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(54) **THRUSTER USING NITROUS OXIDE**

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(57) **ABSTRACT**

A thruster is provided that makes it possible to reduce and eventually eliminate the toxicity of storable liquid propellant and improve the low-temperature environment adaptability of propulsion system using the storable liquid propellant. The thruster produces thrust by using catalytic decomposition gas obtained by catalytically decomposing nitrous oxide with a nitrous oxide decomposition catalyst.

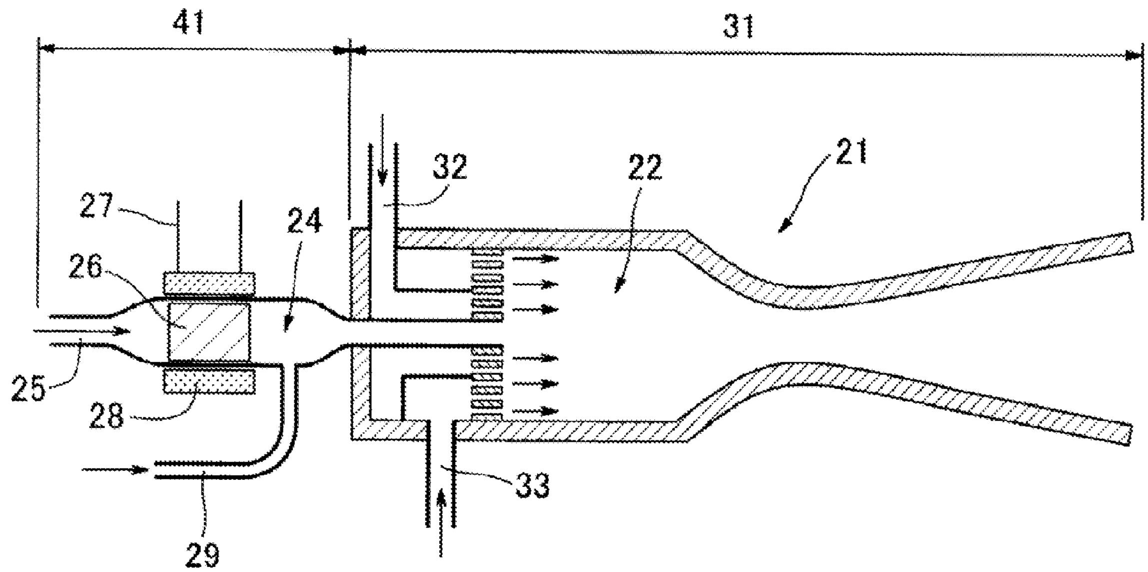


FIG.1

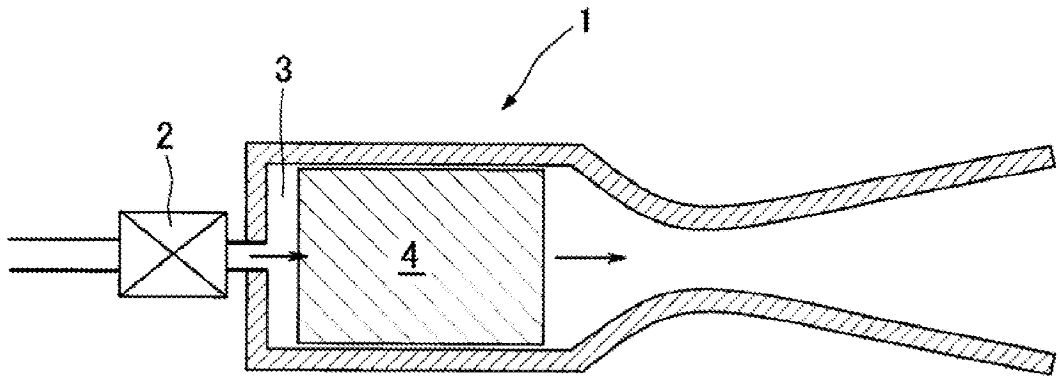


FIG.2

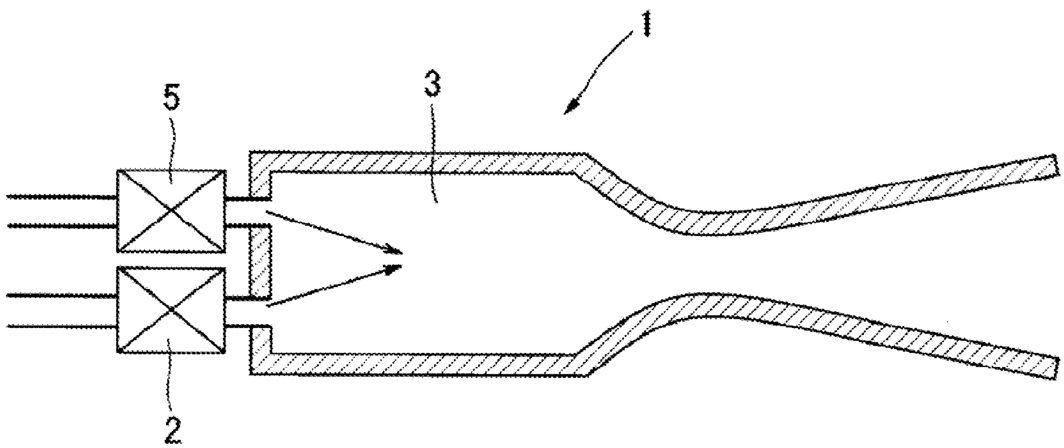


FIG.3

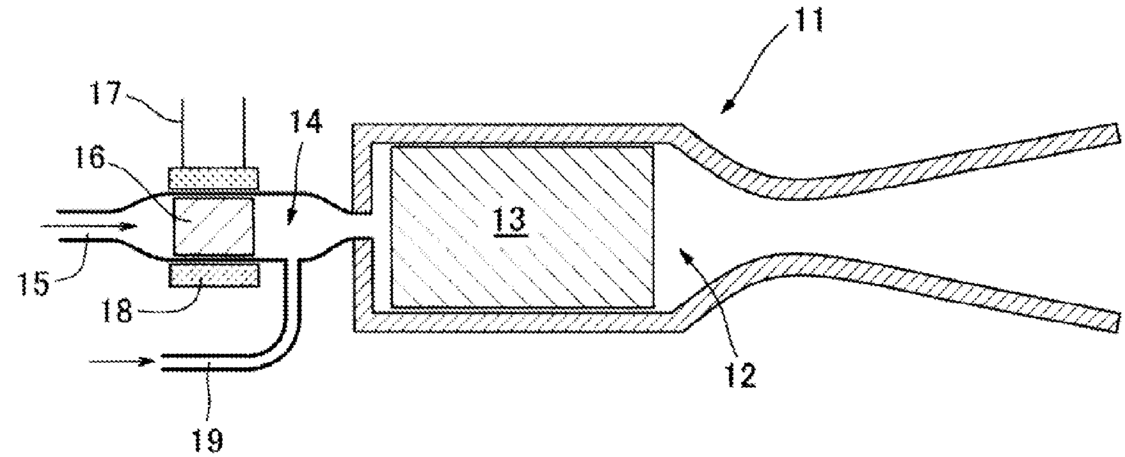


FIG.4

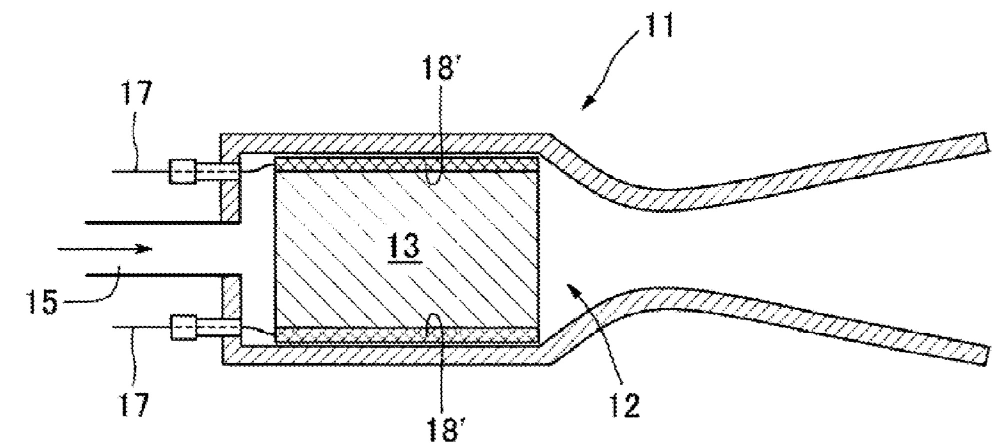


FIG.5

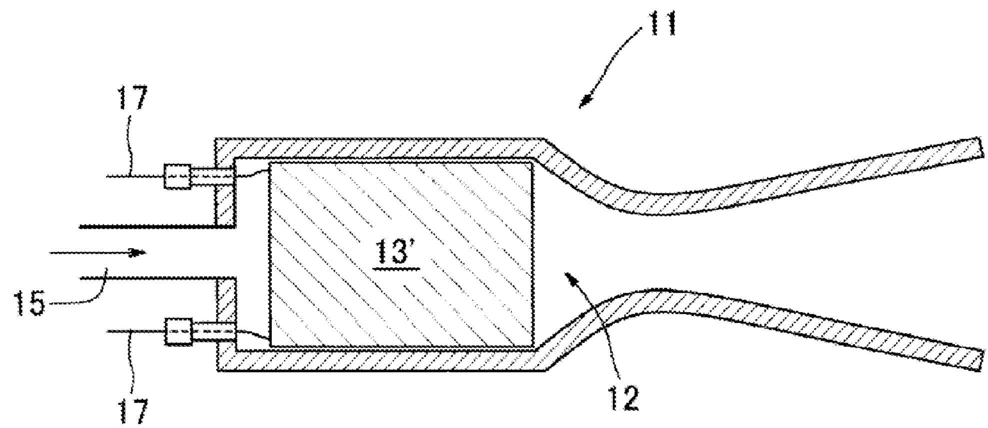


FIG.6

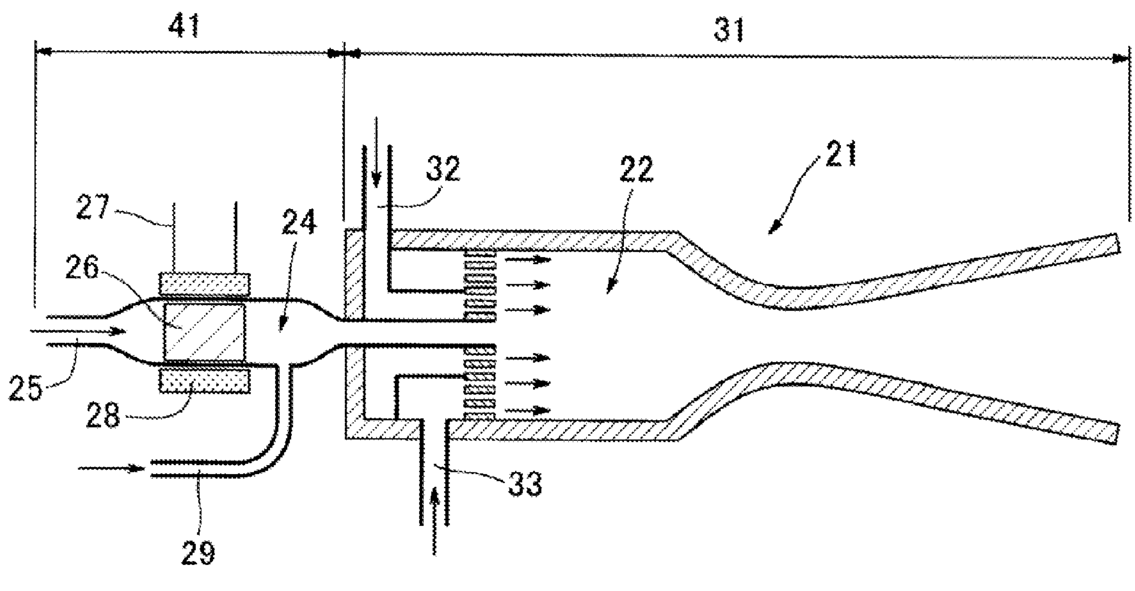
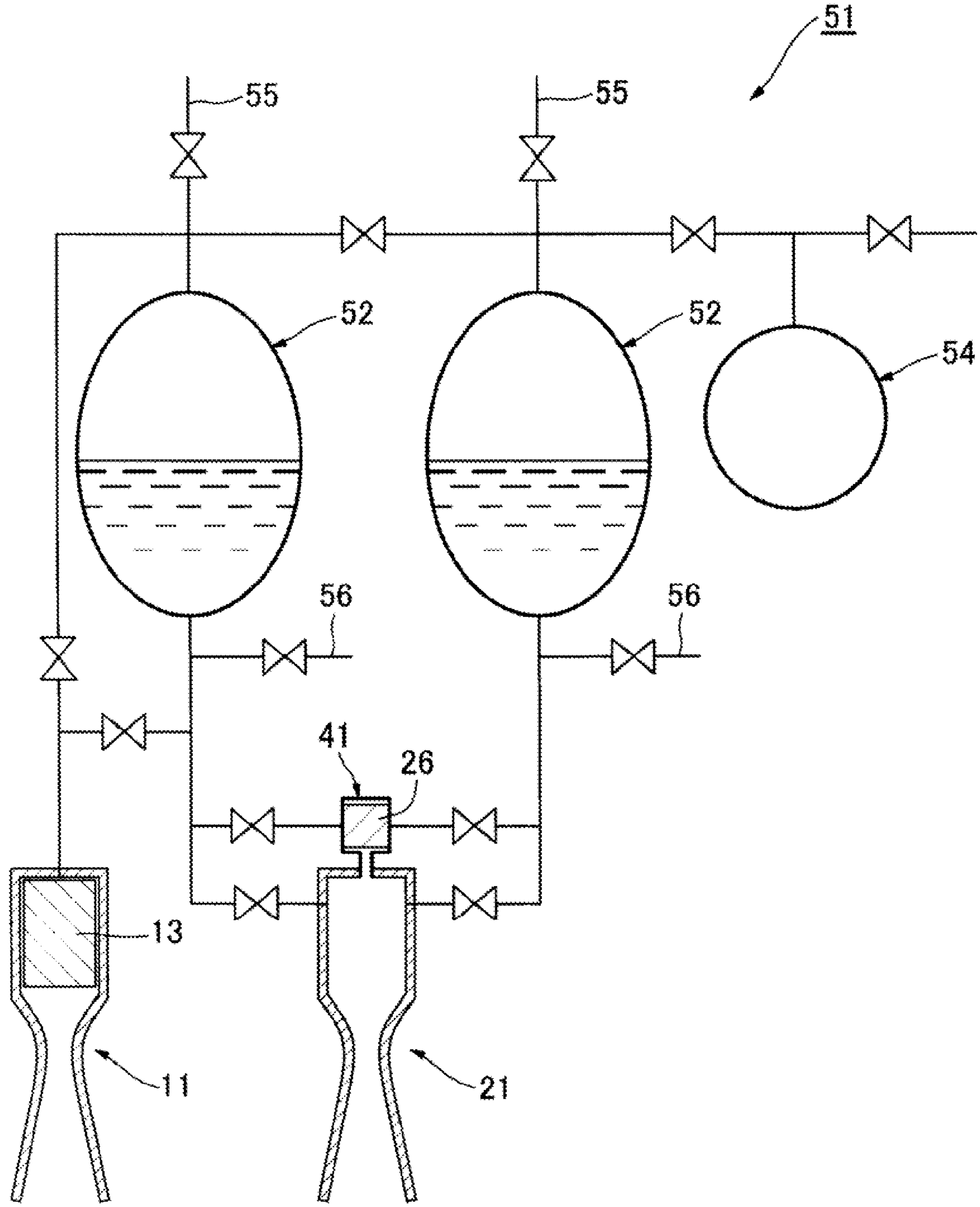


FIG.7



THRUSTER USING NITROUS OXIDE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present patent application claims priority from Japanese Patent Application No. 2006-328971, filed on Dec. 6, 2006.

BACKGROUND OF THE INVENTION

[0002] i) Field of the Invention

[0003] The present invention relates to a thruster that can be used in a propulsion system which is mounted in a rocket, satellite, spacecraft and the like and used to control their orbit and/or attitude. In particular, the present invention relates to a thruster that uses nitrous oxide (N_2O) as a liquid propellant (storable liquid propellant) which is used in the thruster and which can be stored at normal temperature, thereby making it possible to reduce and eventually eliminate the toxicity of the liquid propellant and to improve the low-temperature environment adaptability of propulsion system.

[0004] (ii) Description of the Related Art

[0005] Conventional thrusters used for controlling the orbit and/or attitude of satellites and the like can be classified into monopropellant thrusters (using a single propellant) and bipropellant thrusters (using a propellant comprising an oxidizer and fuel) according to the compositions of liquid propellants used in the thrusters.

[0006] An example of conventional monopropellant thrusters is shown in FIG. **1**. This thruster **1** produces thrust by feeding, e.g. hydrazine (N_2H_4), from a fuel valve **2** into a thruster combustion chamber **3** as a single liquid propellant which can be stored at normal temperature, decomposing the hydrazine by a hydrazine decomposition catalyst layer **4** that is provided in the thruster combustion chamber **3** to exothermically generate decomposition gas and exhausting the decomposition gas. For example, Japanese Patent Laid-Open Publication No. 2001-20808 discloses a catalytic decomposition monopropellant hydrazine engine thruster that can produce thrust required to achieve a mission of a satellite by producing high-temperature and high-pressure gas by a catalytic decomposition reaction of a one-component propellant, wherein a catalyst formed to have a lattice structure is placed in a combustion chamber.

[0007] Further, an example of conventional bipropellant thrusters is shown in FIG. **2**. This thruster **1** produces thrust by feeding a liquid propellant such as hydrazine (N_2H_4) or monomethyl hydrazine (MMH) from a fuel valve **2** to a thruster combustion chamber **3** and feeding an oxidizer such as dinitrogen tetraoxide (N_2O_4) from an oxidizer valve **5** to the thruster combustion chamber **3** so as to cause the fuel and the oxidizer to impinge each other to induce self-ignition in the thruster combustion chamber **3**.

[0008] These conventional thrusters are used, alone or in combination, in propulsion systems for rockets and spacecrafts. For example, Japanese Patent Laid-Open Publication No. 2000-190899 discloses a propulsion system comprising a plurality of monopropellant hydrazine reaction control thrusters for attitude control and a plurality of bipropellant (e.g. hydrazine and dinitrogen tetraoxide) SCAT (secondary combustion amplification thruster) for speed control.

[0009] All of the above conventional thrusters use highly toxic propellants. Thus, when propulsion systems comprising these thrusters are operated on the ground, environmental care and securing of safety in handling are essential. Accordingly, there has been a demand for development of thrusters that can use propellants of low or no toxicity.

[0010] Further, since hydrazine in particular, which is currently used as a propellant in attitude control thrusters for satellites and spacecrafts, has a high freezing point (of about 1° C.), it is necessary to provide an antifreezing heater to the whole propellant feeding system in the thruster, when the satellite or spacecraft is used in a low-temperature space environment. Further, there is also a problem that when hydrazine is frozen for some reason in a low-temperature environment, the thruster becomes unable to produce thrust. Accordingly, there has been a demand for development of thrusters using propellants which can be used in a low-temperature environment.

[0011] As attempts for development of such thrusters, for example, "Catalytic Decomposition of Nitrous Oxide for Spacecraft Propulsion Applications. (Phase 1)", Surrey Satellite Technology, Ltd., SPC 99-4100 (AD-A392935) (Sep. 30, 2000) discloses that initial heating of catalysts (NiO supported on ZrO_2, Shell405/LCH-212, Rh_2O_3 supported on Al_2O_3) is implemented by catalytic decomposition gas generated by electrothermal catalyst wires (made of rhodium, platinum-rhodium, nickel-chromium alloy, stainless steel) to encourage continuous catalytic decomposition, as a concept of monopropellant thruster that exhausts gas generated by catalytic decomposition or continuous self-decomposition of nitrous oxide; considers a possibility of a self-pressure-feeding system using the vapor pressure of nitrous oxide and a possibility of a bipropellant thruster using nitrous oxide as a propellant; discloses a multimode thruster comprising a two-component-thruster using a combination of nitrous oxide and fuel; and considers design of a thruster component to be mounted on an micro satellite. Further, "The Nitrous Oxide Propane Rocket Engine", Allied Aerospace Industries Inc., GASL TR No. 387 (Aug. 16, 2001) discloses a concept of igniter using catalytic decomposition gas and selection of verification tests and a decomposition catalyst. However, it is a current situation that thrusters free of the problems of the prior art have not been obtained.

Patent Literature 1

[0012] Japanese Patent Laid-Open Publication No. 2001-20808

Patent Literature 2

[0013] Japanese Patent Laid-Open Publication No. 2000-190899

Non-Patent Literature 1

[0014] "Catalytic Decomposition of Nitrous Oxide for Spacecraft Propulsion Applications. (Phase 1)", Surrey Satellite Technology, Ltd., SPC 99-4100 (AD-A392935) (Sep. 30, 2000)

Non-Patent Literature 2

[0015] "The Nitrous Oxide Propane Rocket Engine", Allied Aerospace Industries Inc., GASL TR No. 387 (Aug. 16, 2001)

[0016] Therefore, an object of the present invention is to provide a thruster that makes it possible to reduce and eventually eliminate the toxicity of liquid propellant (storable liquid propellant) which is used in the thruster and which can be stored at normal temperature and to improve the low-temperature environment adaptability of propulsion system using the storable liquid propellant.

SUMMARY OF THE INVENTION

[0017] To solve the above problems, the present inventors have made intensive studies. As a result, they have conceived use of nitrous oxide (N_2O) that is low in toxicity as a propellant, i.e. a single propellant used in a monopropellant thruster or an oxidizer used in a bipropellant thruster.

[0018] That is, nitrous oxide is a chemically stable substance that causes little harm even if taken in a human body and is also approved as a food additive (ministerial ordinance No. 34 of the Ministry of Health, Labor and Welfare, Mar. 22, 2005). Therefore, when nitrous oxide is used as a single propellant used in a monopropellant thruster and catalytic decomposition gas obtained by catalytically decomposing the nitrous oxide is used to produce thrust, the propellant used in the thruster can be made substantially nontoxic.

[0019] Further, for fuel of low toxicity, a number of choices including alcohols and LPG are available. Thus, when these fuels are used in combination with nitrous oxide serving as an oxidizer, the toxicity of propellant used in a bipropellant thruster can be reduced. In this case, by taking advantage of a fact that nitrous oxide, unlike a toxic dinitrogen tetraoxide (N_2O_4)/hydrazine (N_2H_4) based propellant used in conventional bipropellant thrusters, does not have a characteristic of spontaneously igniting at normal temperature but is a energetic material having high energy (temperature of exothermic decomposition gas is about 1,600° C.), heat obtained by catalytically decomposing nitrous oxide can be used as ignition energy.

[0020] Further, in a deep space exploration mission which may be realized in the near future, a low-temperature environment of about −50° C. is expected, and the freezing point of nitrous oxide is sufficiently low as −91° C. Accordingly, even in a propulsion system used in such a low-temperature environment, there is no need to provide an antifreezing heater in a propellant supply system in a thruster, when nitrous oxide is used as a propellant. Further, when ethanol (freezing point: −114° C.) is selected as low-toxicity fuel used in combination with nitrous oxide, for example, a propulsion system having a bipropellant thruster that can be used without a heater even in a low-temperature environment can be obtained.

[0021] In view of a fact that the saturated vapor pressure of nitrous oxide is relatively high (for example, about 6.4 atm at −50° C.), it is conceived that while high-pressure helium gas is used as gas (so-called pressurant) for pressure-feeding a propellant in conventional thrusters, use of nitrous oxide as a propellant can obviate use of other pressurant since nitrous oxide gas itself can be used as pressurant. Further, in the case of a bipropellant thruster, when fuel having high saturated vapor pressure is used, a thruster having a propellant supply system using no pressurant can be attained, and even when the saturated vapor pressure of fuel is not so high, use of other pressurant can be obviated by supplying the fuel by use of the vapor pressure of nitrous oxide gas.

[0022] The present inventors have conceived the present invention based on these findings.

[0023] That is, the present invention provides a thruster that produces thrust by using catalytic decomposition gas obtained by catalytically decomposing nitrous oxide with a nitrous oxide decomposition catalyst.

[0024] In one respect, the present invention provides a monopropellant thruster as described above that produces thrust by directly exhausting catalytic decomposition gas to the outside of the thruster.

[0025] In another respect, the present invention provides a monopropellant thruster as described above that produces thrust by exhausting exothermic decomposition gas obtained by self-decomposing additional nitrous oxide with thermal energy of catalytic decomposition gas to the outside of the thruster.

[0026] According to one embodiment of the present invention, the above thruster comprises heating means for heating the nitrous oxide decomposition catalyst.

[0027] In one aspect, the heating means may direct combustion gas generated by mixing the catalytic decomposition gas with fuel to the nitrous oxide decomposition catalyst.

[0028] In another aspect, the heating means may be a heater attached to the nitrous oxide decomposition catalyst.

[0029] In still another aspect, the heating means may be a heater constituted by the nitrous oxide decomposition catalyst.

[0030] In still another respect, the present invention provides a bipropellant thruster as described above that produces thrust by exhausting combustion gas obtained by combusting a mixture of nitrous oxide and fuel by use of catalytic decomposition gas and/or combustion gas generated by mixing the catalytic decomposition gas with fuel, to the outside of the thruster.

[0031] According to one embodiment of the present invention, the above fuel is fuel of no or low toxicity selected from the group consisting of alcohols and LPG. Further, it is also possible to use nitromethane as the above fuel.

[0032] In still another respect, the present invention provides a thruster as described above that uses nitrous oxide gas as pressurant for pressure-feeding nitrous oxide and/or fuel.

[0033] According to the present invention, a thruster using nitrous oxide which is low in toxicity as a propellant is obtained. Thereby, the safety and operability of propulsion system can be improved. Further, since nitrous oxide has a low freezing point, a propulsion system that can adapt even to a low-temperature environment expected in a deep space exploration mission in the near future becomes possible. Further, a propulsion system can also be expected that has conventionally used gas for pressure-feeding a propellant in a reduced amount by taking advantage of the relatively high saturated vapor pressure of nitrous oxide.

[0034] Nitrous oxide used in the thruster according to the present invention is almost completely decomposed into oxygen and nitrogen by a decomposition catalyst. Hence, it is conceived that nitrous oxide can also be used as a source of life-support gaseous oxygen or thermal energy in a closed system such as a spaceship or space station. Further, it is also conceived that oxygen obtained by catalytic decomposition of nitrous oxide is combined with proper fuel such as hydrogen or methanol and applied to fuel cells.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] FIG. **1** is a schematic cross-sectional view of a conventional monopropellant thruster.

[0036] FIG. **2** is a schematic cross-sectional view of a conventional bipropellant thruster.

[0037] FIG. **3** is a schematic cross-sectional view of one embodiment of monopropellant thruster according to the present invention.

[0038] FIG. **4** is a schematic cross-sectional view of another embodiment of the monopropellant thruster according to the present invention.

[0039] FIG. **5** is a schematic cross-sectional view of still another embodiment of the monopropellant thruster according to the present invention.

[0040] FIG. **6** is a schematic cross-sectional view of one embodiment of bipropellant thruster according to the present invention.

[0041] FIG. **7** is a schematic diagram illustrating a propulsion system using the thrusters according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

(1) Nitrous Oxide Decomposition Catalyst

[0042] A nitrous oxide decomposition catalyst used for decomposition of nitrous oxide in a thruster of the present invention is not particularly limited as long as it can decompose nitrous oxide into gaseous oxygen and gaseous nitrogen at high efficiency. For example, there can be suitably used such a catalyst having aluminum, magnesium and rhodium supported on a carrier or a catalyst having at least one metal selected from the group consisting of zinc, iron, manganese and nickel, aluminum and rhodium supported on a carrier as described in Japanese Patent Laid-Open Publication No. 2002-153734 as catalysts used to decompose and remove nitrous oxide contained in exhaust gas discharged from factories and incinerators. Similarly, there can also be suitably used such a catalyst having at least one noble metal selected from the group consisting of rhodium, ruthenium and palladium supported on a carrier selected from silica or silica-alumina as described in Japanese Patent Laid-Open Publication No. 2002-253967 as a catalyst that decomposes nitrous oxide contained in excess anesthetic gas discharged from an operating room. By use of these catalysts, nitrous oxide can be decomposed into gaseous oxygen and gaseous nitrogen at a decomposition efficiency close to 100%. More specifically, a catalyst prepared by impregnating a carrier comprising alumina wash-coated cordierite and metal honeycomb or porous ceramics with rhodium which is effective in decomposition of nitrogen oxide at amass fraction of 2 to 3% is useful. A specific example of catalysts that are preferably used in the thruster is a catalyst having rhodium, which is effective in decomposition of nitrogen oxide, supported on an alumina carrier layer formed on a ceramic honeycomb structure comprising alumina, cordierite or silicon carbide.

(2) One-Component-Type Thruster

[0043] When the thruster of the present invention is a monopropellant thruster, the thruster can produce thrust by directly exhausting oxygen-nitrogen mixed gas of high temperature exceeding 1,000° C. which is obtained by catalytically decomposing nitrous oxide to the outside of the thruster.

[0044] Further, the present thruster can also produce thrust by exhausting thermal decomposition gas obtained by self-decomposing additional nitrous oxide with thermal energy of the catalytic decomposition gas to the outside of the thruster, by taking advantage of a fact that the above mixed gas obtained by catalytic decomposition of nitrous oxide has high thermal energy.

[0045] Particularly when the thruster of the present invention is a monopropellant thruster, it is desirable to provide the thruster with heating means for heating a nitrous oxide decomposition catalyst so that the decomposition catalyst can be preheated. As monopropellant thrusters having such heating means, the following are conceivable.

a. Precombustion Heating Type:

[0046] A schematic cross-sectional view of a monopropellant thruster of this type is shown in FIG. **3**.

[0047] A thruster **11** has a secondary decomposition chamber **14** for producing combustion gas which is fed to a primary decomposition chamber **12** to preheat a nitrous oxide decomposition catalyst layer **13** before nitrous oxide is decomposed by the nitrous oxide decomposition catalyst layer **13** provided in the primary decomposition chamber **12**. This secondary decomposition chamber **14** has a nitrous oxide inlet **15** for feeding nitrous oxide from the outside and is communicated with the primary decomposition chamber **12** so that fed nitrous oxide can be transported. Further, inside the secondary decomposition chamber **14**, a small nitrous oxide decomposition catalyst layer **16** that can decompose a small amount of nitrous oxide and thereby generate catalytic decomposition gas is provided. To this small nitrous oxide decomposition catalyst layer **16**, a heater **18** is attached that can heat the small nitrous oxide decomposition catalyst layer **16** by receiving power from the outside through power supply lines **17** so that catalytic decomposition of nitrous oxide can be implemented efficiently. The heater **18** is prepared by coating a carbon material such as graphite having high heat resistance with oxidation-resistant SiC or the like. The secondary decomposition chamber **14** also has a fuel inlet **19** for feeding fuel that is mixed with catalytic decomposition gas generated by the small nitrous oxide decomposition catalyst layer **16** in the secondary decomposition chamber **14** to generate combustion gas that is to be fed to the primary decomposition chamber **12**.

[0048] The operation of the thruster **11** proceeds as follows. First of all, a small amount of nitrous oxide is fed from the nitrous oxide inlet **15** to the secondary decomposition chamber **14**, and the nitrous oxide is catalytically decomposed by the small nitrous oxide decomposition catalyst layer **16** to generate a small amount of nitrous oxide decomposition gas. This catalytic decomposition gas is mixed and burned with a small amount of fuel fed from the fuel inlet **19** to generate a small amount of combustion gas. This combustion gas is applied to the nitrous oxide decomposition catalyst layer **13** provided in the primary decomposition chamber **12** so as to be preheated. Once the nitrous oxide decomposition catalyst layer **13** in the primary decomposition chamber **12** is heated sufficiently, a required amount of nitrous oxide is fed from the nitrous oxide inlet **15**, through the secondary decomposition chamber **14** and to the primary decomposition chamber **12** so as to generate catalytic decomposition gas by the nitrous oxide decomposition catalyst layer **13** and thereby produce thrust.

[0049] As for the structure and size of the decomposition catalyst layer, a cylindrical square honeycomb structure of 10 mm in diameter and about 20 mm in length which is filled in a pipe having an inner diameter of 10 mm and made of a heat-resistant alloy or a ceramic composite (CMC) comprising silicon carbide as a base material can be used. An example of the catalyst is a catalyst having rhodium, which is effective in decomposition of nitrogen oxide, supported on an alumina carrier layer formed on a ceramic honeycomb structure comprising alumina or silicon carbide. As for the reaction temperature, the initial temperature of the catalyst heated by the heater is 350° C. (recommended temperature). The flow rates of nitrous oxide and fuel (ethanol) are about 2 g/s or lower and about 1 g/s or lower, respectively. As the fuel, fuel of no or low toxicity such as ethanol or propane is used, as described above.

b. Catalyst Heating Type:

[0050] A schematic cross-sectional view of a monopropellant thruster of this type is shown in FIG. **4**.

[0051] To a nitrous oxide decomposition catalyst layer **13** that is provided in a decomposition chamber **12** of a thruster **11**, an internal heater **18'** is attached that can heat the nitrous oxide decomposition catalyst layer **13** by receiving power from the outside through power supply lines **17** so that catalytic decomposition of nitrous oxide fed from a nitrous oxide inlet **15** can be implemented efficiently.

[0052] The operation of the thruster **11** proceeds as follows. First of all, the nitrous oxide decomposition catalyst layer **13** is heated by the internal heater **18'**. Once the nitrous oxide decomposition catalyst layer **13** in the decomposition chamber **12** is heated sufficiently, a required amount of nitrous oxide is fed from the nitrous oxide inlet **15** to the decomposition chamber **12** so as to generate catalytic decomposition gas by the nitrous oxide decomposition catalyst layer **13** and thereby produce thrust.

c. Heater Catalyst Carrier Type:

[0053] A schematic cross-sectional view of a monopropellant thruster of this type is shown in FIG. **5**.

[0054] A nitrous oxide decomposition catalyst layer **13'** that is provided in a decomposition chamber **12** of a thruster **11** constitutes a heater that can heat the nitrous oxide decomposition catalyst layer **13'** by receiving power from the outside through power supply lines **17** so that catalytic decomposition of nitrous oxide fed from a nitrous oxide inlet **15** can be implemented efficiently.

[0055] The operation of the thruster **11** proceeds as follows. First of all, the nitrous oxide decomposition catalyst layer **13'** is supplied with power to be preheated. Once the nitrous oxide decomposition catalyst layer **13'** in the decomposition chamber **12** is heated sufficiently, a required amount of nitrous oxide is fed from the nitrous oxide inlet **15** to the decomposition chamber **12** so as to generate catalytic decomposition gas by the nitrous oxide decomposition catalyst layer **13'** and thereby produce thrust.

[0056] Silicon carbide (SiC) has high oxidation resistance and heat resistance up to about 1,600° C. Thus, it is desirable to use a silicon carbide structure as a carrier that also serves as a heater for a nitrous oxide decomposition catalyst.

[0057] In this embodiment, since the whole catalyst can be uniformly heated, heat loss is small and power can be saved.

(3) Two-Component-Type Thruster

[0058] The thruster of the present invention may be a bipropellant thruster that produces thrust by exhausting combustion gas obtained by combusting a mixture of fuel and nitrous oxide used as an oxidizer to the outside of the thruster. In this case, since nitrous oxide, unlike a toxic dinitrogen tetraoxide (N_2O_4)/hydrazine (N_2H_4) based propellant used in conventional bipropellant thrusters, does not have a characteristic of spontaneously igniting at normal temperature, ignition means is required. As this ignition means, there can be used gaseous oxygen-containing high-temperature catalytic decomposition gas obtained by decomposing a part or all of nitrous oxide by a nitrous oxide decomposition catalyst, self-decomposition gas obtained by decomposing additional nitrous oxide by the above catalytic decomposition gas, or combustion gas generated by mixing the catalytic decomposition gas with fuel. Thus, if a system of thermally decomposing the whole nitrous oxide in a chain reaction by use of thermal energy generated by catalytically decomposing a small amount of nitrous oxide is realized, the amount of energy supplied from the outside for ignition of fuel can be decreased, resulting in power saving.

[0059] A schematic cross-sectional view of a bipropellant thruster according to the present invention is shown in FIG. **6**.

[0060] A thruster **21** comprises a combustor **31** that has a nozzle and an igniter **41**. The combustor **31** comprises a nitrous oxide inlet **32** and a fuel inlet **33** for feeding nitrous oxide and fuel from the outside to its thruster combustion chamber **22**, respectively. Nitrous oxide fed from the nitrous oxide inlet **32** requires the igniter **41** because it does not spontaneously ignite even if mixed with fuel fed from the fuel inlet **33** at room temperature in the combustor **31**.

[0061] The igniter **41** has a nitrous oxide inlet **25** for feeding nitrous oxide from the outside to its igniter combustion chamber **24** and is communicated with the thruster combustion chamber **22** so that fed nitrous oxide can be transported. Further, inside the igniter combustion chamber **24**, a small nitrous oxide decomposition catalyst layer **26** that can decompose a small amount of nitrous oxide and thereby generate catalytic decomposition gas is provided. To this small nitrous oxide decomposition catalyst layer **26**, a heater **28** is attached that can heat the small nitrous oxide decomposition catalyst layer **26** by receiving power from the outside through power supply lines **27** so that catalytic decomposition of nitrous oxide can be implemented efficiently. The heater **28** is prepared by coating a carbon material such as graphite having high heat resistance with oxidation-resistant SiC or the like. The igniter combustion chamber **24** also has a fuel inlet **29** for feeding fuel that is mixed with catalytic decomposition gas generated by the small nitrous oxide decomposition catalyst layer **26** in the igniter combustion chamber **24** to generate combustion gas that is to be fed to the thruster combustion chamber **22**.

[0062] The operation of the thruster **21** proceeds as follows. First, in the igniter **41**, high-temperature gas comprising high-temperature catalytic decomposition gas, or combustion gas generated by mixing the high-temperature gas with fuel is exhausted into the combustor **31** of the thruster **21**. Meanwhile, in the combustor **31**, nitrous oxide and fuel are fed from the nitrous oxide inlet **32** and the fuel inlet **33**, respectively, and while they are being mixed, they are ignited and combusted by the high-temperature gas/combustion gas exhausted from the igniter **41**. The thruster **21** produces thrust by exhausting generated combustion gas from an nozzle as in the case of conventional liquid rockets.

[0063] FIG. **7** shows a schematic diagram of a propulsion system **51** that can be built by use of the monopropellant thruster **11** and bipropellant thruster **21** according to the present invention. According to the propulsion system **51**, while the bipropellant thruster **21** is used as an orbital maneuvering engine with relatively high thrust or the like, the monopropellant thruster **11** can be used as an attitude control thruster with low thrust or the like. As shown in the drawing, the propulsion system **51** may comprise one monopropellant thruster **11** and one bipropellant thruster **21**. However, the propulsion system **51** is preferably constituted by one bipropellant thruster **21** and a plurality of monopropellant thrusters **11** or may comprise a plurality of monopropellant thrusters **11** and a plurality of bipropellant thrusters **21**. To these thrusters, nitrous oxide and fuel are fed from a nitrous oxide tank **52** and a fuel tank **53** that each have an exhaust port **55** and a filling port **56**, respectively. In that case, gaseous nitrogen or helium gas is fed from a pressurized gas tank **54** and used as pressurant. Meanwhile, it is considered to be also possible to build a complete self-pressure-feeding system that uses nitrous oxide as pressurant by use of the vapor pressure (5 MPa at 20° C.) of nitrous oxide.

[0064] The following table shows comparisons of the characteristics of the thrusters according to the present invention with those of conventional thrusters.

TABLE 1

Type of Thruster		Gas Temperature	Density *	Specific Thrust **
One-Component-Type	N_2H_4 Catalytic Decomposition (conventional)	to 600° C.	1.0 g/cc	220s
	N_2O Catalytic Decomposition	to 1600° C.	0.78 g/cc	190s
	N_2O Cold Gas	20° C.	0.78 g/cc	60s
Two-Component-Type	N_2O_4/N_2H_4 (conventional)	to 3000° C.	1.2 g/cc	320s
	N_2O/ethanol	to 3000° C.	0.78 g/cc	290s

* Density of propellant, or average of oxidizer density and fuel density in the case of bipropellant.
** Specific impulse is inversely proportional to the mass of loaded propellant. To obtain the same capability as that of N_2H_4 with nitrous oxide in the case of monopropellant, nitrous oxide must be loaded in an amount of 220s/190s = 1.16 times. Since tank volume is nearly inversely proportional to propellant density, the tank volume is 1.16 × 1.0/0.78 = 1.5 times.
(specific thrust [s]) = (thrust [N]))/(propellant mass flow rate [kg/s])/(gravity acceleration 9.807 [m/s2])

[0065] As described above, the thruster of the present invention has achieved elimination of toxicity and low-temperature environment adaptability while securing excellent handling safety, by use of a catalyst having high decomposition performance (decomposition rate: nearly 100%), without degrading the performance of conventional thrusters significantly. The thruster of the present invention has improved range operability (shortened operation time at a rocket range, improved safety, reduced costs) and can be used in multimode, i.e. as a monopropellant thruster, bipropellant thruster (and cold gas jet). Meanwhile, the thruster has performance of practicable level, can be stored in a normal-temperature to low-temperature environment and is nontoxic. Accordingly, it is expected that its utility value is to be found in academic users or exterior planet exploration missions in particular.

[0066] The present invention makes it possible to reduce and eventually eliminate the toxicity of storable liquid propellant and improve the low-temperature environment adaptability of propulsion system using the storable liquid propellant.

What is claimed:

1. A thruster that produces thrust by using catalytic decomposition gas obtained by catalytically decomposing nitrous oxide with a nitrous oxide decomposition catalyst.

2. The thruster of claim **1**, which is a monopropellant thruster that produces thrust by directly exhausting the catalytic decomposition gas to the outside of the thruster.

3. The thruster of claim **1**, which is a monopropellant thruster that produces thrust by exhausting thermal decomposition gas obtained by self-decomposing additional nitrous oxide with thermal energy of the catalytic decomposition gas to the outside of the thruster.

4. The thruster of claim **2**, comprising heating means for heating the nitrous oxide decomposition catalyst.

5. The thruster of claim **4**, wherein the heating means directs combustion gas generated by mixing the catalytic decomposition gas with fuel to the nitrous oxide decomposition catalyst.

6. The thruster of claim **4**, wherein the heating means is a heater attached to the nitrous oxide decomposition catalyst.

7. The thruster of claim **4**, wherein the heating means is a heater constituted by the nitrous oxide decomposition catalyst.

8. The thruster of claim **3**, comprising heating means for heating the nitrous oxide decomposition catalyst.

9. The thruster of claim **8**, wherein the heating means directs combustion gas generated by mixing the catalytic decomposition gas with fuel to the nitrous oxide decomposition catalyst.

10. The thruster of claim **8**, wherein the heating means is a heater attached to the nitrous oxide decomposition catalyst.

11. The thruster of claim **8**, wherein the heating means is a heater constituted by the nitrous oxide decomposition catalyst.

12. The thruster of claim **1**, which is a bipropellant thruster that produces thrust by exhausting combustion gas obtained by combusting a mixture of nitrous oxide and fuel by use of the catalytic decomposition gas and/or combustion gas generated by mixing the catalytic decomposition gas with fuel, to the outside of the thruster.

13. The thruster of claim **12**, wherein the fuel is fuel of no or low toxicity selected from the group consisting of alcohols and LPG.

14. The thruster of claim **1**, using nitrous oxide gas as pressurant for pressure-feeding the nitrous oxide and/or the fuel.

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