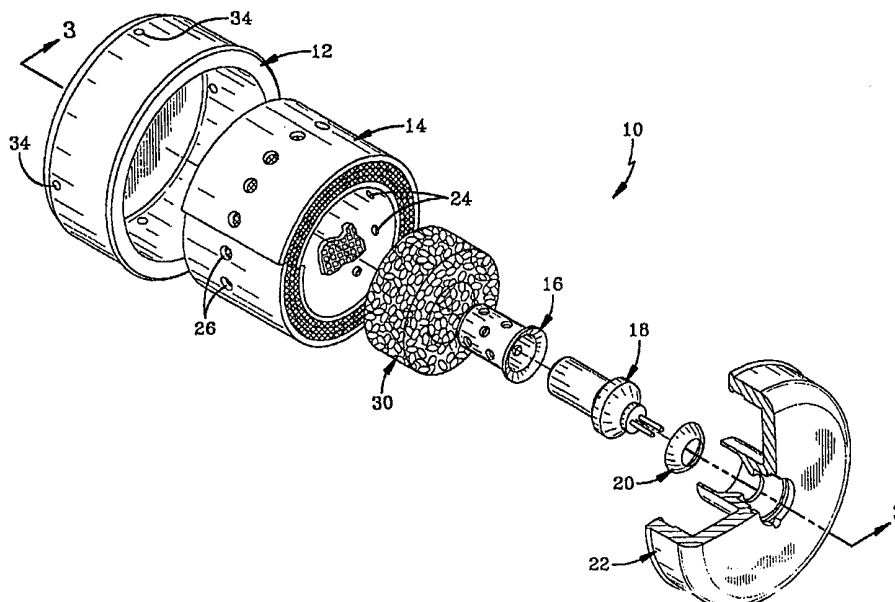




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(54) Title: GAS GENERANT COMPOSITIONS CONTAINING GUANADINES

**(57) Abstract**

Improved non-azide gas generant compositions (30) that may be used in a vehicle airbag system (10). The new compositions overcome the problems of moisture and thermal cycling in a non-azide gas generant pellet (30) through the use of at least two fuels selected from guanidine nitrate, nitroguanidine, triaminoguanidine nitrate, diaminoguanidine nitrate, and monoguanidine nitrate and an oxidizer system comprising mixtures of strontium nitrate, sodium nitrate, and ammonium perchlorate.

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GAS GENERANT COMPOSITIONS CONTAINING GUANADINES

This invention relates to non-azide gas generants and methods for their manufacture. More specifically, the invention is directed to the use of strontium nitrate (SN), guanidines such as guanidine nitrate
5 (GN), ammonium perchlorate (AP) and copper chromite to produce a thermally stable gas generant.

The use of airbags to cushion vehicle occupants in crash situations is widely known. The requirements of a gas generant used in a vehicle airbag inflator
10 are very demanding. The gas generant must have a burning rate such that the airbag is inflated rapidly (within approximately 30-100 milliseconds) and the burning rate must not vary over long term storage (aging and/or thermal cycling) or as a result of shock
15 and vibration encountered during the life of the vehicle. The burning rate must also be relatively insensitive to changes in humidity and temperature. When pressed into pellets, wafers, cylinders, discs or whatever shape, the hardness and mechanical strength
20 of the gas generant bodies must be adequate to withstand the conditions to which they will be exposed without any fragmentation or change of exposed surface area. Excessive breakage of the generant bodies will lead to system failure where, for example, an
25 undesirable high pressure condition will be created within the inflator, possibly resulting in catastrophic rupture of the inflator housing.

The gas generant must efficiently produce a relatively cool, non-toxic, non-corrosive gas which is
30 easily filtered to remove solid and liquid combustion

by-products. This filtering is needed to preclude damage to the inflatable airbag or injury to the occupant of the automobile. These requirements limit the applicability of many otherwise suitable chemical compositions, shapes and configurations from being used in automotive airbag inflators. Gas generants can also be used for fire extinguishing. Recently, a number of companies have begun using the gases produced by solid energetic or pyrotechnique materials for fire extinguishing.

An important parameter relating to gas generants is physical stability of the gas generant pellet. As mentioned above, physical forces, such as vibration, can abrade or crack the gas generant pellets. This damage is unacceptable as the surface area is increased and thus the ballistics (rate of combustion) is altered. Ballistics can also be altered through the absorption of water and thermal cycling. It is known that most non-azide based gas generants, especially 5-aminotetrazole, are hygroscopic and soften upon heating. These changes cause the gas generant pellet to degrade or crumble. This change in surface area can result in catastrophic failure of the inflator housing due to excessive pressure build up in the housing at the time of ignition.

A source of water for degradation of a generant pellet is the gas generant itself. Many non-azide gas generants are prepared by an aqueous mixing process. Water is used to mix the non-azide fuel, oxidizer, and other components of the gas generant composition. The majority of the water is removed during a drying step, however, at least 1% by weight and sometimes as high as 5% by weight water still remains in the generant composition. This drying step is expensive and

dangerous. Any method that would allow the gas generant to be prepared without the use of water would be readily accepted by the industry.

In its broadest aspect, as set forth in appended
5 claim 1, the present invention overcomes the
previously described problems through the use of
guanidines as the fuel and an oxidizer system
comprising strontium nitrate and ammonium perchlorate.
Other aspects of the invention are set forth in the
10 subordinate claims.

US 5 035 757 teaches gas generant compositions
devoid of azides which yields solid combustion
products which are easily filtered. This patent
provides a good discussion of formulating non-azide
15 based gas generants. US 5 035 757 also teaches that
alkaline earth and cerium nitrate oxidizers are
hygroscopic and are difficult to use effectively.

US 5 500 059 teaches a gas generant composition
comprising an oxidizer and anhydrous 5-aminotetrazole
20 (5-AT) as the fuel. US 5 500 059 teaches that 5-AT is
generally in the monohydrate form and that gas
generating compositions based upon hydrated tetrazoles
have unacceptably low burning rates.

US 5 467 715 relates to a gas generant
25 composition that contains, as a fuel, a mixture of
triazoles or tetrazoles with a minor portion of a
water-soluble fuel and an oxidizer component wherein
20 weight % of the oxidizer component is a transition
metal oxide.

30 US 5 529 47 teaches a gas generant for airbags
which comprises between 2 and 45 weight % of a
tetrazole or triazole compound; from 50-75 weight % of
an oxidizer such as ammonium nitrate, ammonium
perchlorate, transition metal oxides and mixtures

thereof; from 0.5 to about 30 weight % of alumina fibers; and between about 1 and 10 weight % of a binder such as molybdenum disulfide, graphite, nitrocellulose, calcium stearate and mixtures thereof.

5 US 5 531 941 teaches an azide-free gas generant composition that comprises a mixture of triaminoguanidine nitrate (TAGN) as the fuel and phase stabilized ammonium nitrate (PSAN) as the oxidizer. US 5 531 941 teaches that one of the major problems
10 with the use of ammonium nitrate (AN) is that it undergoes several crystalline phase changes. One of these phase changes occurs at approximately 32°C and is accompanied by a large change in crystal volume. This is totally unacceptable in a gas generant because
15 the burning characteristics would be altered such that the inflator would not operate properly or might even blow up because of the excess pressure generated.

 US 3 031 347 teaches solid propellant materials useful in rocket or jet propulsion motors. The slow
20 burning propellant composition taught in US 5 031 347 uses an oxidizer selected from ammonium perchlorate, ammonium nitrate and mixtures thereof at concentrations of from 45 to 72 weight %. This composition also uses 5-22 weight % of an oxygen rich
25 additive selected from the group consisting of guanidine nitrate, nitroguanidine, cellulose nitrate and mixtures thereof; and 23-36 weight % of a polymerized resin fuel.

 In a publication by Ebeling et al. entitled,
30 "Development of gas generators for fire extinguishing", Propellants, Explosives, Pyrotechnics, (July, 1997) Vol. 22(3), p. 170-175, the authors evaluate the idea of using gases or aerosols produced by solid energetic or pyrotechnique materials for fire

extinguishing. The authors considered the class of nitrogen rich, low carbon content compounds, such as NQ, TAGN and 5-amino-1H-tetrazole. This publication does not suggest that NQ be combined with GN, TAGN,
5 DAGN and/or MGN, ammonium perchlorate and copper chromite to produce a gas generant which has excellent thermal stability, good gas production properties and produces a low level of toxic gases upon combustion.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the invention which are believed to be novel are set forth with particularity in the appended claims. The present invention, both as to its structure and manner of operation, may best be understood by referring to the following detailed description, taken in accordance with the accompanying drawings in which:

10

FIG. 1 is an exploded view of an inflator used in the tests described herein and employing the inventive filter system;

15

FIG. 2A is a top plan view of one embodiment of the metallic ribbon used to prepare the filter coil according to the invention;

20

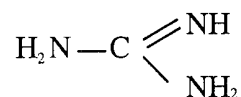
FIG. 2B is a top plan view of a second embodiment of the metallic ribbon; and

FIG. 3 is a side view in cross section of the inflator taken along line 3-3 of FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

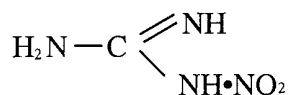
The gas generant formulations used in this invention are formulated from the guanidine family of fuels such as guanidine nitrate (GN), triaminoguanidine nitrate (TAGN) and the like. The fuel component will typically comprise between about 45 and about 70 weight %, more preferably between 50 and 60 weight %, of the gas generant composition, while the oxidizer system will typically comprise between about 35 and about 50 weight %, more preferably between 40 and 50 weight %, of the gas generant composition. Processing aids, such as silicon dioxide, may also be used in formulating the gas generant pellets. Those skilled in the art understand that depending upon the particular oxidizers and fuels utilized, certain processing aids have beneficial properties over others.

The fuel useful in the gas generant of the present invention is a mixture of at least two guanidine fuels selected from guanidine nitrate (GN), nitroguanidine (NQ), triaminoguanidine nitrate (TAGN), diaminoguanidine nitrate (DAGN) and monoguanidine nitrate (MGN). Guanidine or iminourea (CH_5N_3) has the structural formula:



Guanidine is soluble in water and alcohol, volatile and strongly alkaline. It forms many salts, e.g., nitrate and the like. Nitroguanidine is a white crystalline powder that is usually manufactured from calcium carbide via calcium cyanamide, dicyandiamide

and guanidine nitrate which is converted to nitroguanidine by action of concentrated sulfuric acid. Nitroguanidine has the structural formula:



5

Oxidizers useful in the gas generant compositions include ammonium perchlorate and the alkali metal and alkaline earth metal nitrates such as strontium
10 nitrate and sodium nitrate. The preferred oxidizer system is a mixture of strontium nitrate, sodium nitrate and ammonium perchlorate. Ammonium perchlorate is important to the gas generant of the invention due to its gaseous decomposition and lack of
15 particulate production. The potential problem of HCl generation may be overcome through the use of copper chromite and/or iron oxide as a catalyst and/or the sodium from the sodium nitrate. One aspect of the invention is the discovery that AP, which is a
20 component that the industry has a propensity to avoid due to HCl generation, is useful in the inventive gas generants. As set forth in the Examples, the gas generants of the invention produce barely detectable levels of chloride containing gases.

25 The ratio of oxidizer to fuel in the inventive gas generant is adjusted such that the amount of oxygen allowed in the equilibrium exhaust gases is from zero to 2 or 3% by volume, and more preferably from zero to 2.0% by volume.

30 The gas generant composition may optionally contain up to about 1.0 weight %, typically between about 0.1 and about 0.3 weight %, of iron oxide, copper chromite or mixtures thereof as catalysts.

Copper chromite (CuCr) has known properties as a catalyst. It is a mixed oxide of copper and chromium obtained by igniting copper ammonium chromate under controlled conditions. Barium is frequently added to prevent poisoning of the catalyst, however, the CuCr used in the present invention is preferably free of barium. Copper chromite is principally used for the reduction of carboxyl groups (e.g., ketones to alcohols, and esters to alcohols). The preferred level of copper chromite in the inventive composition is about 0.25 weight %. The iron oxide (Fe₂O₃) useful in the inventive compositions may be obtained by all the usual methods. The particle size of the iron oxide and CuCr may vary from about 1 to 10 microns.

The invention will now be described in greater detail by way of specific examples.

Referring to FIG. 1, there is represented in exploded view, an inflator 10 employed in testing several of the gas generant compositions disclosed herein. A first housing member 12 and a second housing member 22 are attached to one another through "friction or inertia welding". The inflator 10 also comprises an inventive strip filter 14, an enhancer tube 16, a squib with enhancer cup 18 and a room temperature vulcanizing rubber seal 20. A bed of gas generant pellets 30 is disposed between the strip filter 14 and the enhancer tube 16. Metal foil, not shown, lines the annular surface of the first housing 12 covering gas exit portals 34 in the first housing.

FIGS. 2A and 2B, show two embodiments of suitable filter strips 14. Both embodiments of the filter strip contain at least three segments wherein the first segment 28 (a.k.a. the inside portion) has two

rows of apertures therethrough positioned along each edge of the ribbon, an expanded metal segment 29 and second segment 15 wherein at least one row of apertures are present. FIG. 2A is an embodiment
5 wherein the second segment 15 has two (2) rows of a plurality of apertures 26 therethrough with diameter of about 2.0 mm. FIG. 2B represents a second embodiment where the second segment 15 has a single row of apertures 26 therethrough with a diameter of
10 about 4 mm. The placement of the apertures is important for complete combustion of the generant. The first segment, which is adjacent the generant bed, requires apertures along each edges, while the second or final segment must have the aperture in the center
15 of the ribbon. The size and number of the apertures can be varied to control the desired combustion level (i.e., rate of pressure generation). In use, the filter strip is coiled or rolled into a tubular configuration which is placed inside the inflator 10.

20 A metallic filter strip or ribbon with a combination of segments with holes and a segment of expanded metal can economically produce a filter that effectively cools the gas and removes particulates and slag generated when the gas generant is burned. The
25 metal from which the filter strip 14 is produced can be any metal with a melting point high enough to survive the combustion of the gas generant. The thickness of the strip can range from about 0.25 mm to 1.27 mm with about 0.51 mm to 0.76 mm being more
30 preferred, about 0.63 mm being the most preferred.

The length and height of the strip can vary widely depending upon the size and configuration of the inflator housing into which it is placed. Dependent on the size of the housing, the filter strip

is designed such that first segment 28 will complete the first turn during the formation of the coil and the expanded metal segment 29 will complete at least two turns of the coil. Preferably, the expanded metal
5 segment 29 will complete at least three turns. The second segment 15 is of such length that it will completely circumferentially cover the outside of the coil.

Another important aspect of the filter strip is
10 that apertures 24 in the first segment 28 are not aligned with, and do not overlay, the apertures 26 in the second segment 15. In the embodiment set forth in FIG. 2A, the apertures 24 are disposed towards the outside edge of segment 28 while the apertures 26 in
15 the second segment 15 are disposed towards the interior. This aspect is important as it aids in creating a tortuous path for the gases. Further, the use of the expanded metal segment provides a large surface area for the capture of particulates and
20 cooling of the gas and also creates a tortuous path for the gases.

As mentioned previously, the expanded metal segment 29 should be long enough to provide at least two turns during the formation of the coil. The
25 diamond shaped openings in the expanded metal segment 29 should have a dimension of about 0.04 to 0.12 mm by 0.32 to 0.8 mm. The expanded metal strip can be made by die cut stamping and the apertures can be drilled or stamped out.

30 FIG. 3 is a cross section of an inflator housing taken along line 3-3 of FIG. 1 except that the squib with enhancer cup 18 is not shown in cross section. The bed of gas generant 36 is not shown for clarity. The inflator housing 10 comprises a first housing

member 12 and a second housing member 22 that, in this representative embodiment, are attached by a spin weld 32. Other forms of attachment such as threaded engagement, laser welds and mechanical fixation, are within the scope of the invention. The filtration strip 14 in coiled configuration, is shown as having five turns in FIG. 1. The apertures 24 through the first segment 28 can be in other arrangements than shown, i.e., in a random pattern, provided the apertures 24 are not directly across from the apertures 26 through the second segment. This is required so that the combustion gas must take a tortuous path through the expanded metal to the apertures 26 and then through the exit portals 34.

One additional aspect of the invention is that through subtle changes in the levels of the various components, the combustion temperature and igniting behavior of the generant can be modified to function in a variety of inflator configurations. As those skilled in the art will appreciate, changing the combustion level and temperature will change the CO and NOx content of the combustion gas as well as output. As an example, reduction of the combustion temperature by using a coolant, on the one hand, gives disadvantages relating to CO and NOx content as well as output levels. On the other hand, at high output temperature, it leads to potential disadvantages with respect to damage to the airbag. Gas generant development should be understood to be a task of balancing contradicting properties in order to fulfill very special requirements.

In addition, it should be considered that reaction behavior of a gas generant, in areas other than basic chemistry, depends on igniting behavior,

combustion surface area and design of the inflator housing which influences pressure build-up. Lastly, the design of the inflator housing can influence the properties of the gas generated through pressure build up as a result of filtering capabilities.

EXAMPLE I

Preparation of Gas Generant

10 A one Kg batch of a gas generant composition was formulated according to Table I below. The compositions were prepared by grinding the individual components (when needed, i.e., NaN) to a particle size of less than 100 microns and then all of the
15 components of the generant were sifted and then blended in a Turbula® mixer (manufactured by W.A.B. of Switzerland). Mixing continued for one (1) hour.

TABLE I
Values in Weight %

Sample No.	Nitro-guanidine	Guanidine nitrate	Strontium nitrate	Ammonium perchlorate	Sodium nitrate	Nitro-cellulose	DPA*	CuCr
1	15	40	10	22	11	2	0.1	--
2	15	40	10	22	11	2	-	-
3	15	42	10	22	11	-	-	-
4	15	41.5	10	22	11	-	-	0.5
5	15.5	41.5	8.8	22.8	11.4	-	-	0.25
6	13.5	44	9	22	11	-	-	0.5
7	15	40	10	22	11	2	0.1	0.25

* DPA diphenylamine

The material was then pelletized with a rotary pellet press. The pellets were about 5 mm in diameter, 1.8 mm high, weighed about 55 to 65 mg each and had a density of about 1.6 to 1.7 g/cm³.

5 The formed pellets were then loaded into steel inflators of the type shown in FIG. 1. Either about 19 or 23 gms of the pellets was loaded into each of the steel housings. The 19 gm charge of generant was for a 40 liter airbag while the 23 gm charge was for a 60 liter airbag. The burst foil or tape comprises a thin sheet (about 0.005 mm. thick) of stainless steel with an adhesive on one side. The adhesive side of the burst foil is placed against the inside surface of the inflator housing to hermetically seal all of the apertures 34. The apertures 34 are exhaust ports for the gases generated by the generant and were about 2.4 mm in diameter for the 40 liter airbag and about 2.5 mm for the 60 liter airbag. The number of apertures 34 was four. The test inflator housing had a total volume of about 88 cm³, while the region of the housing located inwardly of the filter and containing the pellets of gas generating material had a volume of about 46 cm³ for the 40 liter airbag and about 46 cm³ for the 60 liter airbag. The inflator also incorporated about 0.9 g of BKNO₃ (a mixture of boron nitrate and potassium nitrate, conventionally used in the industry), as an enhancer and was associated with the squib with enhancer cup 18.

30

EXAMPLE II

Testing of Gas Generants

Particulates

Two assembled inflators containing 19 gms of the inventive gas generant pellets (Sample No. 5) were

evaluated in a 60 liter test chamber fitted with equipment to record the pressure and time profile of the combustion and to analyze the gases exiting the inflator. The amount of particulate or slag produced by the burning generant was also determined using standardized techniques. The inflators were installed into the test chamber and the gas generant pellets were ignited. The temperature of the inflator at firing was about $23^{\circ}\text{C} + 2^{\circ}\text{C}$ at a relative humidity of about 43%. Immediately after firing of the inflator, gas samples were withdrawn from the test chamber for analysis by FTIR (Fourier Transform Infrared Spectroscopy).

Airborne particulate production was measured by filtering post ignition air from the test chamber through a fine filter and measuring the weight gained by the filter. The average total airborne particulate mass for the two tests was 6.85 mg. The average total particulate concentration for the two (2) tests was 68.5 mg/m^3 .

Gaseous Reaction Products

The test chamber was attached to a vacuum pump, a bubble flow meter, filters and a FT/IR gas analyzer (spectrophotometer). Gas samples were analyzed using an FTIR spectrometer at zero time (before deployment) and at 1, 5, 10, 15 and 20 minute intervals after ignition or via gas chromatography.

The ammonia, benzene, carbon dioxide, formaldehyde, hydrogen chloride, hydrogen cyanide, methane, sulfur dioxide, carbon monoxide (CO), nitric oxide (NO) and nitrogen dioxide (NO₂) and water vapor levels of the gases produced in the 60 liter test chamber for the two test samples are set forth in

Table II. Samples were transferred directly to the FTIR gas cell from the 2.8 cubic meter test chamber via 2 meters of .6 cm OD fluoropolymer tubing.

TABLE II

Gaseous Effluent Data

	Ammonia	Benzene	Chloride	Carbon Dioxide	Carbon Monoxide	Formaldehyde	Hydrogen Chloride	Hydrogen Cyanide	Methane	Nitric Oxide	Nitrogen Dioxide	Phosphine	Sulfur dioxide	Water Vapor
Analysis Method	FTIR	FTIR	Tube	FTIR	FTIR	FTIR	FTIR	FTIR	FTIR	FTIR	FTIR	Tube	FTIR	FTIR
Detection Limit (ppm)	5	5	0.2	50	10	2	2	2	5	2	0.5	0.02	5	500
Analysis Delay (min)	0.2	0.2	30	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	30	0.2	0.2
Sample No. 5 (Test I)	1	<5	*	995	142	<2	<2	12	19	28	<0.5	*	<5	1379
	5	<5	*	840	117	<2	<2	10	16	22	1.1	*	<5	515
	10	<5	*	792	109	<2	<2	9	14	20	1.7	*	<5	<500
	15	<5	*	765	106	<2	<2	8	14	18	2	*	<5	<500
	20	<5	*	745	103	<2	<2	8	13	17	2.4	*	<5	<500
TWA	<5	<5	**	811	113	<2	<2	9	15	20	1.6	**	<5	<500

Sample No. 5 (Test II)	20	<5	<5	*	805	107	<2	<2	8	14	25	<0.5	*	<5	3159
	5	<5	<5	*	863	108	<2	<2	8	14	24	1.4	*	<5	3337
	10	<5	<5	<0.2	796	100	<2	<2	8	12	22	2	<0.0	<5	3104
	15	<5	<5	*	765	96	<2	<2	8	12	20	2.7	*	<5	2897
	20	<5	<5	*	754	94	<2	<2	7	12	18	3.1	*	<5	2780
	TWA	<5	<5	**	799	101	<2	<2	8	13	22	2	**	<5	3068
	20														

* Compound was not analyzed at this time interval

** TWA (total weighted average) could not be calculated

+ Gas chromatography tube

The results set forth in Table II demonstrate that the gas generants of the present invention produce an acceptable gas for use in vehicle occupant restraint systems. The gas generants of the present invention produce a reasonably clean combustion gas and the pellets of the generant also resist degradation due to moisture and thermal cycling.

Both firings of the inflator demonstrated acceptable bag inflation, peak bag pressure and sustained bag pressure and thus would be useful in a vehicle airbag occupant safety system.

EXAMPLE III

Thermal Stability

To test the thermal stability of the gas generant according to this invention, 1.0 gm of the Sample No. 5 composition from Table I was placed in a petri dish and then in an oven at 135°C for two (2) hours. The sample was removed and allowed to cool at room temperature. Inspection of the pellets revealed that no melting of the gas generant composition had occurred and that the pellets were intact and did not evidence any cracking, crumbling or change in shape.

25

EXAMPLE IV

Thermal Stability

In this experiment, 19 gms of Sample No. 5 was placed in an inflator as set forth in Example II. After assembly of the inflator, the unit was placed in an oven at 107°C for two hours. The inflator was removed from the oven, allowed to cool to room temperature and then fired. The inflator performed similar to the tests set forth in Example II, thus

demonstrating the thermal stability of the compositions according to the invention.

EXAMPLE V

5 Hot and Cold Ignition

In this experiment, the ignition characteristics of the gas generant at 90°C, ambient (about 24°C) and -40°C was investigated. Nineteen gms of the generant Sample No. 5 was loaded into the housings. A total of
10 nine inflators were prepared. Three were placed in an oven at 90°C for two hours and three were placed in a freezer at -40°C for two hours. Three inflators remained at room temperature. The inflators were fired at their respective soak temperatures in a
15 60 liter test chamber fitted to measure combustion gases, pressure and particulates. Plots of pressure versus time were recorded. Table III sets forth the maximum chamber pressure, time to maximum pressure and area under the curve for each test.

TABLE III
Tank Pressure for Ambient, 90°C and -40°C Tests

Test	Max. Pressure (psi)	Time to Max Pressure (ms)	Area under the Curve (PSI *ms)
Ambient I	30.1	49.8	4672.7
Ambient II	29.7	51.6	4615.2
Ambient III	29.5	50.2	4561.3
90°C I	33.9	40.6	5221.7
90°C II	32.9	42.2	5093.1
90°C III	32.3	42.0	4979.0
-40°C I	26.8	57.4	4119.4
-40°C II	26.8	58.8	4101.0
-40°C III	26.2	54.8	4012.3

The data evidence that the gas generant according to the invention provides satisfactory combustion properties over a wide range of temperatures to properly inflate the airbag.

5 Total particulate production from each test was also collected. Following venting of the tank to the atmosphere, the interior of the 60 liter test chamber was carefully scrubbed and rinsed with deionized water to measure particulate production. The particulate
10 produced by gas generants comprises a mixture of water soluble and insoluble reaction products. The aqueous mixture of the soluble reaction products and the insoluble dust were analyzed to determine total particulate production. Table IV sets forth the
15 insoluble, soluble and total particulates for each run.

TABLE IV
Particulate Production

Test	Insoluble Particulates (mg)	Soluble Particulates (mg)	Total (mgs)
Ambient I	217	760	977
Ambient II	128	658	786
Ambient III	162	727	889
90°C I	335	1008	1343
90°C II	363	1041	1404
90°C III	180	1036	1216
-40°C I	273	819	1092
-40°C II	319	760	1079
-40°C III	271	777	1048

The data evidence that the gas generant composition according to the invention produces a relatively clean gas upon combustion; that is, from a 19 gm charge of generant, less than 1.5 gms of solids exit the inflator.

Toxicity testing was also conducted on the ambient firings of the generant and the results are set forth in Table V.

10

TABLE V
Gas Toxicity Testing - PPM

Test	CO	NO	NO2	NH3	CO2	HCl	Cl2	H2S	COCL2
Ambient I	3746	467	214	<5	(2.6%)	<5	<0.2	<0.2	<0.02
Ambient II	3513	320	325	<5	(2.6%)	<5	<0.2	<0.2	<0.02
Ambient III	3773	253	391	<5	(2.7%)	<5	<0.2	<0.2	<0.02

() = value may be inaccurate, exceeds highest calibration standard.

These data indicate that the generant according to the invention produces a gas that is relatively non-toxic and would therefore be useful in the inflation of air bags and as fire extinguishers.

5 From these experiments and others that are being conducted at the time of the filing of this application, it is clear that the gas generant according to the invention is useful for inflating airbags and can also be used as fire extinguishers.

10 The generants of the invention are virtually unaffected by temperature extremes and possess excellent ignition and combustion properties. Surprisingly, the use of ammonium perchlorate (AP) does not cause a chlorine problem in the combustion
15 gas. This is quite an unexpected result to those skilled in the art.

CLAIMS:

1. A gas generant composition comprising:
a fuel component which is used at a
level between 45 and 70 weight %, which comprises a
5 mixture of at least two fuels selected from the group
consisting of guanidine nitrate (GN), nitroguanidine
(NQ), triaminoguanidine nitrate (TAGN),
diaminoguanidine nitrate (DAGN) and monoguanidine
nitrate (MGN); and
10 an oxidizer component which is used at
a level of between 25 and 50 weight %, which comprises
a mixture of alkali metal nitrates, alkaline earth
metal nitrates, and ammonium perchlorate.
- 15 2. The gas generant composition according to
claim 1 further comprising a catalyst selected from
copper chromite, iron oxide and mixtures thereof.
- 20 3. The gas generant composition according to
claim 2 wherein said catalyst is present at a
concentration of 0.1 to 1.0 weight % of the
composition.
- 25 4. The gas generant composition according to
claim 2 wherein: said fuel component comprises a
mixture of NQ and GN; said oxidizer component
comprises a mixture of strontium nitrate (SN),
ammonium perchlorate (AP) and sodium nitrate (NaN);
and said catalyst is copper chromite (CuCr).
- 30 5. The gas generant composition according to
claim 4 wherein: said NQ is at a concentration of
10-20 weight % said GN is at a concentration of

35-50 weight %; said SN is at a concentration of
5-15 weight %; said AP is at a concentration of 15-25
weight %; said NaN is at a concentration of 5-25
weight %; and said copper chromite is at a
5 concentration of 0.1-0.5 weight %.

6. The gas generant composition according to
claim 5 wherein: said NQ is at a concentration of
14-17 weight % and said GN is at a concentration of
10 40-43 weight %; said SN is at a concentration of
7-10 weight %; said AP is at a concentration of 21-24
weight %; and said NaN is at a concentration of 10-13
weight %; and said CuCr is at a concentration of 0.2-
0.3 weight %.

15

7. The gas generant composition according to
claim 2 wherein said composition is prepared by the
steps comprising:

dry blending said fuel component with
20 said oxidizer component until a homogenous blend is
achieved;

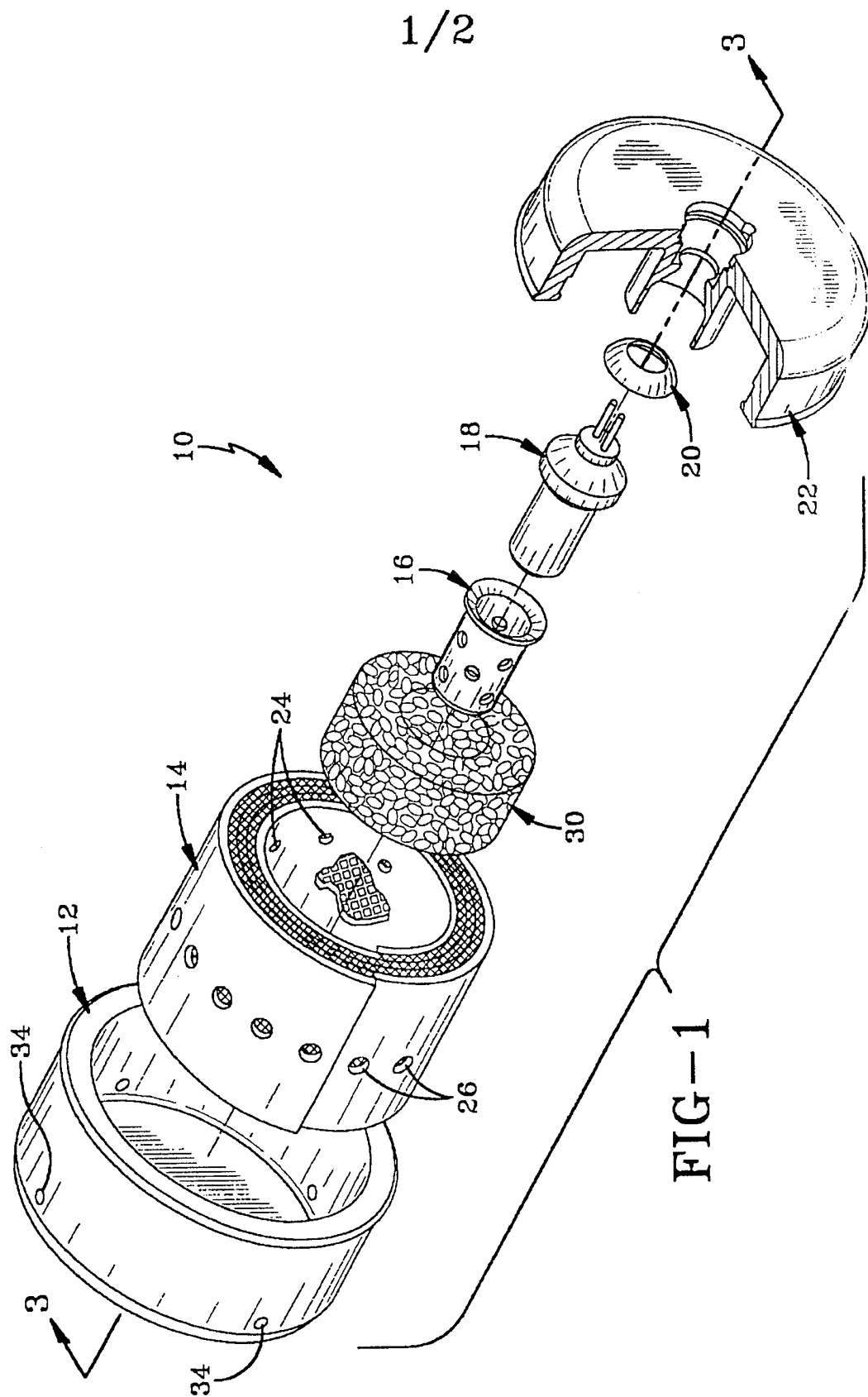
adding said catalyst to said homogenous
blend and blending until a second homogenous
blend is achieved; and

25 pelletizing said second homogenous blend to
produce pellets of from 5-500 mgs.

8. The gas generant composition according to
claim 7 wherein: said fuel component comprises a
30 mixture of NQ and GN; said oxidizer component
comprises a mixture of strontium nitrate (SN),
ammonium perchlorate (AP) and sodium nitrate (NaN);
and said catalyst is copper chromite (CuCr).

9. The gas generant composition according to claim 7 wherein said fuel, oxidizer and catalyst are substantially anhydrous.

- 5 10. The gas generant composition according to claim 1 further comprising at least one component selected from nitrocellulose and diphenylamine.



2/2

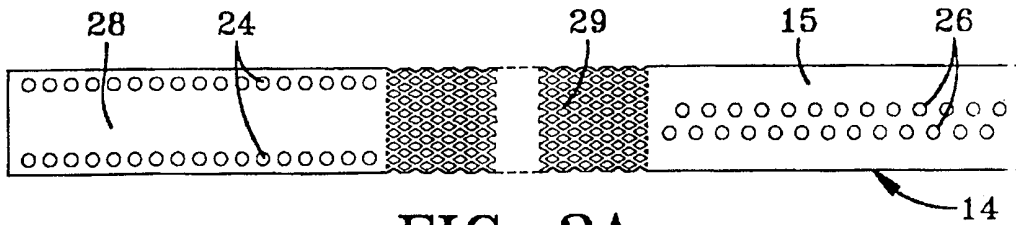


FIG-2A

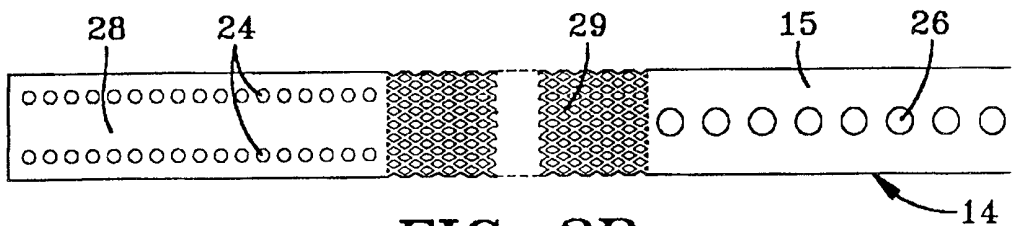


FIG-2B

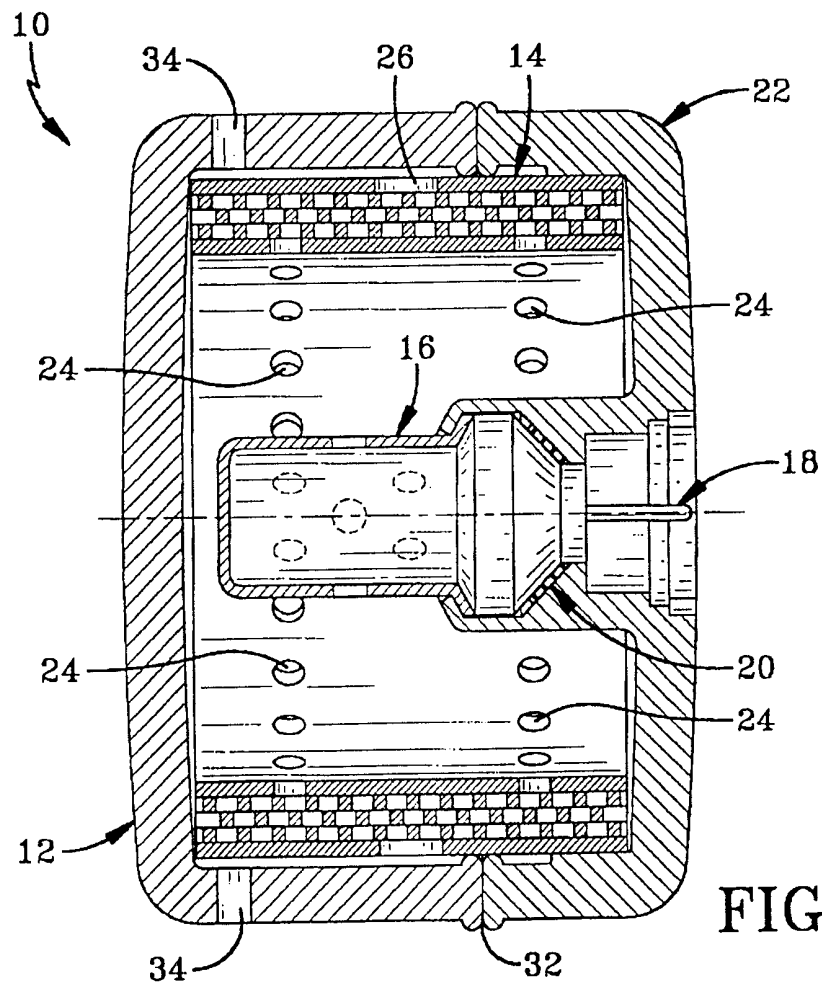


FIG-3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/13128

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : C06B 31/12, 29/22, 25/34

US CL : 149/62, 76, 92

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)

U.S. : 149/62, 76, 92

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

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

APS (NITROGUANIDINE AND AMMONIUM PERCHLORATE, GUANIDINE NITRATE AND AMMONIUM PERCHLORATE, STRONTIUM NITRATE, SODIUM NITRATE, COPPER CHROMITE, NITROCELLULOSE, DIPHENYLAMINE)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,739,460 A (KNOWLTON ET AL) 14 April 1998, (14.04.98)	NONE
A	US 4,971,640 A (CHI) 20 November 1990, (20.11.90)	NONE



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	*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
A document defining the general state of the art which is not considered to be of particular relevance	*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
E earlier document published on or after the international filing date	*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
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z* document member of the same patent family
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	

Date of the actual completion of the international search

21 JULY 1999

Date of mailing of the international search report

23 AUG 1999

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