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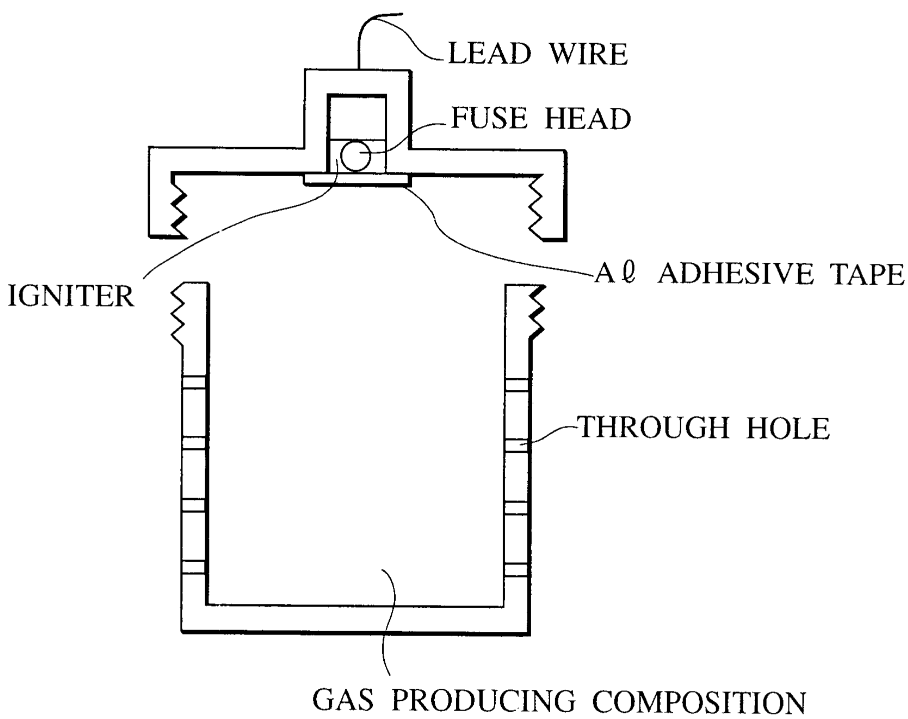
(54) Gas producing composition

(57) There is provided ammonium nitrate (NH_4NO_3), metal nitride, and, as the need arise, inorganic oxidizing agent or metal powder.

FIG.1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a gas producing composition applied to a gas producing apparatus for an airbag, and more particularly, to a gas producing composition which produces a predetermined gas to be easily handled.

2. Description of Relevant Art

[0002] There is mainly used metal azide as gas producing agent applied to an airbag, the agent specially containing sodium azide (Na_3N). The sodium azide itself is difficult to handle, and it is popular to conduct a research of gas producing agent which does not use it.

[0003] As a representative example, there was invented and has been used gas producing agent of which main component is a mixture of an organic compound containing a lot of amino groups and nitrogen. For example, there is gas producing agent for an airbag which main components are ammonium nitrate, amino tetrazole (CH2NH4NH2), and binder (Japanese Patent Application Laid-Open Publication No. 10-130086). The composition is superior in not using metal azide. It can increases gas production amount per unit weight and decreases solid residue to be produced. Weight of a filter components for filteration of the residue are lowered and amount of gas producing agent can be smaller, and a gas producing apparatus can be miniaturized, thus beginning to put the agent into practical use.

SUMMARY OF THE INVENTION

[0004] This composition, however, uses an organic compound, thus containing four chemical elements of carbon, nitrogen, hydrogen, and oxygen naturally. When the compound produces gas under high temperatures, undesirable nitric oxide, and/or carbon monoxide are produced. If the composition includes oxygen increased to sufficiently oxidize carbon monoxide to be changed to carbon dioxide, excessive oxygen reacts with nitrogen, thus producing nitric oxide. On the other hand, if the composition includes oxygen decreased to reduce nitric oxide, there occurs phenomenon that carbon monoxide increases, thus cannot producing neither at the same time.

[0005] After actuating an airbag, gas environment inside a vehicle needs that of no influence for a human body, but it is very difficult to realize. Further, these gas producing composition produces high temperature gas during actuation of the airbag, so safety measure should be installed to the inflator. This causes an airbag a more complicate structure and factor for cost increase.

[0006] It is an object of the present invention to provide a gas producing composition which does not substantially accompany undesirable gas produced such as nitric oxide or ammonia.

[0007] Another object of the present invention is to prepare gas producing compositions which produce large amount of the gas production per unit weight of the compositions and decrease residue produced from the compositions.

[0008] The inventor investigated wholeheartedly and, as a result, took notice to a gas producing composition which was consisted of inorganic compound not basically containing carbon, thus completing the invention.

[0009] To achieve the object, a first aspect of the invention provides a gas producing composition including: ammonium nitrate (NH_4NO_3); and metal nitride.

[0010] The gas producing composition, preferably, further includes inorganic oxidizing agent.

[0011] The gas producing composition, preferably, further includes metal powder.

[0012] The inorganic oxidizing agent is, preferably, inorganic nitrate.

[0013] The metal nitride, preferably, is nitride containing boron (B), silicon (Si), aluminum (Al), or mixture thereof.

[0014] The ammonium nitrate, preferably, is within a range between 10% and 95% by weight, the metal nitride is within a range between 5% and 30% by weight, and the inorganic oxidizing agent is within a range between 0% and 50% by weight. The gas producing composition is adapted for production of a predetermined gas containing an oxygen gas. The inorganic oxidizing agent, preferably, is within a range between 1% and 15% by weight and, further preferably, within a range between 3% and 10% by weight. In order to generate the gas which does not contain large amount of the water (less than 25% water) and increase the amount of the gas production per unit weight, following compositions are preferable.

[0015] The ammonium nitrate is, preferably, within a range between 50% and 70% by weight, and the metal nitride is boron nitride within a range between 30% and 50% by weight.

[0016] The ammonium nitrate is, preferably, within a range between 40% and 60% by weight, metal nitride is silicon nitride within a range between 25% and 40% by weight and boron nitride within a range between 10% and 15% by weight, and the inorganic oxidizing agent is potassium nitrate within a range under 20.0% by weight.

[0017] The ammonium nitrate is, preferably, about 50% by weight, metal nitrate is silicon nitride within a range between 20% and 30% by weight, and boron nitride is about 10% by weight, the inorganic oxidizing agent is strontium nitrate within a range between 10% and 20% by weight.

[0018] A second aspect of the invention provides a gas producing composition includes: main agent which contains boron nitride and ammonium nitrate; and

one of oxidizing agent, metal nitride, and metal powder which is mixed with the main agent. The gas producing composition is adapted for production of water not more than 25% by weight relative to production of all gas.

[0019] According to the gas producing compositions of the invention, the compositions did not produce monoxide at all which had been produced by a conventional gas producing agent. Concentration of nitric oxide decreased to minimum 1/10 and maximum 1/1000 compare to that in the gas produced from existing gas producing agent. Further, it was found that compound of compositions were capable of reducing production of water or producing oxygen. In addition, it was found that gas production per unit weight was equal to or more than twice than that of conventional one.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

[0020] The above and further objects and novel features of the present invention will more fully appear from the following detailed description when the same is read in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic view of a combustion container;
Fig. 2 shows results of two and three component-system containing ammonium nitrate and boron nitride;
Fig. 3 shows results of compositions in which a combination of silicon nitride and aluminum nitride or boron nitride and further a metal powder of Si or Al was used as reducing agent and single ammonium nitrate or mixture oxidizing agent containing ammonium nitrate and potassium nitrate was used as oxidizing agent;
Fig. 4 shows results of compositions in which a combination of silicon nitride and boron nitride or a metal powder of Al and B was used as reducing agent and mixture of ammonium nitrate and strontium nitrate was used as oxidizing agent;
Fig. 5 shows results of compositions in which aluminum nitride, single ammonium nitrate, or mixture oxidizing agent of ammonium nitrate and potassium nitrate was used; and
Fig. 6 shows results of comparative examples.

[0021] In above-Figs, character "-" means the component is not included and "nd" means the component is not detected.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] There will be detailed below the preferred embodiments of the present invention with reference to the accompanying drawings.

Embodiments are

[0023]

(1) a gas producing composition which includes ammonium nitrate (NH_4NO_3) and metal nitride;
(2) a gas producing composition which includes ammonium nitrate (NH_4NO_3), metal nitride, and inorganic oxidizing agent;
(3) a gas producing composition which includes ammonium nitrate (NH_4NO_3), metal nitride, inorganic oxidizing agent, and metal powder.
(4) the gas producing composition according to (2) or (3), in which inorganic oxidizing agent is inorganic nitrate;
(5) the gas producing composition according to (1) to (4), in which the metal nitride is nitride containing boron (B), silicon (Si), aluminum (Al), or mixture thereof; and
(6) a gas producing composition which includes main agent which contains boron nitride and ammonium nitrate, and one of oxidizing agent, metal nitride, and metal powder which is mixed with the main agent, the gas producing composition being adapted for production of water not more than 25% by weight relative to production of all gas; and
(7) a gas producing composition which has ammonium nitrate between 10% and 95% by weight, metal nitride between 5% and 30% by weight, and inorganic oxidizing agent between 0% and 50% by weight, the gas producing composition being adapted for production of a predetermined gas containing an oxygen gas.

[0024] The embodiments are explained in detail. Ammonium nitrate applied to the embodiments is not restricted especially. In general, ammonium nitrate for industry, fine crystal granular ammonium nitrate, or phase stabilizing ammonium nitrate containing metal oxide such as potassium nitrate or nickel oxide between 3% and 10% by weight as phase stabilizing agent may be preferable for example. Metal nitride may be boron nitride, aluminum nitride, silicon nitride, strontium nitride, calcium nitride, chromium nitride, titanium nitride, copper nitride, magnesium nitride, or zirconium nitride, for example. Among them, from a view of stability or price, boron nitride, aluminum nitride, or silicon nitride may be preferable. It is noted that sodium azide is distinguished from nitride and nitride in the embodiments does not include the metal azide.

[0025] In case of including metal nitride and ammonium nitrate, the mixture ratio may be the ammonium nitrate within a range between 20% and 95% by weight, or, preferably, between 40% and 90% by weight, and the metal nitride within a range between 5% and 80% by weight, or, preferably, between 10% and 60% by weight. If the ammonium nitrate is more than this ranges, production of oxygen increases and gas having tendency to cause a fire is produced. If the ammonium nitrate is less than this ranges, supply amount of oxygen decreases, and metal nitride reduces water, thus producing a lot of hydrogen gas.

[0026] It is said that hydrogen is less toxic for human body, however, produce explosion tendency gas or combustion tendency gas by mixing with air.

Explosion gas of three components of oxygen-nitrogen-hydrogen does not explode or burn under not more than 4% of hydrogen. Under more than 4% of hydrogen, it become combustion gas, and, under much more than 4 % of hydrogen, it become "mixture gas" which shows explosion tendency. It is considered that hydrogen amount from gas producing agent may preferably be not more than 6% to 7%, depending on mixing amount of air.

[0027] In gas producing compound of the embodiments, ammonium nitrate is basically a main component for gas producing source. It has a role as oxidizing agent and metal nitride is reducing agent, thus oxidation-reduction reaction being made use of. Therefore, there can be added other oxidizing agent not including hydrogen, such as inorganic nitrate or perchlorate including sodium, potassium, or strontium, which generally has oxidizing action. Nitrate may preferably be due to both having a role as oxidizing agent and producing nitrogen. Metal nitrate does not include hydrogen, and is able to control production of water. The inorganic oxidizing agent, preferably, is within a range between 1% and 15% by weight or, further preferably, within a range between 3% and 10% by weight. Since the inorganic oxidizing agent tends to produce burned residue and has tendency to deteriorate efficiency of gas production, smaller amount of the agent is better. Metal nitride is applied to reducing agent and more than two kinds of metal nitrides may be mixed with each other to be used. Further, there may be mixed metal powder having reducing action, such as aluminum, magnesium, magnalium (Mg-Al alloy), silicon, or boron. In this case, ammonium nitrate may be contained equal to or more than 10 % or, preferably, 20 %. Adding metal powder makes combustion temperature higher, thus promoting to decompose metal nitride. Metal powder may be added within a range between 0 % and 10 % or, preferably , between 0 % and 4 %. When exceeding these ranges, the amount of gas production per unit weight tends to decrease, and small amount of it is desirable.

[0028] In general, ammonium nitrate, metal nitride, oxidizing agent, and reducing tendency metal used for the embodiments are granulated or powdered. After mixing these with each other, the mixture is formed by pressure molding or granulation molding in a predetermined shape, such as a flake-shape, a disc-shape, a tablet, a annular shape, a granule, thus being filled in a gas producing apparatus for an airbag. In the case of performing this forming, there may be added binder to help forming and adhering, such as water glass, silicon oxide, or very small amount of organic binder. Further, inorganic binder may be preferably selected. There may be added catalyst to adjust combustion property, such as metal oxide including copper, iron, cobalt, or nickel, or alkali metal perchlorate.

[EXAMPLES]

[0029] 2% (external proportion) of water glass as an aqueous solution was added to the formulations shown in the composition column of Figs. 2 to 5 and the mixture was air-dried until the water content was reduced to the level enabling granulation. The dried mixture was placed on a 30 mesh stainless wire net and pressed by a rubber plate to granulate into a granular form. The granulated substance was extended thinly on paper and dried at 70°C until the water content was reduced to 0.1% or less to produce each composition in an amount of 5 g or more. While, a combustion container (made of iron) which had a content volume of 10 ml and in which 60 through-holes having a diameter of 1.5 mm were opened was prepared on the external peripheral portion of a 20 mm diameter cylinder having a wall thickness of 2 mm and provided with one side bottom as shown in Fig. 1 and an 8-micron thick aluminum foil was placed so as to seal peripheral holes (not shown). About 5 g of the granular product which was exactly weighed was placed on the aluminum foil. A screw for assembling an ignition device was disposed at the opening end of the combustion container. The ignition device (made of iron) was provided with a screw fitting to the combustion container and a convex portion having an inside diameter of 7 mm, a wall thickness of 2 mm and a depth of 17 mm. On the bottom of the convex portion, a through-hole for penetrating a lead wire of a fuse head with lead was provided. The fuse head with a lead wire was disposed in the convex portion. 0.1 g of an ignition charge, as major components, 55% of zirconium and 45% of potassium perchlorate was placed around the fuse head and an aluminum adhesive tape was applied to the opening end. This ignition device was attached to the combustion container using the screw to produce a combustor assembly. A pressure withstanding vessel was produced to attain combustion in the combustor assembly. The cylindrical pressure vessel (made of stainless) has a proof pressure of 50 MPa and a content volume of 1000 ml and provided with a lid which could be secured by a quarter round threaded screw, a threaded hole for fitting up a thermocouple, a gas exhaust pipe with a valve, a threaded hole to which a sensor measuring internal pressure could be set and a terminal which could apply ignition current from the outside of the vessel. The thermocouple was formed of a platinum/platinum alloy (0.05 mm diameter), attached to the lid and connected to a direct current amplifier. A pressure gage was a strain gage type sensor and was connected to a strain gage amplifier. Each output of the direct current amplifier and strain gage amplifier were designed so that recording could be made by connecting it to a recorder which could record the output as a function of time. The combustor assembly was placed in the vessel. After the lead wire of the fuse head was connected to the inside portion of the terminal applying ignition current, the pressure vessel was sealed by rotating the lid by a quarter round. Thereafter, vacuum horse, which is connected to a vacuum pump and argon gas bump, was attached to the end of the gas exhaust pipe with valve. This was also provided with a charge valve enabling argon to be filled vacuum. The valve was opened to create vacuum and argon gas was introduced into up to atomosphere pressure into the pressure vessel, thereby substituting the air to argon in the pressure vessel and thereafter the valve was closed.

[0030] Prior to this experiment, a gas chromatograph with two packed column was prepared in which one packed column was used to measure nitrogen and oxygen (argon gas could also be measured) by using helium as a carrier gas and another packed column was used to measure hydrogen by using nitrogen as a carrier gas. Each gas with a standard concentration was introduced to produce a calibration curve or line. Also, in consideration of the presence of undesired gases including nitrogen oxide and ammonia, a detector tube (manufactured by Gastech Co.) capable of measuring these gases and a device for the detector tube were prepared.

[0031] After completion of these preparations, one end of the lead wire used for applying ignition current was connected to a terminal used for applying ignition current disposed outside the pressure vessel and the other end was connected to a blasting machine. Then, the direct current amplifier, the strain gage amplifier and the recording device were made to work to apply ignition current. Each pressure at two temperature points of 500°C and 90°C was afterwards measured. In each vicinity of these temperatures, temperature cooling rate was so gentle that temperature and pressure were measured with relative accuracy. Also, since the pressure data at 90°C was obtained after almost all water was condensed, it was considered that the remainder was only nitrogen, oxygen, hydrogen and argon which was initially filled and hence the total mol number of these three types of gas was calculated. At this time, although the presence of the gas dissolved in the condensed water was expected, it was neglected because the gas had high temperature and small solubility. The gas was supposed to be ideal gas. As for the pressure data obtained at 500°C, in turn, water was expected to be in a gas state, the gas was supposed to be ideal gas to calculate the total mol number of the mixture gas and a difference between this total mol number and the above total mol number measured at 90°C was defined as the mol number of the water (steam). In parallel to these measurements, each measurement of derivative gas by using the detector tube and the concentration of the major gas by using gas chromatography were made. From these results, each weight of the gas components other than water can be calculated. Also, from the mol number of water, its weight was calculated. Thus the ratio (%) by weight of each component can be obtained and each amount of produced gases per unit weight can be calculated.

[0032] The results of these measurements and calculations are shown in Figs. 2 to 5.

[0033] Fig. 2 shows results of two and three component-system containing ammonium nitrate and boron nitride.

[0034] Two component-system included ammonium nitrate within a range between 50.0% and 95.0% by weight and boron nitride within a range between 5.0% and 50.0% by weight. Three component-system included ammonium nitrate within a range between 15.0% and 70.0% by weight, boron nitride of 25.0% by weight, and potassium nitrate within a range between 5.0% and 60.0% by weight. The two and three component-system obtained good results.

[0035] Fig. 3 shows the results of compositions in which a combination of silicon nitride and aluminum nitride or boron nitride and further metal powder of Si and Al was used as reducing agent and single ammonium nitrate or mixture oxidizing agent containing ammonium nitrate and potassium nitrate was used as oxidizing agent.

[0036] Three component-system included ammonium nitrate within a range between 50.0% and 70.0% by weight, silicon nitride within a range between 15.0% and 40.0% by weight, and metal nitride (AlN or BN) within a range between 5.0% and 15.0% by weight. Four component-system included ammonium nitrate within a range between 20.0% and 65.0% by weight, silicon nitride within a range between 20.0% and 33.0% by weight, potassium nitrate within a range under 40.0% by weight, and metal powder or metal nitride within a range between 4.0% and 15.0% by weight. Both of the three and four component-system compounds obtained good result.

[0037] Fig. 4 shows results of compositions in which a combination of silicon nitride and boron nitride or a metal powder of Al and B was used as a reducing agent and mixture of ammonium nitrate and strontium nitrate was used as oxidizing agent.

[0038] Four component-system included ammonium nitrate within a range between 45.0% and 65.0% by weight, silicon nitride within a range between 20.0% and 31.0% by weight, strontium nitrate within a range between 10.0% and 20.0% by weight, and metal powder or metal nitride within a range between 3.0% and 10.0% by weight. The four component-system compounds obtained good result.

[0039] Fig. 5 shows results of compositions in which aluminum nitride, single ammonium nitrate, or mixture oxidizing agent of ammonium nitrate and potassium nitrate was used.

[0040] Two component-system included ammonium nitrate within a range between 70.0% and 90.0% by weight, and aluminum nitride within a range between 10.0% and 30.0% by weight. Three component-system included ammonium nitrate within a range between 60.0% and 70.0% by weight, aluminum nitride within a range between 10.0% and 20.0% by weight, and potassium nitrate of 20.0% by weight. Both of the three and four component-system obtained good results.

[0041] Incidentally, the "Solid" in Figs. 2 to 5 is a solid substance left after the gas producing-agent is completely burned.

[0042] As is seen from the results of the examples, it is surprised to find in almost all compositions that nitrogen oxide is extremely small and even if in the case of oxygen gas concentration is very high (No. 10 to No. 12). That is, compounds preferably have compositions including ammonium nitrate within a range between 15.0% and 95.0% by weight, boron nitride within a range between 5.0% and 25.0% by weight, and potassium nitrate within a range under 60.0% by weight.

[0043] Also, compositions (No.1 to No.4, No.37, No. 39 to No.41, No.68 and No.70) to produce small amount of water which is desired level to keep clean and safety of the crew when an airbag actuates and the amount of the produced gas per unit weight was greater than those of conventional product were found, whereby the problem was solved. That is, compositions including ammonium nitrate within a range between 50.0% and 70.0% by weight, and boron nitride within a range between 30.0% and 50.0% by weight (No.1 to No.4). Compositions are including ammonium nitrate within a range between 40.0% and 60.0% by weight, silicon nitride within a range between 25.0% and 40.0% by weight, potassium nitrate within a range under 20.0% by weight, and boron nitride within a range between 10.0% and 15.0% by weight (No.37 and No. 39 to NO. 41). Compositions are including about 50% by weight of ammonium nitrate, silicon nitride within a range between 20.0% and 30.0% by weight, strontium nitrate within a range between 10.0% and 20.0% by weight, and about 10% by weight of boron nitride (NO.68 and No.70).

[0044] Note 1: Comparative Example, h1 is a compound according to Japanese Patent Application Laid-Open No. 6-239683. It is to be noted that the amount of the produced gas is a theoretical value in a formulation according to a stoichiometrically ratio.

[0045] Note 2: Comparative Example, h2 is a compound according to Japanese Patent Application Laid-Open No. 10-130086, Example 1.

[0046] While preferred embodiments of the present invention have been described using specific terms, such description is for illustrative purposes, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the following claims.

Claims

1. A gas producing composition comprising:

ammonium nitrate (NH_4NO_3); and
metal nitride.

2. A gas producing composition according to claim 1, further comprising:

inorganic oxidizing agent.

3. A gas producing composition according to claim 2, further comprising:

metal powder.

4. A gas producing composition according to claim 2, wherein the inorganic oxidizing agent is inorganic nitrate.

5. A gas producing composition according to claim 1, wherein the metal nitride is nitride containing boron (B), silicon (Si), aluminum (Al), or mixture thereof.

6. A gas producing composition comprising:

main agent containing boron nitride and ammonium nitrate; and
one of oxidizing agent, metal nitride, and metal powder mixed with the main agent,
the gas producing composition being adapted for production of water not more than 25% by weight relative to production of all gas.

7. A gas producing composition according to claim 2,

wherein the ammonium nitrate is between 10% and 95% by weight, the metal nitride is between 5% and 30% by weight, and the inorganic oxidizing agent is between 0% and 50% by weight, the gas producing composition being adapted for production of a predetermined gas containing an oxygen gas.

8. A gas producing composition according to claim 2, wherein the ammonium nitrate is within a range between 10% and 95% by weight, the metal nitride is within a range between 5% and 30% by weight, and the inorganic oxidizing agent is within a range between 1% and 15% by weight.

9. A gas producing composition according to claim 1, wherein the ammonium nitrate is within a range between 50% and 70% by weight, and the metal nitride is boron nitride within a range between 30% and 50% by weight.

10. A gas producing composition according to claim 2, wherein the ammonium nitrate is within a range between 40% and 60% by weight, metal nitride is silicon nitride within a range between 25% and 40% by weight and boron nitride within a range between 10% and 15% by weight, and the inorganic oxidizing agent is potassium nitrate within a range under 20% by weight.

11. A gas producing composition according to claim 3, wherein the ammonium nitrate is 50% by weight, metal nitride is silicon nitride within a range between 20% and 30% by weight, and boron nitride is 10% by weight, the oxidizing agent is strontium nitrate within a range between 10% and 20% by weight.

FIG.1

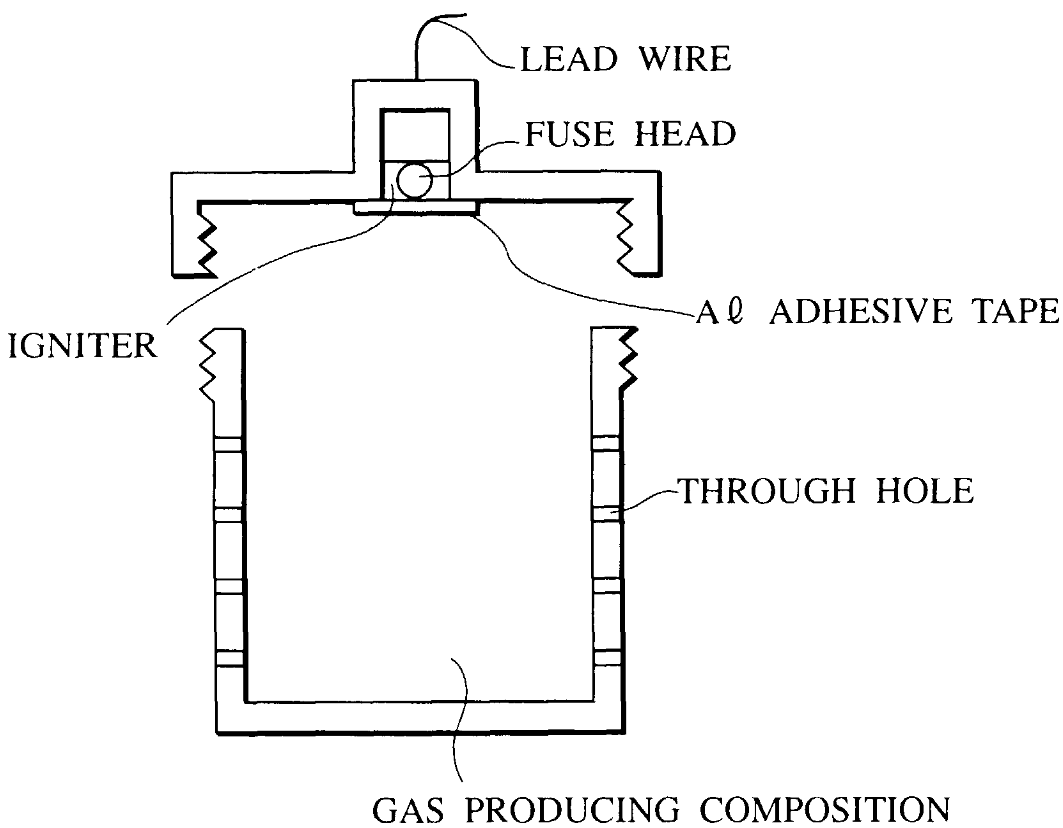
LEAD WIRE
FUSE HEAD
Aℓ ADHESIVE TAPE
IGNITER
THROUGH HOLE
GAS PRODUCING COMPOSITION

FIG.2

NO.	COMPOSITIONS OF GAS PRODUCING COMPOSITION (%)						PRODUCED GASES (%)					SOLID (%)	GAS AMOUNT mol/100g	DERIVATIVE GASES (ppm)		
	NH_4NO_3	BN	KNO_3			TOTAL	H_2	H_2O	N_2	O_2	TOTAL			NH_3	NO	NO_2
1	50.0	50.0	—			100.0	6.2	4.4	89.5	nd	100.0	61.0	2.5	nd	nd	nd
2	55.0	45.0	—			100.0	6.1	4.5	89.3	nd	100.0	55.9	2.9	nd	nd	nd
3	65.0	35.0	—			100.0	6.4	4.3	89.3	nd	100.0	53.1	3.1	nd	nd	nd
4	68.0	32.0	—			100.0	4.0	20.2	75.7	nd	100.0	45.6	3.2	10	nd	nd
5	72.0	28.0	—			100.0	2.6	29.7	67.7	nd	100.0	39.4	3.3	10	nd	nd
6	75.0	25.0	—			100.0	1.7	35.9	62.4	nd	100.0	35.3	3.3	nd	nd	nd
7	80.0	20.0	—			100.0	0.6	44.6	54.9	nd	100.0	28.4	3.4	nd	nd	nd
8	85.0	15.0	—			100.0	nd	48.2	48.7	3.1	100.0	21.6	3.5	nd	80	nd
9	90.0	10.0	—			100.0	nd	46.4	43.8	9.8	100.0	15.3	3.8	nd	20	nd
10	95.0	5.0	—			100.0	nd	44.8	39.6	15.6	100.0	8.8	4.0	nd	nd	nd
11	15.0	25.0	60.0			100.0	nd	16.6	76.5	6.9	100.0	63.8	1.4	nd	6	nd
12	25.0	25.0	50.0			100.0	nd	26.7	71.8	1.4	100.0	58.5	1.7	nd	nd	nd
13	35.0	25.0	40.0			100.0	0.4	30.5	69.0	nd	100.0	53.8	2.0	nd	10	nd
14	45.0	25.0	30.0			100.0	0.8	32.1	67.1	nd	100.0	49.3	2.3	nd	nd	nd
15	55.0	25.0	20.0			100.0	1.3	33.6	65.2	nd	100.0	44.6	2.7	nd	nd	nd
16	65.0	25.0	10.0			100.0	1.5	34.8	63.7	nd	100.0	40.0	3.0	nd	nd	nd
17	70.0	25.0	5.0			100.0	1.6	35.6	62.8	nd	100.0	37.4	3.1	nd	nd	nd

FIG.3

NO.	COMPOSITIONS OF GAS PRODUCING COMPOSITION (%)						MAIN COMPONENTS (%)					SOLID (%)	GAS AMOUNT mol/100g	DERIVATIVE GASES (ppm)		
	NH_4NO_3	Si_3N_4	KNO_3	COMPONENT	AMOUNT	TOTAL	H_2	H_2O	N_2	O_2	TOTAL			NH_3	NO	NO_2
31	20.0	33.0	40.0	Si	7.0	100.0	0.3	35.4	62.8	1.5	100.0	60.2	1.7	nd	150	nd
32	65.0	21.0	10.0	Al	4.0	100.0	0.2	46.3	53.5	nd	100.0	39.3	2.8	nd	60	nd
33	44.0	32.0	20.0	Al	4.0	100.0	2.3	25.1	72.5	nd	100.0	57.4	2.2	10	30	nd
34	70.0	15.0	—	AlN	15.0	100.0	2.3	32.2	65.4	nd	100.0	40.4	3.2	nd	nd	nd
35	70.0	20.0	—	AlN	10.0	100.0	1.1	40.9	58.0	nd	100.0	38.1	3.0	nd	nd	nd
36	70.0	25.0	—	AlN	5.0	100.0	1.3	40.0	58.7	nd	100.0	38.3	3.1	nd	nd	nd
37	50.0	40.0	—	BN	10.0	100.0	4.7	9.4	85.9	nd	100.0	57.5	2.5	nd	nd	nd
38	50.0	20.0	20.0	BN	10.0	100.0	1.4	31.6	67.0	nd	100.0	49.4	2.4	nd	nd	nd
39	40.0	25.0	20.0	BN	15.0	100.0	4.5	6.2	89.2	nd	100.0	58.2	2.4	nd	nd	nd
40	50.0	25.0	10.0	BN	15.0	100.0	4.8	6.2	89.0	nd	100.0	58.1	2.5	nd	nd	nd
41	60.0	25.0	—	BN	15.0	100.0	5.3	10.5	84.2	nd	100.0	53.2	2.9	10	nd	nd

FIG.4

NO.	COMPOSITIONS OF GAS PRODUCING COMPOSITION (%)						MAIN COMPONENTS (%)					SOLID (%)	GAS AMOUNT mol/100g	DERIVATIVE GASES (ppm)		
	NH_4NO_3	Si_3N_4	$Sr(NO_3)_2$	COMPONENT	AMOUNT	TOTAL	H_2	H_2O	N_2	O_2	TOTAL			NH_3	NO	NO_2
61	60.0	21.0	15.0	Al	4.0	100.0	nd	46.0	54.0	nd	100.0	41.9	2.60	nd	70	nd
62	65.0	21.0	10.0	Al	4.0	100.0	0.2	46.1	53.7	nd	100.0	39.5	2.76	nd	20	nd
63	52.0	25.0	20.0	Al	3.0	100.0	0.4	40.7	58.9	nd	100.0	47.7	2.38	nd	10	nd
64	60.0	21.0	15.0	B	4.0	100.0	1.4	36.4	62.2	nd	100.0	49.5	2.49	nd	nd	nd
65	65.0	21.0	10.0	B	4.0	100.0	1.5	37.1	61.4	nd	100.0	47.1	2.65	nd	nd	nd
66	50.0	26.0	20.0	B	4.0	100.0	2.6	24.2	73.1	nd	100.0	58.3	2.20	nd	nd	nd
67	45.0	31.0	20.0	B	4.0	100.0	4.7	9.5	85.8	nd	100.0	64.1	2.14	nd	nd	nd
68	50.0	30.0	10.0	BN	10.0	100.0	5.0	9.0	86.1	nd	100.0	57.7	2.56	nd	nd	nd
69	50.0	20.0	20.0	BN	10.0	100.0	1.4	31.3	67.3	nd	100.0	49.8	2.43	nd	nd	nd
70	50.0	30.0	10.0	BN	10.0	100.0	4.7	9.0	86.3	nd	100.0	57.8	2.51	nd	nd	nd
71	50.0	20.0	20.0	BN	10.0	100.0	1.4	31.3	67.3	nd	100.0	49.8	2.43	nd	nd	nd

FIG.5

NO.	COMPOSITIONS OF GAS PRODUCING COMPOSITION (%)						MAIN COMPONENTS (%)					SOLID (%)	GAS AMOUNT mol/100g	DERIVATIVE GASES (ppm)		
	NH_4NO_3	AlN	KNO_3			TOTAL	H_2	H_2O	N_2	O_2	TOTAL			NH_3	NO	NO_2
81	90.0	10.0	—			100.0	nd	46.3	39.9	13.7	100.0	12.6	3.9	nd	90	nd
82	85.0	15.0	—			100.0	nd	47.1	42.9	10.1	100.0	18.6	3.6	nd	60	nd
83	80.0	20.0	—			100.0	nd	47.9	46.3	5.7	100.0	24.9	3.4	nd	230	nd
84	70.0	30.0	—			100.0	0.8	43.8	55.4	nd	100.0	37.4	3.0	nd	970	nd
85	70.0	10.0	20.0			100.0	nd	38.8	40.1	21.0	100.0	23.5	3.2	nd	nd	nd
86	60.0	20.0	20.0			100.0	nd	39.4	47.9	12.7	100.0	36.1	2.7	nd	110	nd

FIG.6

COMPARATIVE EXAMPLE

NO.	COMPOSITIONS OF GAS PRODUCING AGENTS (%)						MAIN COMPONENTS (%)					SOLID (%)	GAS AMOUNT mol/100g	DERIVATIVE GASES (ppm)			
	NH_4NO_3	NaN_3	CH_3N_5	$Sr(NO_3)_2$	CuO	TOTAL	CO_2	H_2O	N_2	O_2	TOTAL			NH_3	NO	NO_2	CO
h1	—	60.0	0.0	—	40.0	100.0	0.1		88.0	11.9	100.0	59.9	1.44	0	15	30	250
h2	75.0	—	25.0	—	—	100.0									200		5000

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EUROPEAN SEARCH REPORT

Application Number
EP 99 12 2585

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	DE 37 33 177 C (BAYERN-CHEMIE GESELLSCHAFT FÜR FLUGCHEMISCHE ANTRIEBE MBH) 11 May 1989 (1989-05-11) * page 2, line 53 - line 62 * * page 3, line 25 - line 29; claims *	1-6	C06D5/06 C06B31/28
X	US 5 557 062 A (R.O. MACLAREN ET AL.) 17 September 1996 (1996-09-17) * column 2, line 43 - line 49 * * column 3, line 2 - line 31; claims *	1,2,6	
X	WO 98 29361 A (NIPPON KAYAKU KABUSHIKI-KAISHA ET AL.) 9 July 1998 (1998-07-09) * claims * & EP 0 952 131 A	1	
A	WO 95 18780 A (THIOKOL CORPORATION) 13 July 1995 (1995-07-13) * page 10, line 22 - line 29; claims *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
C06D
C06B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 February 2000	Schut, R

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The members are as contained in the European Patent Office EDP file on
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21-02-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 3733177 C	11-05-1989	JP 1122987 A	16-05-1989
		JP 6084274 B	26-10-1994
		US 4865667 A	12-09-1989
US 5557062 02 A		NONE	
WO 9829361 A	09-07-1998	EP 0952131 A	27-10-1999
WO 9518780 A	13-07-1995	AU 1521595 A	01-08-1995

EPO FORM P0459

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