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Baum

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[54] **METHOD OF FEEDING LIQUID PROPELLANTS TO GAS GENERATORS OR ROCKET COMBUSTION CHAMBERS AND FEEDING SYSTEM FOR PERFORMING THE METHOD**

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[58] **Field of Search** 60/207, 218, 219, 259, 39.48, 60/240; 417/158

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[57] **ABSTRACT**

A method of feeding liquid monergolic propellants, either alone or with liquid non-monergolic propellants, to gas generators or rocket combustion chambers, utilizes jet pumps, connected to propellant supplies, to feed the propellants. The monergolic propellants are catalytically dissociated to provide decomposition gases which are supplied to the jet pumps as the pump operating fluids to aspirate propellants into the jet pumps. The pressure drop across the catalysts is compensated by utilizing the energy of a source of gas under pressure. The pressure gas source may be connected to the container for the monergolic propellant, or may be connected to the container for an auxiliary propellant fed to an auxiliary combustion chamber. The auxiliary combustion chamber is supplied with the decomposition gases, and may be used to drive a turbine in turn driving an auxiliary pump for the decomposition gases.

8 Claims, 4 Drawing Figures

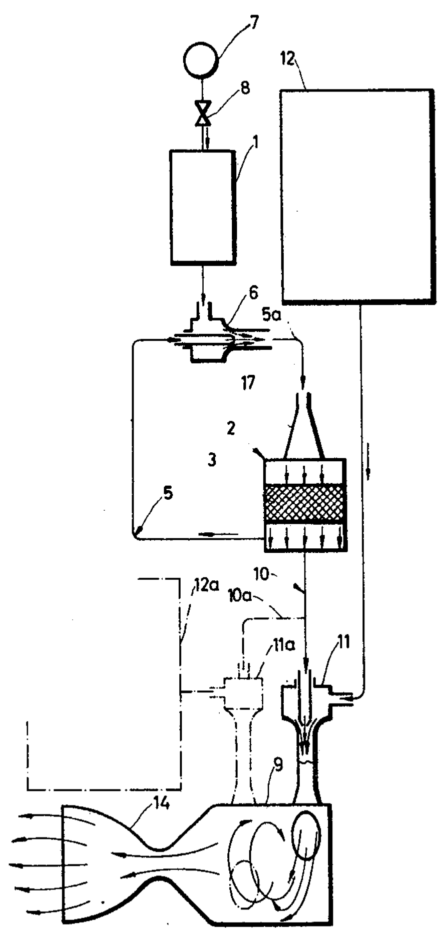

Fig.1

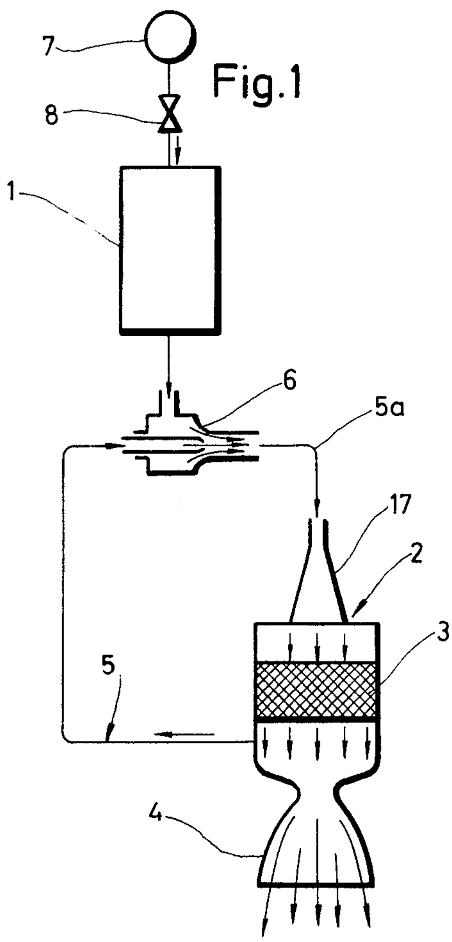

Fig.2

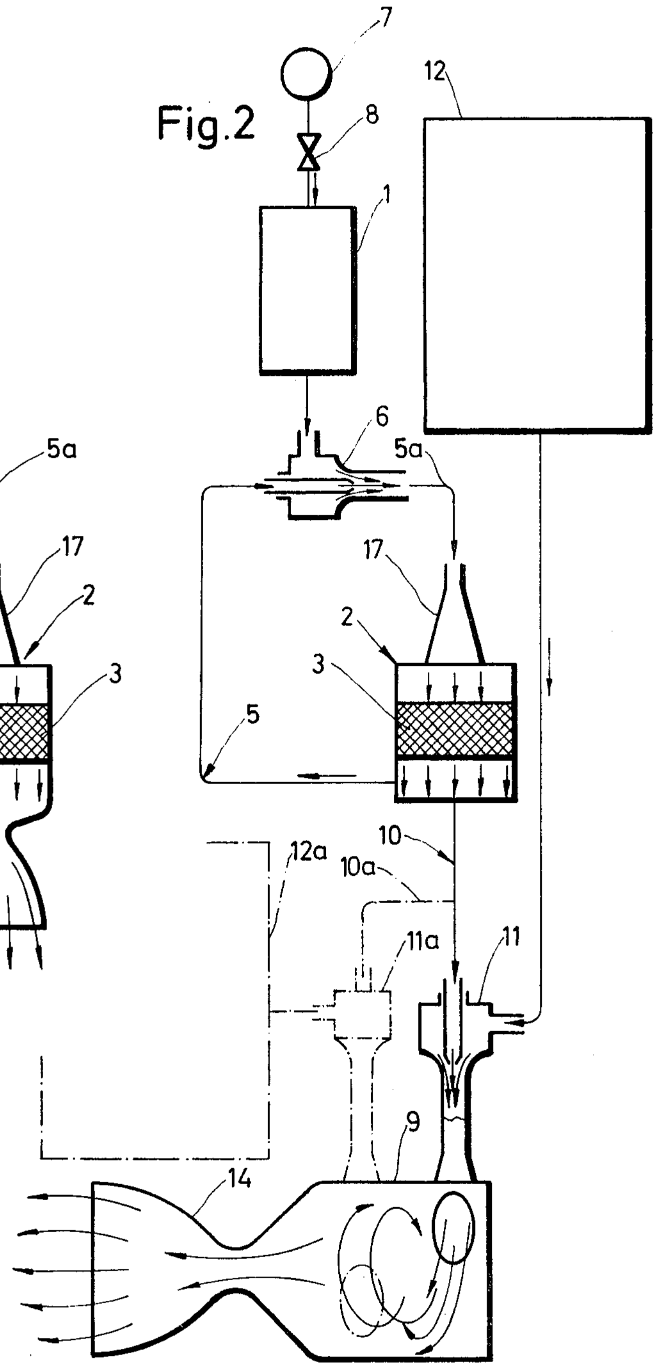

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Fig. 3

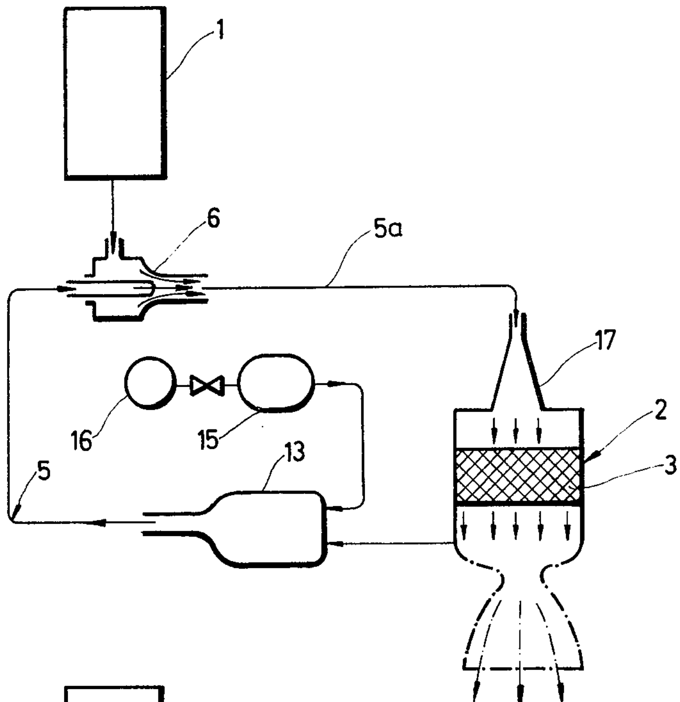
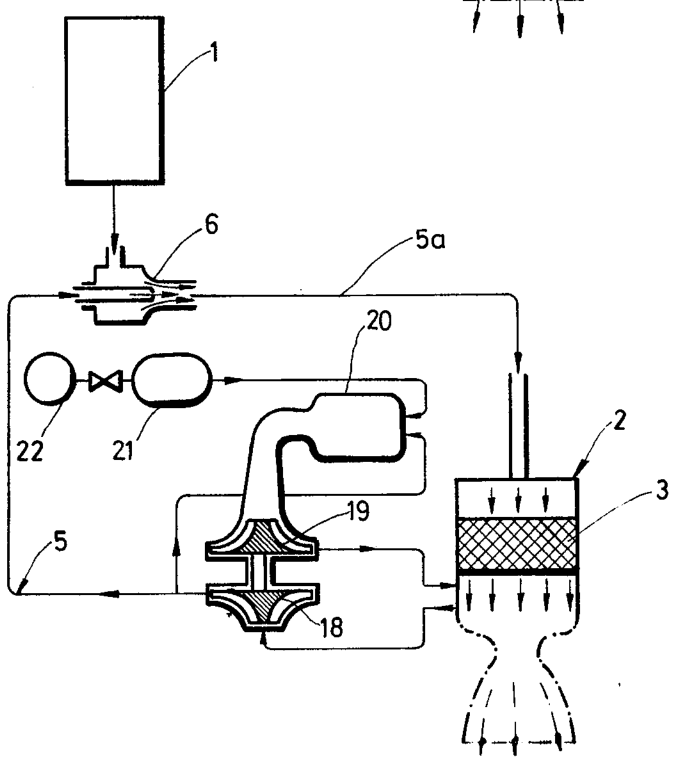


Fig. 4



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METHOD OF FEEDING LIQUID PROPELLANTS TO GAS GENERATORS OR ROCKET COMBUSTION CHAMBERS AND FEEDING SYSTEM FOR PERFORMING THE METHOD

BACKGROUND OF THE INVENTION

Liquid fuel rocket engines are complicated and expensive in design and manufacture. A propellant system, meaning the storage of the propellant inside the missile, the feeding of the propellant to the combustion chamber and the introduction of the propellant into the latter, constitutes a considerable portion of the manufacturing costs. The liquid propellants are stored in containers and fed to the combustion chamber either directly, by means of pressure gas, or indirectly, by the interposition of displacer pistons or by centrifugal pumps through the injection system.

Feeding arrangements using pressure gas require not only voluminous fittings, but also thick-walled containers and pipes, and this leads to a functionally complicated and trouble susceptible arrangement, and particularly to constructionally difficult systems.

Feeding of the propellants with centrifugal pumps also presents difficulties in many respects, because the pumps, in order to save weight, are designed for maximum output and, in addition, are highly stressed technologically by the aggressiveness of the propellants. In this respect, the pump bearings, which are extremely difficult to design, and their cooling and protection against reactive gases, also play an important role. Furthermore, unavoidable power losses, in the form of residual energies still contained in the exhaust gases of the turbines, result in the rocket process by virtue of the pump driving turbines being installed, as a rule, in the secondary current. Moreover, centrifugal pumps rotating at high speed cause relatively high gyroscopic couples in adjustments of the flight position, and which cannot be disregarded.

In rocket engines using a pump feed, and which are provided for disconnection and re-ignition, for space missiles, the exact determination of the operating points, such as the starting point and the end of operation, is extremely difficult, due to the inertia of the rotating masses of the pump.

SUMMARY OF THE INVENTION

This invention relates to the feeding of propellants to utilization devices, such as gas generators or rocket combustions chambers, and, more particularly, to a method and system for feeding liquid monergolic propellants, either alone or with liquid non-monergolic propellants, to the utilization devices with catalytic dissociation of the monergolic propellants into decomposition gases.

The objective of the invention is to provide a propellant feeding method and system free of the disadvantages of prior art methods and systems, as well as to provide a method and system for feeding liquid monergolic propellants, either alone or with liquid non-monergolic propellants, to gas generators or rocket combustion chambers, and which is simple and inexpensive to design and manufacture and which is also safe and light weight.

In accordance with the invention, the monergolic propellant or propellants, either alone or with the liquid non-monergolic propellant or propellants, are fed by jet pumps operated with decomposition gases, and the pressure drop between a catalyst inlet and a catalyst outlet is equalized or compensated by an additional feed pressure acting on the monergolic propellant or propellants, or is equalized or compensated by an additional energy supply for the decomposition gases used to operate the jet pump or jet pumps for feeding the monergolic propellant or propellants.

In carrying out the invention, at least one secondary flow line, charged with decomposition gases, is provided for gas generators or rocket combustion chambers operated only with monergolic propellants. These decomposition gases are used to operate jet pumps feeding the monergolic propellants, this secondary line being connected to the gas generator or combustion chamber downstream of the catalyst and leading to the inlet side of the gas generator or combustion chamber.

In accordance with a further feature of the invention, the jet pump or pumps for feeding the non-monergolic propellants are operated by the main current of the decomposition gases, in gas generators or combustion chambers fed with decomposition gases obtained catalytically from monergolic propellants and also fed with non-monergolic propellants. In this arrangement, it is possible to split the main current of the decomposition gases, depending on the number of feed jet pumps and on the types of non-monergolic propellants, respectively, into several parallel currents, or else to connect the individual jet pumps in series.

The same holds true for the jet pumps for feeding the monergolic propellants and installed in the secondary current line. Here, too, the secondary current can be divided into several parallel branches, with one jet pump each, for feeding one type of monergolic propellant, or the individual jet pumps can be arranged in series in the secondary current line.

In a preferred embodiment of the invention, one or more pressure gas tanks can be arranged ahead of the containers for the monergolic propellant, in order to equalize the pressure drop in the catalyst.

The invention has a number of principal advantages. Thus, thin-walled propellant containers and propellant pipes can be used, since the propellants are fed primarily by the underpressure or negative pressure of the jet pumps, and only the unavoidable and relatively small pressure loss in the catalyst has to be compensated by an additional "foreign" pressure source. Due to the fact that this small pressure loss is compensated, so-to-speak, by the existence of a relatively small, and understandably thick-walled, pressure gas tank, compared to the thin-walled large propellant container, a substantial reduction of the total weight is achieved.

The jet pumps themselves are mechanically simple and inexpensive units, as far as design and manufacture are concerned, and they are extremely safe, due to their ruggedness. The invention feeding system, wherein jet pumps for feeding the non-monergolic propellants are also installed in the main current of the decomposition gases, is particularly suitable for rocket engines with a very high power which must be produced, for known reasons, by non-monergolic propellants.

But if large amounts of propellants are necessary for operating the combustion chamber, and if these large amounts of propellants are supplied by jet pumps, the amounts of monergols, whose decomposition gases are used to operate the jet pumps, increase at the same time. Since these even absolutely large amounts of monergols would have to be forced through the catalysts by means of pressure gas, large thick-walled pressure gas tanks would be required, but these are very heavy, however. For this reason, the feed of the monergolic as well as the non-monergolic propellants by jet pumps results, in addition to other advantages, in a particularly favorable feeding method and system for high power rocket engines, as far as weight is concerned.

The conversion of the monergols in the catalysts into decomposition gases represents, as mentioned above, a wear-free release and production, respectively, of energy, with very little losses. This makes the jet pumps, in the ratio between the starting product monergol and the propellants to be fed, regarding the masses of the two starting products "monergol" and "propellant" by the high chemical-mechanical-dynamic "translation"of the monergol into decomposition gases in the catalyst, high-power feeding machines with a high unit power.

Last, but not least, the intensive thermal workup of the propellants by the transfer of heat from the decomposition gases to the propellants, and by the "internal" generation of heat by an, if necessary, hypergolic preliminary reaction between the decomposition gases and the propellants, upstream of the jet pumps, plays a favorable role for the following main reaction process in the combustion chamber proper, particularly insofar as the length of the combustion chamber is reduced. A decisive advantage of the invention lies in the application of these monergols, whose decomposition gases are actively involved in the combustion chamber reaction process, after the operation of the jet pumps, for reaction with the non-monergolic propellants, thus increasing the overall efficiency of the system or at least being responsible for a high total efficiency.

In accordance with another feature of the invention, a diffusor, opening into the combustion chamber or into an associated spin chamber, is connected in series with the jet pumps in order to convert flow energy into pressure of the order of the desired combustion chamber pressure.

The pressure gas tank arranged upstream of the monergolic propellant container, for compensating the pressure loss in the catalyst, can be replaced by supplying energy for the decomposition gases by an auxiliary combustion chamber arranged upstream of the jet pump for feeding the monergolic propellant into the secondary current line. This auxiliary combustion chamber is supplied, in addition to the catalytically produced decomposition gases, with a propellant reacting particularly hypergolically with the decomposition gases and fed to the auxiliary combustion chamber in a relatively small amount. This latter propellant is stored in an auxiliary container in advance of which is arranged a pressure gas tank. Due to the fact that the pressure losses in the catalyst are very small, the energy supply for the decomposition gases is likewise small, so that only very small quantities of propellant and pressure gas are required for introducing the latter into the auxiliary combustion chamber. The energy supplied for the decomposition gases, in the form of an increased flow, is then converted into pressure energy in a diffusor arranged in advance of the gas generator or combustion chamber and the catalyst, respectively.

In accordance with the invention, another arrangement for compensating the pressure loss produced in the catalyst comprises providing, upstream of the jet pump or pumps for feeding the monergolic propellant or propellants and in the secondary current line, an auxiliary pump operable to increase the pressure of the decomposition gases to a value equal to or slightly above the catalyst inlet pressure, in order to compensate the subsequent flow losses between the auxiliary pump and the catalyst inlet. This auxiliary pump can be driven by an auxiliary turbine, in turn driven by stored pressure gases or, and preferably, with combustion gases. These combustion gases are produced in an auxiliary combustion chamber supplied, through a line connected to the secondary current line downstream of the auxiliary pump, with decomposition gases and also supplied, at the same time, and over a second line, with an energy-rich propellant reacting with the decomposition gases. This energy-rich propellant is stored in a container in advance of which is connected a pressure gas tank. The turbine is so designed that its exhaust gases still have a pressure corresponding to the pressure in the main current downstream of the catalyst, so that the turbine exhaust gases can be introduced into the gas generator or combustion chamber. This also has a favorable effect on the overall efficiency.

An object of the invention is to provide an improved method and system of feeding liquid monergolic propellants to utilization devices such as gas generators or rocket combustion chambers.

Another object of the invention is to provide such a feeding method and system in which the liquid monergolic propellants are fed either alone or with liquid non-monergolic propellants.

A further object of the invention is to provide such a method and apparatus in which the monergolic propellants are catalytically dissociated to provide decombustion gases for operating jet pumps feeding the propellants to the utilization devices.

Another object of the invention is to provide such a method and system in which the pressure drop across the catalyst is compensated by utilizing the energy of a source of gas under pressure.

A further object of the invention is to provide such a method and system of feeding propellants to a gas generator or rocket combustion, and which is free of disadvantages of prior art methods and systems.

Another object of the invention is to provide such a method and system which is simple and inexpensive to design and manufacture, and which is also safe and light weight.

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a somewhat schematic diagram illustrating one system, embodying the invention, for feeding monergolic propellants;

FIG. 2 is a view, similar to FIG. 1, showing a system, embodying the invention, for feeding monergolic and non-monergolic propellants;

FIG. 3 is a view, similar to FIGS. 1 and 2, illustrating one arrangement for increasing the pressure of decomposition gases flowing in the secondary current line; and

FIG. 4 is a view, similar to FIG. 3, illustrating another arrangement for increasing the pressure of the decomposition gases flowing in the secondary current line.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, a feeding system for a rocket engine operated with a monergol comprises substantially a container 1, for the monergolic propellant, a gas generator 2 with a catalyst 3, and a thrust nozzle 4 for gas generator or combustion chamber 2. A secondary current line 5 is connected to gas generator 2 downstream of catalyst 3, and is also connected to a jet pump 6 for operating the latter. A pressure gas tank 7, is connected to container 1 through a reducing valve 8 which is designed as a pilot valve.

To start the engine, valve 8 is opened and a monergolic propellant is fed to gas generator 2 over the line section 5*a* and forced through catalyst 3 where the monergol is split into decomposition gases. The major portion of the decomposition gases flow to the thrust nozzle while a minor part of the decomposition gases flows through secondary current line 5 connected to gas generator 2 downstream of catalyst 3, and this minor part of the decomposition gases operates the jet pump 6. Jet pump 6 thereby aspirates additional monergolic propellant from container 1 and feeds it to catalyst 3. That is, during operation, jet pump 6 takes over primarily the feed of the monergolic propellant from container 1 to catalyst 3. The pressure loss appearing between the inlet and outlet of catalyst 3 is compensated, however, during operation of the feeding system, by the pressure of the pressure gas stored in tank 7 and which acts on the monergolic propellant in container 1.

Essentially the same operation occurs in the embodiment of the invention illustrated in FIG. 2. In FIG. 2, however, a combustion chamber, or reaction chamber, 9, having a thrust nozzle 14, is arranged downstream of gas generator 2. In a main current line 10 for the decomposition gases there is arranged another jet pump 11 for feeding a non-monergolic propellant stored in a container 12. If several containers, for example two containers 12 and 12*a*, are provided for different propellants, such as fuel propellant and an oxidizer propellant, main current line 10 can be divided into an additional main current line 10*a*, extending parallel to line 10, and having arranged therein a jet pump 11*a* which aspirates the second non-monergolic propellant from container 12*a* and feeds it, separately from the first-mentioned non-monergolic propellant, to combustion chamber 9. Both propellant-decomposition mixtures are introduced tangentially into combustion chamber 9, where they react with each other in a known manner, forming a spin current with a central return flow core.

In the embodiment of the invention shown in FIG. 3, an auxiliary combustion chamber 13 is provided in the secondary current line 5. Auxiliary combustion chamber 13 is charged, in addition to decomposition gases, with an auxiliary propellant stored in an auxiliary container **15** to which is connected a pressure gas tank **16**. The decomposition gases and the auxiliary propellant react in auxiliary combustion chamber **13**, so that an energy supply for the decomposition gases in the secondary current, in the form of a gas or mass increase, occurs. This is converted into pressure energy in a diffusor **17** arranged upstream of gas generator **3** in order to attain the operating pressure.

Diffusors **17** can also be provided in the system shown in FIGS. **1** and **2**, as indicated therein, these diffusors being arranged upstream of gas generator **2** and combustion chamber **9**, respectively, in order to increase the pressure of monergol-decomposition gas mixtures and the propellant-decomposition mixtures, respectively.

FIG. **4** illustrates an embodiment of the invention in which compensation of the pressure loss in catalyst **3** is effected by an auxiliary pump **18** connected in secondary current line **5** and driven by an auxiliary turbine **19**. Turbine **19** is supplied with propellant gases of an auxiliary combustion chamber **20**. Chamber **20** is fed both with propellant, from an auxiliary container **21** to which is connected a pressure gas tank **22**, and with decomposition gases, which are withdrawn downstream of auxiliary pump **18**. The propellant gases, produced particularly hypergolically in auxiliary combustion chamber **20**, are expanded in auxiliary turbine **19** only to the pressure prevailing downstream of catalyst **3**, so that the turbine exhaust gases can be fed to the main current and the overall efficiency of the system is not reduced.

Auxiliary pump **18** and auxiliary turbine **19** represent relatively small units, which cannot be compared, as far as difficulties and problems are concerned, with large propellent feed pumps and their driving turbines and which must expend the entire feed power in the conventional propellant feeding systems.

It will be understood that the arrangements shown in FIGS. 3 and 4 can also be applied in connection with the embodiment illustrated in FIG. 2.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A method of feeding liquid monergolic and non-monergolic propellants to a combustion chamber, said method comprising the steps of utilizing a jet pump, connected to a monergolic propellant supply, to feed the monergolic propellant to a reaction chamber; catalytically dissociating the monergolic propellant to provide decomposition gases; supplying decomposition gases to the jet pump as the pump operating fluid to aspirate the monergolic propellant into the jet pump; utilizing a second jet pump, connected to a non-monergolic propellant supply, to feed the non-monergolic propellant to the combustion chamber; supplying such decomposition gases to the second jet pump as the pump operating fluid to aspirate the non-monergolic propellant into the second jet pump; and compensating the pressure drop, during the catalytic dissociation of the monergolic propellant, by utilizing the energy of a source of gas.

2. A method, as claimed in claim **1**, in which the pressure drop during the catalytic dissociation is compensated by applying the pressure of said source of gas under pressure to the monergolic propellant.

3. A feeding system, for feeding a liquid monergolic propellant to a gas generator, said feeding system comprising, in combination, a container for a monergolic propellant; a gas generator having a catalyst therein; a jet pump connected to said container for aspirating propellant therefrom, and discharging into said gas generator; a current line, for decomposition gases, connected to said gas generator downstream of said catalyst and connected to said jet pump to operate the same, said current line leading to the inlet side of said gas generator; a combustion chamber connected to the outlet of said gas generator and fed with both monergolic and non-monergolic propellants; at least one container for a non-monergolic propellant; and at least one second jet pump connected between said gas generator and said combustion chamber and operated by the decomposition gases, said second jet pump being connected to said container for the non-monergolic propellant to aspirate the non-monergolic propellant into said second jet pump.

4. A feeding system, as claimed in claim **3**, including a container for a second non-monergolic propellent; and an additional second pump connected between said gas generator and said combustion chamber and operated by the main current of the decomposition gases, said second jet pumps being in parallel with each other in the main current of the decomposition gases; said additional second jet pump being connected to said second container for a non-monergolic propellant to aspirate the non-monergolic propellant from said second container.

5. A feeding system, as claimed in claim **3**, including a pressure gas tank connected to said container for the monergolic propellant to exert pressure on the latter to compensate pressure losses in said catalyst.

6. A feeding system, as claimed in claim **3**, including a diffusor discharging into the inlet of said gas generator to increase the pressure of the monergol-decomposition gas mixture.

7. A feeding system, as claimed in claim **3**, including respective diffusors discharging into the inlets of said gas generator and said combustion chamber to increase the pressure of the monergol-decomposition gas mixture and to increase the pressure of the propellant-decomposition gas mixture, respectively.

8. A feeding system, as claimed in claim **4**, in which each of said second jet pumps discharge tangentially into said combustion chamber.

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