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ROCKET PROPULSION METHOD

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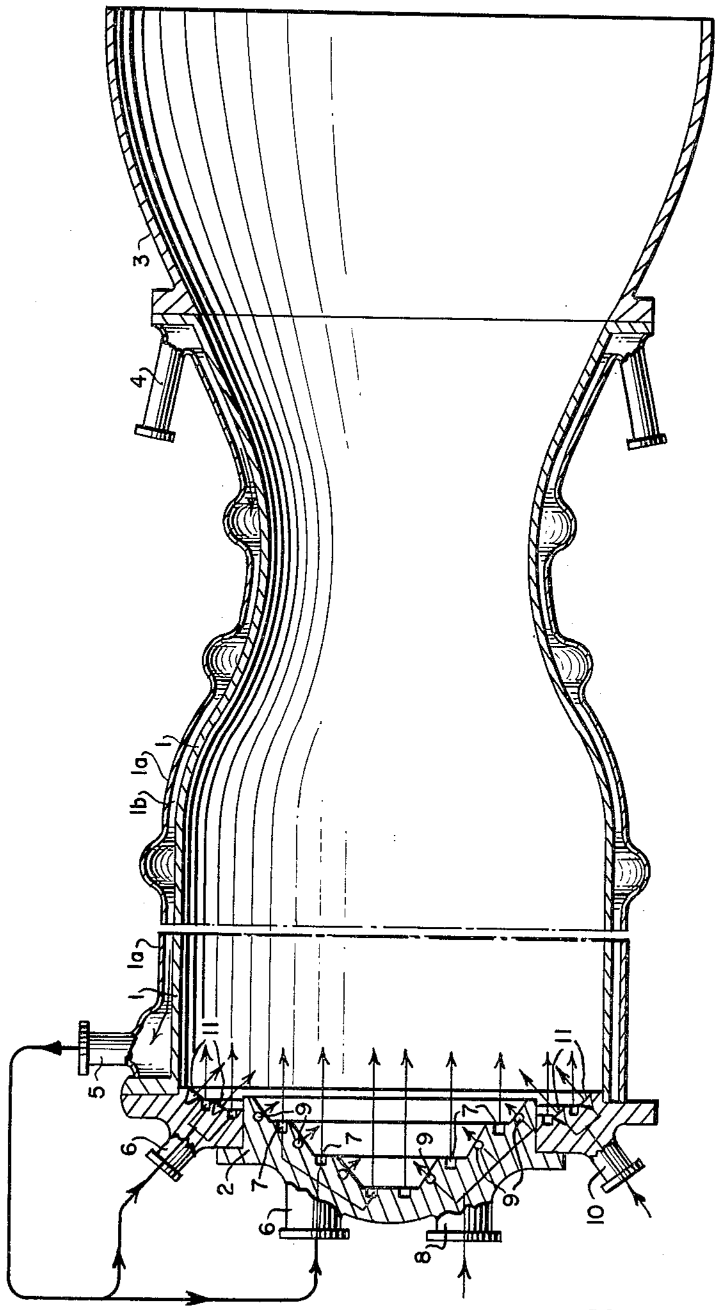

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ROCKET PROPULSION METHOD

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The study of high-speed rockets has led to the adoption of high ejection speeds (that is to say: specific impulses) and considerable mass ratios.

It will be recalled that the term "specific impulse" is understood to mean the product of the thrust in kilograms into the operating time of the rocket in seconds, in relation to the weight of the propellant which is used in kilograms. Moreover, the expression "mass ratio" is understood as meaning the ratio between the sum of the masses of the fuel and combustion-supporting agent on the one hand and the sum of the masses of the empty rocket, the fuel and the combustion-supporting agent, on the other hand.

The high ejection speeds require the use of very hot ejected gases of low molecular weight and high expansion ratio.

Obtaining high mass ratios is facilitated by the use of very dense fuels and combustion-supporting agents.

In short, therefore, the theoretical requirements for propellants for rockets are as follows:

(1) a high calorific power (in order to obtain a high temperature before expansion);

(2) a high density of the propellant before reaction in the combustion chamber of the rocket;

(3) low density of ejected gases.

One of the objects of the present invention is to provide a propellant which satisfies these conditions.

The preferred substance is lithium in the molten condition, which can be injected under pressure into the combustion chamber by a pump or any other means.

A further object of the invention is to protect the walls of the chamber and of the rocket discharge nozzle from excessively high temperatures. According to the invention, this is achieved by arranging for the basic exothermic reaction with great combustion heat to be followed by an exothermic reaction which gives a considerably reduced heat and which will be brought into effect in the vicinity of the walls.

The oxidising agent or other reactive agent can be the same for both reactions, but it will be clear that, if it is found advantageous to do so, it is possible to use a second oxidising agent or reactive agent, thus supplying the combustion chamber with two completely different substances.

A certain number of simple substances, disengaging by combustion a high quantity of heat, can be listed as follows in the order of decreasing heat production per unit of weight of combustion products:

Substances	Combustion Reaction With O_2	kcal./kg. of substance ejected
Beryllium	$Be+\frac{1}{2}O_2=BeO+135.9$ kcal	5,410
Lithium	$2Li+\frac{1}{2}O_2=Li_2O+142.8$	4,760
Boron	$2B+\frac{3}{2}O_2=B_2O_3+280$	4,000
Aluminium	$2\,Al+\frac{3}{2}O_2=Al_2O_3+380$	3,720
Magnesium	$Mg+\frac{1}{2}O_2=MgO+144$	3,600

In addition to its high calorific power, lithium has the following advantages:

Its melting point is relatively low (180° C.) and can be lowered to the vicinity of 150° C. if it is combined with potassium and sodium in small quantities. On the other hand, its high fusion heat enables it to be kept more easily in the liquid state;

The technique of using pumps for molten metals is known at the present day in work with atomic piles, so that it is possible to construct a pump capable of injecting molten lithium into the combustion chamber of the rocket.

As for the auxiliary fuel of lower reaction heat, applicants have found that it is possible advantageously to use kerosene and that by modifying the relative proportions of kerosene and lithium injected into the combustion chamber, it is possible to achieve great operational flexibility, permitting the selection of the most appropriate values for the temperature of the discharge gases and for the specific weight of these mixed gases.

By way of an advantageous non-limitative example, the substances injected into the combustion chamber of the rocket according to the present invention would be the following:

(1) Oxidising agent: HNO_3 which can be peroxidised

(2) Fuels:

(*a*) mixture of $Li+Na+K$, melted previously and stored in a heat-insulated reservoir;

(*b*) Kerosene or any other liquid substance (hydrazine, xylidine, aromatic amines, etc.) stored in a further reservoir.

The following composition can be recommended:

	Percent
HNO_3	71
Li+Na+K	23
Kerosene	6

This mixture has a specific impulse of 300 seconds, and therefore a very high ejection speed.

The temperature of the combustion products is high. The mean temperature is about 4000° K., and the real temperatures are about between 3200° to 4400° K.

The manipulation and supply of the oxidising agent are known in current practice.

The cooling of the walls of the rocket can be effected in a simple and conventional manner, for example by causing the oxidising agent to circulate through a jacket surrounding the throat of the discharge nozzle and the wall of the combustion chamber before injecting this oxidising agent into the end of the said chamber.

The disadvantage of the spontaneous oxidation of lithium in air can easily be avoided by covering it with a thin layer of oil or siliconised product.

The description which will now be given with reference to the accompanying drawing, given by way of non-limitative example, will make it easy to understand the various features of the invention and the manner in which they are carried into effect, any feature brought out either from the text or from the drawing being understood, of course, to come within the scope of the present invention.

The single FIGURE of the drawings represents a longitudinal sectional view of one form of embodiment of a rocket according to the invention:

The wall 1 (made of refractory material or metal) of the combustion chamber and of the discharge nozzle throat, which is connected on the one hand to the bearing plate 2 forming the end of the chamber and to the divergent portion 3 of the nozzle, is surrounded with a jacket 1*a* providing an annular clearance 1*b* between it and the wall 1. The duct bringing nitric acid from the pump is connected to the nozzle 4 communicating with the said annular clearance **1***b*. In this way, the nitric acid circulates in counter-current between the walls **1** and **1***a*, cools the wall **1** and itself becomes heated, issues from the clearance **1***b* through the flanged pipe **5** and arrives at flanged pipes **6** which are connected by ducts formed in the end of the chamber, flowing to multiple nozzles **7** distributed over the said chamber end. In order not to complicate the drawing, the duct system has not been illustrated, and the nozzles **7** which inject nitric acid have simply been represented by squares.

The wall **1** of the chamber can be porous so as to allow a small quantity of nitric acid to sweat into the chamber, the evaporation of this acid from the internal face of the said wall producing an additional cooling effect.

The molten lithium alloy is delivered by a pump towards the flanged pipe **8** connected by ducts in the chamber end to injection nozzles **9** distributed in the central portion of the said end. These nozzles are represented in the drawing by small circles.

In its turn, the kerosene or other fuel, producing a lower combustion temperature than that of the lithium, is delivered by a pump towards the nozzle **10**, which is connected by ducts to the injection nozzles **11** situated on the periphery of the chamber end. The said kerosene injection nozzles are represented by small triangles.

The nozzles **7** through which the oxidising agent is injected may inject in directions different from the directions in which the fuel nozzles **9** and **11** discharge, as represented by the arrows, so as to facilitate mixing the products to be injected and promoting the uniformity of combustion.

The kerosene combustion temperatures obtained in the peripheral part of the chamber, in the region of 3000° K., are lower than those of the lithium which are obtained in the central portion (about 4700° K.).

The viscosity difference due to the temperature gradient, the difference in chemical nature of the gases, and the longitudinal component of the speed of flow prevent equalisation of temperatures.

The chamber wall is thus protected from too high thermal stresses by the protective screen constituted by the low-temperature zone.

This protective effect can be supplemented, if appropriate, by the cooling action brought about by the circulation of the oxidising agent and the vaporisation thereof in the case of porous walls. It is thus possible to obtain effective protection without allowing a considerable energy loss which would have an unfavourable influence on thermal efficiency. The specific impulse of the mixed injection relatively to that of lithium itself is only slight reduced.

We claim:

1. A method of carrying out combustion in a rocket propulsion chamber of generally circular cross section, comprising the concurrent steps of:

supplying at least one oxidizer to said chamber,

injecting into a central portion of said chamber a metal in liquid state selected from the group consisting of beryllium, lithium, boron, aluminum and magnesium, to perform a combustion of said metal with said oxidizer of such nature as might subject the rocket chamber wall to excessive thermal stress,

and injecting into a peripheral portion of said chamber, around said central portion thereof, a fuel of substantially lower calorific value than that of the metal of least calorific value belonging to said group, to perform a combustion of said fuel with said oxidizer of such nature as will protect said rocket chamber wall from said excessive thermal stress.

2. The method of claim 1 wherein the oxidizer is nitric acid.

3. The method of claim 1 wherein the metal in liquid state is lithium mixed with small proportions of sodium and potassium.

4. The method of claim 1 wherein the fuel is selected from the group consiting of kerosene, hydrazine, xylidine and aromatic amines.

5. The method of claim 1 wherein the oxidizer is nitric acid, the metal in liquid state lithium mixed with small proportions of sodium and potassium, and the fuel kerosene, said three substances being substantially in the proportions of 71%, 23%, and 6% respectively.

6. A method of propulsion for a rocket or other reaction propulsion unit having a propulsion chamber bounded by a wall and a discharge nozzle, comprising heating lithium to the molten state, injecting the molten lithium into the central zone of said combustion chamber, simultaneously injecting into the peripheral zone of said combustion chamber a fuel of lower combustion temperature selected from the group consisting of kerosene, hydrazine, xylidine and aromatic amines, and injecting nitric acid into said combustion chamber for oxidizing said lithium and said fuel of lower combustion temperature prior to the discharge of the combustion gases through said discharge nozzle, whereby combustion of said fuel of lower combustion temperature taking place in a peripheral zone of said combustion chamber separates said wall thereof from the central zone wherein the combustion of said lithium takes place.

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