NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF:

October 15, 1970

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned
U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,298,182

Corporate Source : Calif. Institute of Technology

Supplementary Corporate Source : Jet Propulsion Laboratory

NASA Patent Case No.: XNP-00876

Please note that this patent covers an invention made by an employee of a NASA contractor. Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of. . . ."

Gayle Parker

Enclosure:
Copy of Patent

FACILITY FORM 602

N70-41311 (ACCESSION NUMBER)	(THRU)
5 (PAGES)	0 (CODE)
(NASA CR OR TMX OR AD NUMBER)	28 (CATEGORY)

N70-41311

Jan. 17, 1967 JAMES E. WEBB 3,298,182

ADMINISTRATOR OF THE NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

IGNITION MEANS FOR MONOPROPELLANT

Filed June 24, 1964

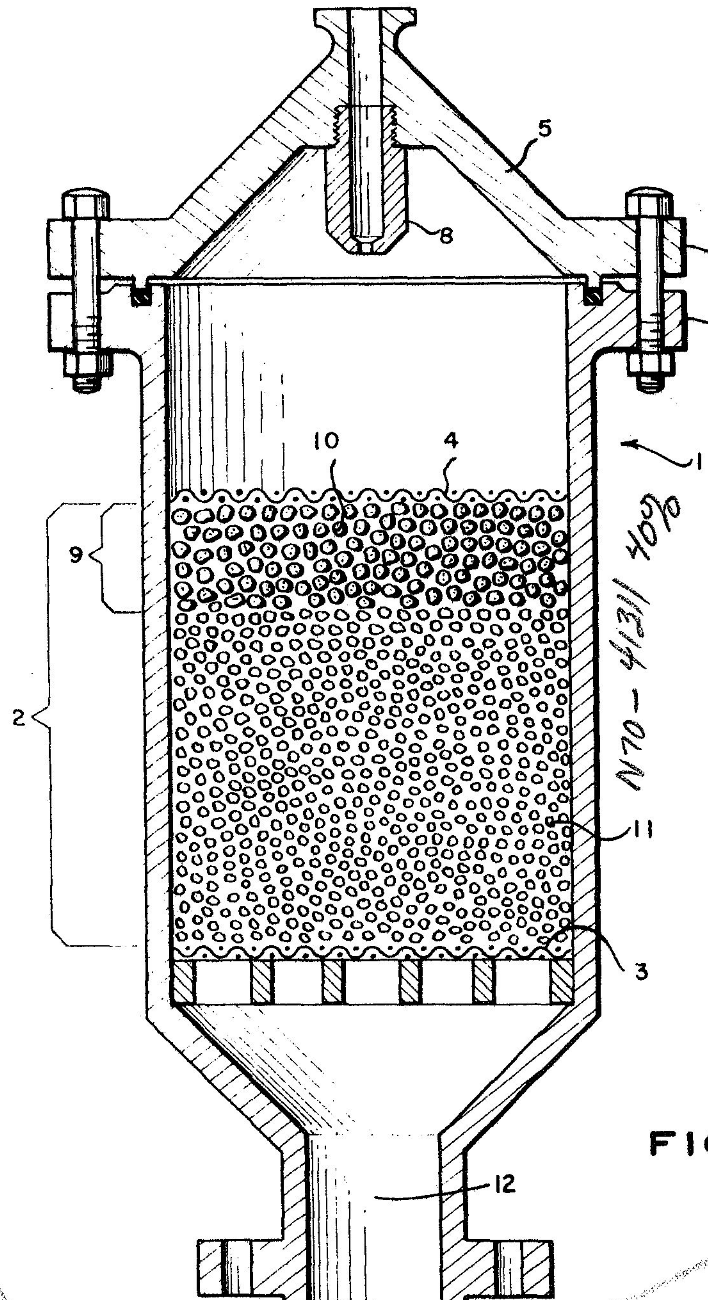

FIG. 1.

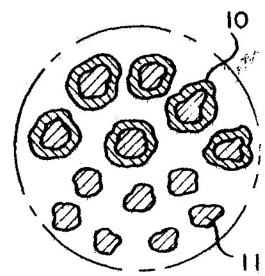

FIG. 2.

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United States Patent Office 3,298,182 Patented Jan. 17, 1967

3,298,182
IGNITION MEANS FOR MONOPROPELLANT

James E. Webb, Administrator of the National Aeronautics and Space Administration with respect to an invention of Donald H. Lee and David D. Evans

Filed June 24, 1964, Ser. No. 377,784
22 Claims. (Cl. 60—251)

This invention relates to a new method for ignition of monopropellant-hydrazine in a thrust type decomposition device. The term monopropellant as used herein refers to a propellant which is a single material rather than a mixture of a fuel and an oxidizer.

An example of an application to which the present invention is intended is in the small thrust engines used in the Ranger moon probe program. The purpose of this program is to examine the surface of the moon in preparation for its exploration by man. The Ranger spacecraft, to be launchced by an Atlas-Agena B type launch vehicle, will carry a group of cameras for transmitting pictures of the lunar surfaces just prior to a "hard" or crash landing thereon. The spacecraft carries a low thrust monopropellant-hydrazine engine used for effecting mid-course trajectory correction. The mid-course correction engine may embody the hydrazine-ignition concept disclosed herein.

It is well known in the art that hydrazine possesses utility as a liquid propellant for rocket engines. It may be combined with an oxidizer in bipropellant reactions and in this form displays excellent self-igniting characteristics. Hydrazine may also be used as a monopropellant by decomposition in the presence of selected catalysts. The heat of decomposition of hydrazine is sufficient to maintain adequate catalyst activity once ignition is obtained, but initiating the decomposition presents a special ignition problem.

A number of ways have been tried in the past for heating a catalyst bed in a combustion chamber to a temperature sufficient to initiate the decomposition of the hydrazine. Some of the prior art efforts in this area have been directed to the use of electrical heaters. Later efforts injected, from an external source, an oxidizer which was hypergolic with the hydrazine, thus causing the catalyst bed to be heated by the resulting combustion. Still further efforts attempted to utilize an electric spark or various glow plug devices. The main disadvantage of such prior art ignition systems is that they require auxiliary equipment which undesirably adds weight and complexity to the overall thrust system. Such auxiliary ignition devices further detract from the thrust system by displacing needed area and also by their additional cost.

In the present invention a combustion chamber is provided with a catalyst bed wherein a thin layer of catalyst pellets are coated with an oxidizer in solid form. A hydrazine flow is introduced into the chamber and undergoes a vigorous oxidation-reduction reaction upon contact with the coating on the catalyst. The energy released from this reaction serves to heat the catalyst bed sufficient to decompose the flowing hydrazine upon contact. The amount of coating used need only be sufficient to raise the catalyst temperature high enough to initiate decomposition of the hydrazine since the heat of decomposition then maintains the catalyst at a temperature necessary to sustain the decomposition.

When compared with the prior art, the ignition system of this invention is simplified, requires no auxiliary equipment such as separate oxidizer injectors, provides a substantially lighter overall system, is less bulky, and has superior heating characteristics, all at a lower cost. These and other advantages and improvements will become evident in light of the following description and drawings wherein:

FIG. 1 shows a cross-sectional view of a typical decomposition chamber and thrust generating unit having a catalytic bed wherein the upper part of the bed has a solid oxidizer coating on each of the catalyst pellets.

FIG. 2 shows a magnified view of a cross-section of a portion of the bed having the coated catalytic pellets lying above the uncoated catalytic pellets.

With reference to FIG. 1, there is shown the cylindrical decomposition chamber **1** which is provided with a granular or pellet type of catalyst bed **2** occupying a portion of the downstream end of the chamber. The catalyst bed may occupy substantially two-thirds of the chamber. The catalyst bed **2** is contained in this area by a pair of apertured screen members **3** and **4** on the downstream and upstream ends respectively. A frustrum-like headplate **5** having a flanged perimeter **6** is bolted to an externally directed flange **7** on the upstream end of the chamber. The injection nozzle **8** through which the hydrazine enters is disposed axially of the chamber in the frustrum-shaped headplate **5** and provides means for injecting the monopropellant into the combustion chamber. The gases produced by the reaction within the chamber are then exhausted through the throat **12**. Many satisfactory catalyst must be heated in order to decompose hydrazine at a rate sufficient for thrust purposes. The effect of these catalyst on the rate of decomposition is enhanced at higher temperatures. In this invention the higher temperature is achieved by bringing a portion of hydrazine in contact with a strong oxidizer coating on a portion of the catalyst bed. Upon contact an exothermic reaction is initiated, providing sufficient heat to the remaining catalyst bed to sustain the catalytic decomposition of additional quantities of hydrazine.

The catalyst is comprised of the carrier pellet **11** having the catalyst substances impregnated therein. It may be used in various shapes or sizes. Examples include a pellet of spherical or a cylindrical shape. The preferred carrier pellet for the present invention ranges in size from a one-eighth to a one-fourth inch sphere. Various types of carriers may be used in the present invention also. Zirconium oxide, silicon carbide, and silicon oxide are noted as examples. However, aluminum oxide provides the most satisfactory results and is therefore preferred.

As previously noted, there are known to be numerous compositions which, when heated, catalyze the decomposition of hydrazine at a rate sufficient for thrust purposes. A few of these are manganese, copper, iron, zinc, zirconium, molybdenum, rhodium, osmium, nickel, and cobalt. It has been found that individual preparations of ferric nitrate, nickel nitrate, or cobalt nitrate provide good activity in the presence of hydrazine. Likewise, combinations of the latter three materials catalyze the hydrazine decomposition. A preferred catalytic composition may be prepared from an equimolal solution of each of the three. In preparing the preferred catalyst one mole each of the nickel nitrate ($NiNO_3$), cobalt nitrate ($CoNO_3$), and ferric nitrate ($FeNO_3$) are dissolved in 500 grams of water. About one thousand (1,000) grams of carrier pellets, which in the preferred case are the aluminum oxide (Al_2O_3) pellets approximately $\frac{3}{16}$ of an inch in diameter, are added to the solution. The pellets are soaked in the solution which is then heated to boiling for about two hours to drive off the water. The pellets are then heated further to 500° in order to drive off the nitrate component and reduce the compounds to oxides or iron, nickel, and cobalt. This process results in the uniform impregnation of the carrier pellets by the catalyst and also provides for a catalytic coating, to some extent, on the surface of the pellets.

In FIG. 2 there is shown an enlarged section of the bed wherein the upper one-fourth inch or more of catalyst pellets **11** is coated further with the solid oxidizer **10** so that upon contact with the hydrazine the energy given off by the upper pellets is sufficient to heat the lower catalytic bed to a temperature which will decompose subsequently introduced hydrazine. This further coating may take the form of a strong oxidizing substance. Examples are potassium permanganate, potassium chlorate, sodium perchlorate, or potassium nitrate. It has been found, however, that crystalline iodine pentoxide (I_2O_5) will form a highly desirable coating because it possesses excellent thermal and shock stability, contains an abundance of oxygen which enhances its reaction with hydrazine, and furthermore is soluble in water. Because of the latter characteristic it is readily processed for coating the catalytic pellets.

This second coating is prepared by first dissolving the oxidizing substance in water, which in the preferred case will be iodine pentoxide (I_2O_5). The ratio of iodine pentoxide (I_2O_5) to water may be varied, depending upon the thickness of the coating which is desired. Since the amount of heat produced upon contact between the hydrazine and iodine pentoxide (I_2O_5) coating will be a function of the coating thickness and since maximum heat from the reaction is desirable a thick coating should be applied to the catalyst. The thickest coating will be realized by adding one part of water to about 1.87 parts by weight of the crystalline iodine pentoxide. Likewise a minimal coating may be obtained by using a lower iodine pentoxide to water ratio. The previously prepared pelleted catalyst is added to the iodine pentoxide-water solution in a one to one weight ratio. The solution is then placed over a low heat to evaporate the excess water until a pasty consistency is obtained. The pellets are then placed in an oven at about 300° F. and dried with slow agitation for twelve hours. They must then be stored in an air-tight container. This procedure provides for a uniform oxidizer coating on the surface of the catalyst pellets.

The pellets having the oxidizer coating are then placed at the end of the bed nearest the fuel inlet and, upon the introduction of hydrazine, energy is released which heats the catalyst to a temperature sufficient to initiate and sustain the catalytic decomposition of additional hydrazine as it is subsequently fed into the chamber.

It will be understood by those skilled in the art, upon a study of this disclosure, that the invention itself permits of various modifications, alterations, and substitutions, and that the concept disclosed herein is not limited in use to hydrazine fuel but is applicable to hydrazine derivatives such as hydrazine nitrate, unsymmetrical dimethyl hydrazine, or other fuels such as boron-hydride which may be catalytically decomposed.

What is claimed and desired to be secured by Letters Patent is:

1. A method for decomposing hydrazine comprising the steps of:

(1) Contacting a quantity of hydrazine with a first catalyst, said first catalyst being effective for decomposing hydrazine at elevated temperatures and said first catalyst being encapsulated with a solid coating of a strong oxidant, whereby at least a portion of said hydrazine undergoes a vigorous oxidation-reduction reaction with the oxidant coating and whereby the oxidant coating is consumed with the liberation of heat;

(2) Exposing a second catalyst to the heat liberated from said oxidation-reduction reaction, said second catalyst also being effective for decomposing hydrazine at elevated temperatures, whereby said first and second catalysts become heated to the point where they are effective for promoting the decomposition of hydrazine; and

(3) Contacting an additional quantity of hydrazine with said first and second catalysts, whereby the hydrazine is decomposed with the liberation of heat, thereby maintaining said first and second catalysts at temperature sufficient to decompose still additional quantities of hydrazine.

2. The method of claim 1 wherein said first and second catalyst each comprise an alumina carrier impregnated with a mixture of the oxides of iron, nickel, and cobalt.

3. The method of claim 1 wherein said first and second catalysts, each comprise an alumina carrier impregnated with a compound selected from the group consisting of the oxides of iron, nickel, and cobalt.

4. The method of claim 1 wherein the strong oxidant coating is iodine pentoxide.

5. The method of claim 2 wherein the strong oxidant coating is iodine pentoxide.

6. A thrust-type rocket engine comprising a combustion chamber having first and second ends;

an injection nozzle for hydrazine connected at said first end of said chanmber and an exhaust means at the second end of said chamber;

a pair of spaced screens within said chamber and connected thereto;

a particulate catalyst bed disposed between said screens;

a solid coating of a strong oxidizer encapsulating a thin layer of particles of said catalyst bed, said thin layer being nearest that part of the bed which is proximate to said injection nozzle so that injection of hydrazine through said nozzle onto said coated catalyst causes an oxidation-reduction reaction.

7. The thrust-type rocket engine as recited in claim 6 wherein said catalyst comprises a carrier impregnated with a compound selected from the group consisting of the oxides of iron, nickel, and cobalt.

8. The thrust-type rocket engine of claim 6 wherein said catalyst comprises a mixture of the oxides of iron, cobalt, and nickel.

9. The thrust-type rocket engine of claim 6 wherein said catalyst is a mixture comprising the oxides of iron, cobalt, and nickel and said coating is iodine pentoxide.

10. The thrust-type rocket engne of claim 6 wherein said catalyst comprises alumina impregnated with a compound selected from the group consisting of the oxides of iron, nickel, and cobalt and wherein said strong oxidant coating is iodine pentoxide.

11. The thrust-type rocket engine of claim 6 wherein said catalyst comprises alumina impregnated with a mixture of the oxides of iron, nickel, and cobalt and wherein said strong oxidizer coating is iodine pentoxide.

12. The thrust-type rocket engine of claim 6 wherein said catalyst comprises a carrier impregnated with a compound selected from the group consisting of the oxides of iron, nickel, and cobalt and wherein said strong oxidizer coating is iodine pentoxide.

13. An ignition means comprising a particulate catalyst effective for decomposing hydrazine at elevated temperatures encapsulated with a solid coating of iodine pentoxide.

14. The ignition means of claim 13 wherein said catalyst comprises alumina impregnated with a mixture of the oxides of iron, nickel, and cobalt.

15. The ignition means of claim 13 wherein said catalyst comprises alumina impregnated with a compound selected from the group consisting of the oxides of iron, nickel, and cobalt.

16. The ignition means of claim 13 wherein said catalyst comprises a carrier impregnated with a compound selected from the group consisting of the oxides of iron, nickel, and cobalt.

17. The ignition means of claim 13 wherein said catalyst comprises a carrier impregnated with a mixture of the oxides of iron, nickel, and cobalt.

18. A catalyst bed comprising a first particulate layer of catalyst effective for decomposing hydrazine at elevated temperatures and a relatively thin particulate second layer of catalyst effective for decomposing hydrazine at elevated temperatures, said second layer being encapsulated with a solid coating comprising a strong oxidant.

19. The catalyst bed of claim 18 wherein said first and second catalyst layers comprise alumina impregnated with a mixture of the oxides of iron, nickel, and cobalt, and wherein said strong oxidant coating comprises iodine pentoxide.

20. The catalyst bed of claim 18 wherein said first and second catalyst layers comprise alumina impregnated with a compound selected from the group consisting of the oxides of iron, nickel, and cobalt, and wherein said strong oxidant coating comprises iodine pentoxide.

21. The catalyst bed of claim 18 wherein said first and second catalyst layers comprise alumina impregnated with a compound selected from the group consisting of the oxides of iron, nickel, and cobalt.

22. The catalyst bed of claim 18 wherein said first and second catalyst layers comprise a carrier impregnated with a mixture of the oxides of iron, nickel, and cobalt.

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