 - 7. Table III sets forth the results of the gas analysis for Formulations 1 AND 4-7.

TABLE III

| Formulation         | 1 <sup>1</sup> | 4 <sup>2</sup> | 5 <sup>2</sup> | 6 <sup>2</sup> | 7 <sup>2</sup> |
|---------------------|----------------|----------------|----------------|----------------|----------------|
| Gas Component ppm * |                |                |                |                |                |
| CO                  | 294            | 179            | 152            | 105            | 135            |
| NO                  | 16             | 12             | 10             | 18             | 12             |
| NO <sub>2</sub>     | 0.7            | 1.0            | 1.1            | 0.6            | 1.0            |
| NH <sub>3</sub>     | 25             | 16             | 14             | 7              | 11             |

\* 100 ft.<sup>3</sup> or about 2.8 m<sup>3</sup>

<sup>1</sup> Actual data

<sup>2</sup> Projections based on data from Formulation 1

This information clearly supports the advancement to the state of the art that the new gas generant provides. The projected values for CO, NO and ammonia for the new gas generant are substantially less than the actual values for a generant that contains no mica and higher levels of 5-AT. Formulation 6 easily meets the USCAR (SAE/USCAR-24) requirements for CO, NO, NO<sub>2</sub> and ammonia gas generation.

Without being held to any particular theory or mechanism, it is believed that the combination of less than 5% by weight mica and 5% by weight or less of a tetrazole and/or triazole provides the advantages presently described. It is believed that the fuel component comprises a major portion of a guanidine compound in combination with a tetrazole and/or triazole fuel provides substantial benefits.

Flame temperatures below about 2000 degrees Kelvin do not require the treatment of the fabric of the airbag. This treatment of the airbag is a problem that those skilled in the art are acutely aware of. Foregoing treatment of the airbag will reduce costs, which is important to the automotive industry.

The presence of mica produces a cleaner effluent than Formulations 1, 2 and 3. The results for Samples 1, 2 and 3 are not significantly different from each other; however, they are significantly different from the results produced by Formulations 4 -7. This data supports the benefits of the new gas generant.

## EXAMPLE II

In this experiment, a higher level of mica is used to demonstrate that the level of mica is important to the new multi-fuel gas generant. The level of components of Formulation 7 are used except that the level of guanidine nitrate is 50% by weight, the level of strontium nitrate is 31% by weight and the level of mica is 7% by weight.

The results from this experiment will evidence levels (presently calculated) of CO at 150 ppm, NO AT 15 ppm, NO<sub>2</sub> at 1.6 ppm and ammonia at 13 ppm. These values are all above the USCAR limits for driver inflators. This experiment will demonstrate that the level of mica should not exceed about 5% by weight.

Fig. 1 is a side view of an exemplary vehicle airbag inflator 10 that can employ the new gas generant compositions disclosed herein. A mounting plate 11 is used to attach the inflator to a steering wheel, instrument panel or other suitable location in the vehicle. When a gas generant inside the airbag inflator is burned it generates gasses that exit the inflator via apertures 12 in the metal inflator housing 13.

Fig. 2 is a cross section of the airbag inflator of Fig. 1 taken along line 2 - 2 of Fig. 1. The airbag inflator 10 is activated by a signal from a crash sensor if a crash of sufficient magnitude to require activation of the inflator 10 is sensed. The activation signal closes an electrical circuit or initiates a firing signal that activates an initiator such as a squib 24, which ignites a booster composition 15, which in turn ignites the new gas generating composition 16. The igniter assembly 22 comprising the squib 24 and two electrodes is attached to the inflator housing through any useful means and

is preferably attached via a weld. As used herein, a "squib" is understood to be an electrical device having two electrodes insulated from one another and connected by a bridge wire. The bridge wire is preferably embedded in one or more layers of a pyrotechnic composition that gives a flash of heat of sufficient intensity to ignite the booster composition 15. Any suitable booster composition 15 may be employed. Various electrical, electronic, mechanical and electro-mechanical initiators known in the art, such as a stab initiator, can be used.

The gas generant 16 is ignited by the heat generated by the booster composition 15 and the resulting chemical reaction generates gas, which passes through a knitted wire annular filter 26 and then through perforated annular tube 17. The knitted wire filter 26 and the perforated tube 17 are preferably made of stainless steel but low carbon steel may be employed. A knitted wire cushion 18 is used to protect the gas generant pellets. Backup ring 19 holds the wire cushion 18 and the wire filter 26 in places.

The combustion gases, after passing through knitted wire filter 26 and the perforated tube 17, enter an annular chamber 25. Apertures 12 in the housing 13 are sealed with stainless steel burst foil 20. When the pressure inside the chamber 25 exceeds a given value, the foil 20 ruptures and the gases escape the inflator 10 through apertures 12 which then inflate an airbag (not shown).

An autoignition substance 21 is in close proximity to the booster composition 15. The autoignition substance 21 is a composition that will spontaneously ignite at a preselected temperature and thereby ignite the booster composition 15 which will then ignite the gas generate 16. The new gas generants may react in a much more violent manner if the ambient temperature is elevated, so it is desirable to ignite the gas generant before such a violent reaction can occur. An autoignition retainer 23 secures the autoignition substance 21 against the interior wall of the metal housing 13 to assure that proper heat transfer occurs for the ignition of the autoignition substance 21 at the desired temperature.

The airbag inflator represented in the drawings and described herein is merely representative and that a new airbag inflator has a metal housing containing the gas generant disclosed herein.

The automotive industry may require in the future that gas generants produce restricted levels of various reaction products. The new gas generants will be able to meet these standards.

The automotive industry is constantly searching for gas generants that produce reduced levels of undesirable gases and provides for savings in the production of airbags. The automotive industry is also in need of gas generants that do not use azide based generants to avoid the problems associated with azide toxicity. The use of a dual non-azide fuel system and a dual oxidizer system, preferably with 1-5 weight % of mica, will address the needs of the industry and promote the use of non-azide fuels.

## CLAIMS

1. An airbag inflator comprising:
  - (a) a metal housing; and
  - (b) a gas generant inside the metal housing, the gas generant comprising:
    - (i) greater than 1 and less than 5 wt. % mica;
    - (ii) a primary fuel selected from the group consisting of guanidine compounds;
    - (iii) a secondary fuel at levels of less than 5 % by weight selected from the group consisting of tetrazoles, triazoles and mixtures thereof; and
    - (iv) an oxidizer system comprising at least two compounds selected from the group consisting of transition metal oxides, alkali metal nitrates and alkaline earth metal nitrates.
2. An airbag inflator according to claim 1 wherein said gas generant comprises guanidine nitrate as the primary fuel and at least one compound selected from the group consisting of 5-amino tetrazole, bitetrazole, 3-nitro-1, 2, 4-tiazol-5-one and mixtures thereof as the secondary fuel.
3. An airbag inflator according to claim 1 wherein said gas generant comprises:
  - (a) 30-70 wt. % of said primary and secondary fuels; and
  - (b) 30-70 wt. % of said oxidizer system.
4. An airbag inflator according to claim 1 wherein said primary fuel is selected from the group consisting of guanidine nitrate, nitroguanidine, aminoguanidine nitrate, diaminoguanidine nitrate, triaminoguanidine nitrate and mixtures thereof.

5. An airbag inflator according to claim 4 wherein said primary fuel is guanidine nitrate and said secondary fuel is 5-amino tetrazole.

6. An airbag inflator according to claim 2 wherein said secondary fuel is 5-aminotetrazole and said oxidizer system comprises potassium nitrate, copper oxide and strontium nitrate.

7. An airbag inflator according to claim 6 wherein said fuel is 30-35 wt. % of said generant, said potassium nitrate is 5-10 wt. % of said generant and said strontium nitrate is 40-50 wt. % of said generant.

8. An airbag inflator according to claim 1 8. An airbag inflator according to claim 1 wherein said generant additionally comprises boron nitride.

9. A gas generant composition comprising:

(a) a primary and secondary fuel ranging from about 30 to 70% by weight of the gas generant composition, said primary fuel is a guanidine compound ranging from about 30 to 70% by weight of the gas generant composition and said secondary fuel is a tetrazole or triazole or mixtures thereof ranging from about 1 to 5 % by weight of the gas generant composition;

(b) an oxidizer system comprising at least two components, said oxidizer system ranging from about 30 to 70% by weight of said gas generant composition, wherein said oxidizer system consists of (i) a transition-metal oxide ranging from about 5 to 15% by weight of the gas generant composition; and (ii) an alkali metal nitrate, an alkaline-earth metal nitrate, or mixtures thereof, wherein said alkali metal nitrate, alkaline-earth metal nitrate or mixtures thereof range from about 30 to 70% by weight of the gas generant composition; and

(c) from 1 to less than 5% by weight of the gas generant composition of mica.

10. A gas generant composition according to claim 9 additionally containing an additive that consists of boron nitride.

11. A gas generant composition according to claim 9 wherein said transition-metal oxide is cupric oxide.

12. A gas generant composition according to claim 9 which consists of 5-aminotetrazole at a level of about 3 % of the total gas generant composition.

13. A gas generant composition according to claim 12 wherein said alkali metal nitrate is potassium nitrate.

14. A gas generant composition according to claim 12 wherein said alkaline-earth metal nitrate is strontium nitrate.

15. A gas generant composition according to claim 9 wherein said secondary fuel is selected from the group consisting of 5-amino tetrazole, bitetrazole, 3-nitro-1, 2, 4-triazol-5-one, and mixtures thereof.

16. A gas generant composition according to claim 15 wherein said secondary fuel is 5-amino tetrazole.

17. A gas generant composition according to claim 9 wherein said primary fuel is selected from the group consisting of guanidine nitrate, nitroguanidine, aminoguanidine nitrate, diaminoguanidine nitrate, triaminoguanidine nitrate, and mixtures thereof.

18. An airbag inflator comprising:

- (a) a metal housing; and
- (b) a gas generant located in the metal housing, the gas generant comprising:
  - (i) greater than 1 and less than 5 wt. % mica;
  - (ii) a primary fuel selected from the group consisting of guanidine compounds; and
  - (iii) a secondary fuel selected from the group consisting of 5-amino tetrazole, bitetrazole, 3-nitro-1, 2, 4-tiazol-5-one and mixtures thereof.

19. A gas generant composition consisting of:
- (a) 35 to 45 weight % guanidine nitrate;
  - (b) 25 to 35 weight % strontium nitrate;
  - (c) 2 to 10 weight % cupric oxide;
  - (d) 2 to 10 weight % potassium nitrate;
  - (e) 1 to 5 weight % 5-amino tetrazole;
  - (f) 1 to 5 weight % boron nitride;
  - (g) 1 to 5 weight % mica; and
  - (h) processing aids.

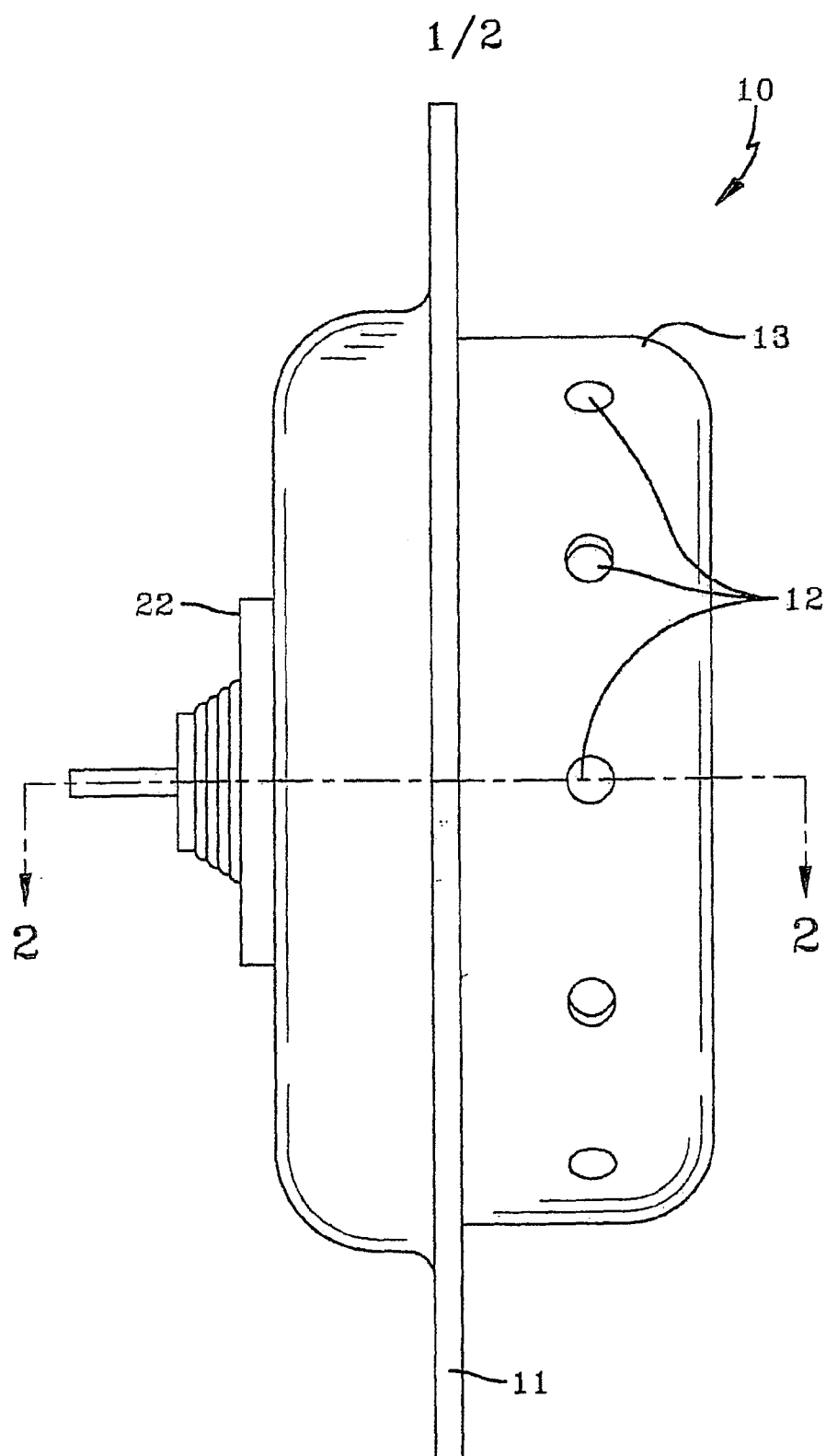


FIG-1

2/2

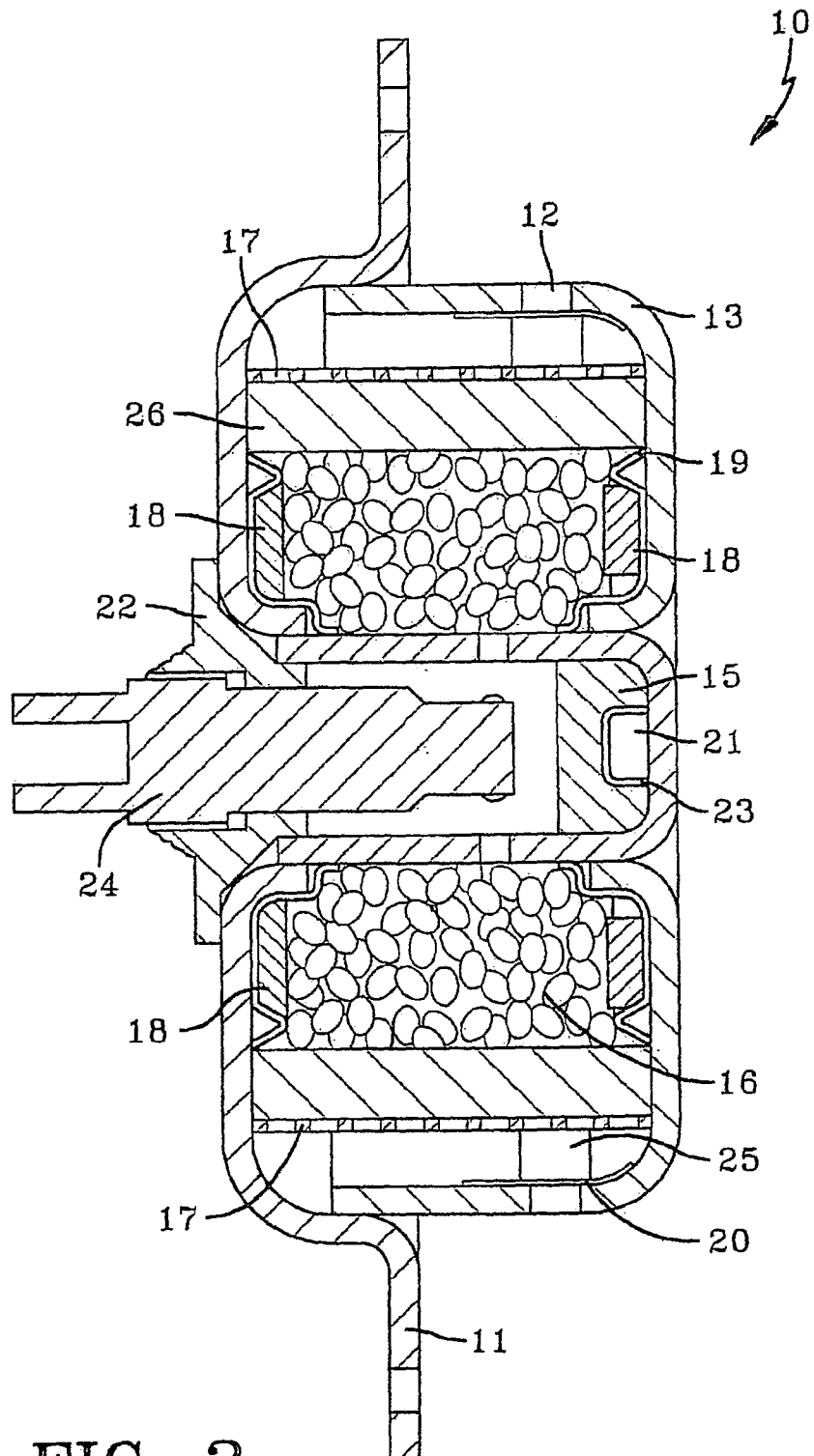


FIG-2

## INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/US2008/008332****A. CLASSIFICATION OF SUBJECT MATTER****C06D 5/00(2006.01)i, B60R 21/26(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 8: C06D 5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Utility Models and Applications for Utility Models: IPC as above

Japanese Utility Models and Applications for Utility Models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

e-KIPASS (KIPO internal) : "gas generat\*", "guanidin nitrate", "tetrazole", "airbag", "inflator"

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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| X         | US 6071364 A (J. B. Canterbury, et al) 06 Jun 2000<br>See abstract and claims 1-10     | 1-19                  |
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Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

30 OCTOBER 2008 (30.10.2008)

Date of mailing of the international search report

**30 OCTOBER 2008 (30.10.2008)**

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Government Complex-Daejeon, 139 Seonsa-ro, Seo-  
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Telephone No. 82-42-481-5581



**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

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