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GELLED HYDRAZINE MONOPROPELLANT

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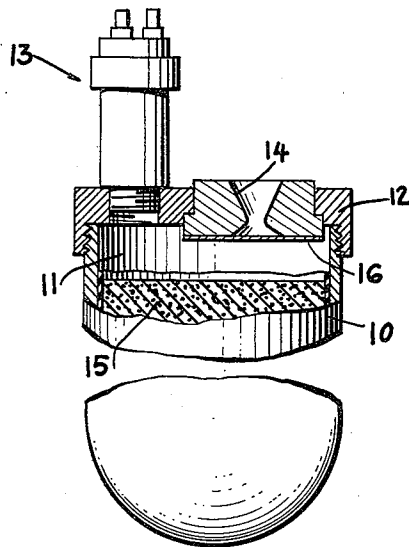
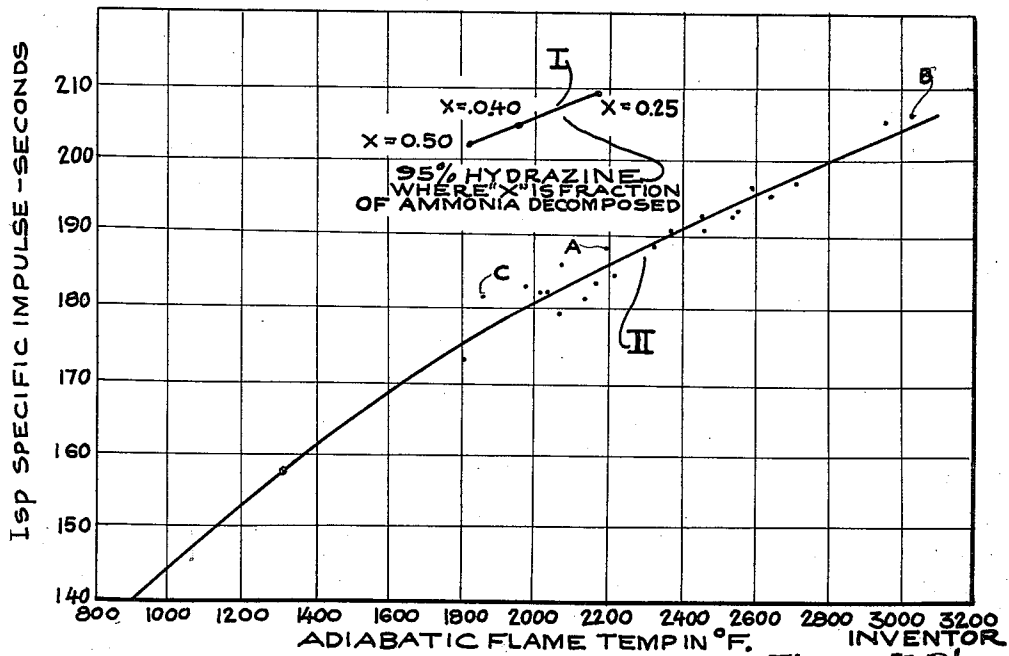


Fig. 1



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## GELLED HYDRAZINE MONOPROPELLANT

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The present invention relates to power plants of the reaction motor type which are capable of supplying power for the operation of craft, rockets and missiles or auxiliary power units, and, more particularly, to an improved propellant for such power plants.

At present, reaction motors are operated by either a liquid or a solid propellant. Both liquid and solid propellants have inherent properties which complicate their use in various applications. The solid propellants possess some advantage in handling but are not easily utilized where variable demand requires start and stop as well as wide variation in power output. Liquid propellants, on the other hand, permit a wide flexibility in power output, but leakage at the seals of the apparatus confining the liquid propellants is a serious problem.

Accordingly, an object of the present invention is to provide a monopropellant for reaction motors which has the advantages of both liquid and solid propellants but does not have any of the disadvantages thereof.

Another object is to provide such a propellant which has a relatively high specific impulse and a relatively low flame temperature.

Another object is to provide such a propellant which has a higher specific impulse at a given flame temperature than solid propellants.

Another object is to provide such a propellant which has a lower flame temperature at a given specific impulse than solid propellants.

Another object is to provide such a propellant which is readily prepared and placed in the charge confining chamber of a reaction motor.

A further object is to accomplish the foregoing in a simple, convenient, practical and economical manner.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

In accordance with the present invention, the foregoing objects are accomplished by gelling hydrazine, burning the gelled hydrazine and utilizing the combustion products thereof as a propelling force.

The term hydrazine, as used herein and in the appended claims, is intended to include its derivatives such as unsymmetrical dimethyl hydrazine, and hydrazine and its derivatives modified by additives such as those mentioned later.

It has been found that hydrazine acts like water in the presence of materials known as hydrophilic sols and therefore can be gelled by the addition of small amounts of such materials. Ethylene oxide, which also is used as a monopropellant, cannot be gelled in this manner.

It has also been found that hydrazine can be gelled by materials such as guar gum, gum arabic, gum tragacanth, Irish Moss extract, karaya gum, locust bean gum, methyl cellulose, and sodium alginate. Experiments have indicated that hydrazine gels of various consistencies can be prepared by the addition of between 0.25% and about 3% by weight of the gelling agent. It is appreciated that larger amounts of gelling agents could be used, but this would not materially increase the consistency of the gel and would adulterate the propellant.

Of these gelling agents, guar gum is preferred because

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much less of it is required to gel hydrazine to a given viscosity or consistency than any of the other materials just named. A hydrazine gel containing about 2.5% guar gum was found to have a consistency comparable to edible gelatin preparations such as "Jello." Hydrazine gels containing between about 0.3% and .7% guar gum can be pumped through fuel lines like a liquid and can be injected into a combustion chamber. A low content of gelling agent in the hydrazine is preferred because a minimum of ash-forming material thereby is present.

Guar gum is a polysaccharide obtained from the guar plant. This gum is a polymer with an average molecular weight of approximately 220,000. Structurally it is composed of galactose and mannose units linked together.

As a specific example, about 25 parts by weight of guar gum were slowly poured into 975 parts by weight of 95% hydrazine at room temperature with continuous stirring during the period of addition. No discernible evolution or absorption of heat occurred. Stirring results in a good dispersion, with no lump formation. After standing one hour, half of the full gel strength is attained. Full gel strength is attained in about twelve to twenty-four hours. This makes it possible to mix the hydrazine and the gelling agent in a vessel equipped with an agitator and then transfer the mixture before it gels to a chamber for confining a charge of hydrazine gel, or to mix the hydrazine and the gelling agent in the chamber to form the gelled charge directly therein.

As another specific example, 5 parts by weight of guar gum were admixed with 995 parts by weight of 95% hydrazine in the manner just described. After standing about twenty-four hours, a gel was formed which had a consistency of a soft, loose jelly. This gel had a viscosity of about 600 centipoises and could be pumped and otherwise handled like a liquid propellant, but, by reason of its viscosity, leakage at the seals was eliminated.

When gelled hydrazine is left standing in a covered receptacle, it will remain indefinitely at room temperature in its gelled state without undergoing either physical or chemical change. The gelled hydrazine adheres to metallic walls and therefore burning is limited to the exposed free surface after ignition. This contrasts with many solid propellants which require inhibitors on several grain surfaces to prevent uncontrolled extension of the burning surface and the consequential rate of burning.

The rate of burning of hydrazine gels at atmospheric pressure was found to be less than that of 96% hydrazine in liquid state. This indicates that the propagation of decomposition in fuel lines would be less likely with gelled hydrazine than with liquid hydrazine.

Hydrazine gels can be modified by incorporating therein varying amounts of an oxidizer such as a nitrate or a perchlorate. Such modification is desirable because it increases the energy contents and permits the incorporation of higher concentrations of gelling agent to get stiffer or more solid gels without reduction in energy content. Modified hydrazine gels containing 20% by weight of either lithium nitrate, potassium nitrate or hydrazine nitrate have been prepared.

In the drawing:

FIG. 1 is a simplified fragmentary view, partly in elevation and partly in section, of a conventional reaction motor adapted to be powered by a solid propellant.

FIG. 2 is a graph comparing the specific impulse at several flame temperatures of gelled hydrazine with the specific impulse at a given flame temperature of various solid propellants.

Referring to FIG. 1 of the drawing in detail, there is shown a reaction motor generally comprising a cylindrical receptacle 10 which is closed at the bottom and is open at the top, as viewed, and provides a combustion chamber 11; a removable closure 12 for the top opening;

an igniter 13 carried by the closure; a nozzle 14 also carried by the closure; a charge 15 of gelled hydrazine in the chamber; and a disc 16 normally closing the nozzle to confine the charge in the chamber and adapted to burst when the charge is ignited.

It will be apparent that the charge may be gelled directly in the chamber or that the charge may be poured into the chamber before gelling takes place, with the closure removed, and then applying the closure.

Combustion tests were made with apparatus simulating such a reaction motor; and observations were made by instrumentation to determine the flame temperature and rate of combustion in the chamber and the pressure and flow of the combustion products. From these data, the specific impulse was calculated by accepted computations. In making these tests, charges of hydrazine gelled by means of 2.5% by weight of guar gum were used.

In FIG. 2, a graph is shown which compares the specific impulse and flame temperature relation of the tested gelled hydrazine with the specific impulse and flame temperature of various solid propellants.

The line I was derived by the plot of the specific impulse in seconds against adiabatic flame temperature in degrees F. of gelled hydrazine at three points each representing the conditions when a given fraction of ammonia is decomposed. It will be observed that when burning takes place with .25 of the ammonia being decomposed, the gelled hydrazine has a specific impulse of almost 210 seconds and the adiabatic flame temperature is less than 2200° F. This temperature, by being below 2500° F., can be tolerated by the combustion chamber for a sufficient duration to completely burn the charge.

The line II was derived by the plot of specific impulse in seconds against adiabatic flame temperature in degrees F. of numerous solid propellants each having a known specific impulse and a flame temperature, as represented by the dots. It will be observed that the solid propellant A has a flame temperature of 2200° F. and has a specific impulse of only about 188 seconds, whereby at that temperature gelled hydrazine has an almost 12% greater specific impulse than solid propellant A. Likewise, a more powerful solid propellant B has a specific impulse of about 206 seconds and has a flame temperature in excess of 3000° F., whereby at an impulse less than that of gelled hydrazine the flame temperature is 36% greater than that of gelled hydrazine.

It should also be observed that when 50% of the ammonia is decomposed, the gelled hydrazine has a specific impulse of about 204 seconds and a flame temperature of about 1820° F., whereas the solid propellant C has a flame temperature of about 1850° F., and has a specific impulse of only about 181 seconds. Thus, at this lower temperature gelled hydrazine has a 12.5% greater specific impulse than solid propellant C.

From the foregoing description, it will be seen that the gelled hydrazine in accordance with the present invention has all the advantages of a solid propellant in so far as storage is concerned and has a higher specific impulse at a lower temperature than the solid propellants and yet has all the advantages of a liquid propellant in so far as handling and control are concerned without any problems of leakage.

As various changes may be made in the form, construction and arrangements of the parts herein, without departing from the spirit and scope of the invention and with sacrificing any of its advantages, it is to be under-

stood that all matter herein is to be interpreted as illustrative and not in any limiting sense.

I claim:

1. The method of providing power, which method comprises decomposing and burning in a combustion chamber of a reaction motor, a composition consisting essentially of hydrazine gelled with between about 0.25% and about 3% by weight of a hydrophilic sol type gelling agent selected from the group consisting of guar gum, gum arabic, gum tragacanth, Irish Moss extract, karaya gum, locust bean gum, methyl cellulose and sodium alginate, and utilizing the products of combustion as a source of power.

2. A gelled monopropellant composition consisting essentially of hydrazine, and between about 0.25% and about 3% by weight of a hydrophilic sol type gelling agent selected from the group consisting of guar gum, gum arabic, gum tragacanth, Irish Moss extract, karaya gum, locust bean gum, methyl cellulose and sodium alginate.

3. The method of making a jelly-like propellant charge, which method essentially consists of providing a mixture of hydrazine and between about 0.25% and about 3% by weight of a hydrophilic sol type gelling agent in a propellant charge chamber, and sealing the chamber and allowing the mixture to gel, the gelling agent being selected from the group consisting of guar gum, gum arabic, gum tragacanth, Irish Moss extract, karaya gum, locust bean gum, methyl cellulose and sodium alginate.

4. The method of making a jelly-like propellant charge, which method essentially consists of introducing liquid hydrazine into a propellant charge chamber, mixing between about 0.25% and about 3% by weight of a hydrophilic sol type gelling agent with the hydrazine while in the chamber, and sealing the chamber and allowing the mixture to gel, the gelling agent being selected from the group consisting of guar gum, gum arabic, gum tragacanth, Irish Moss extract, karaya gum, locust bean gum, methyl cellulose and sodium alginate.

5. The method of making a jelly-like propellant charge, which method essentially consists of mixing between about 0.25% and about 3% by weight of a hydrophilic sol type gelling agent with hydrazine, introducing the mixture into a propellant charge chamber before the mixture gels, and sealing the chamber and allowing the mixture to gel, the gelling agent being selected from the group consisting of guar gum, gum arabic, gum tragacanth, Irish Moss extract, karaya gum, locust bean gum, methyl cellulose and sodium alginate.

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