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HYBRID ROCKET ENGINE

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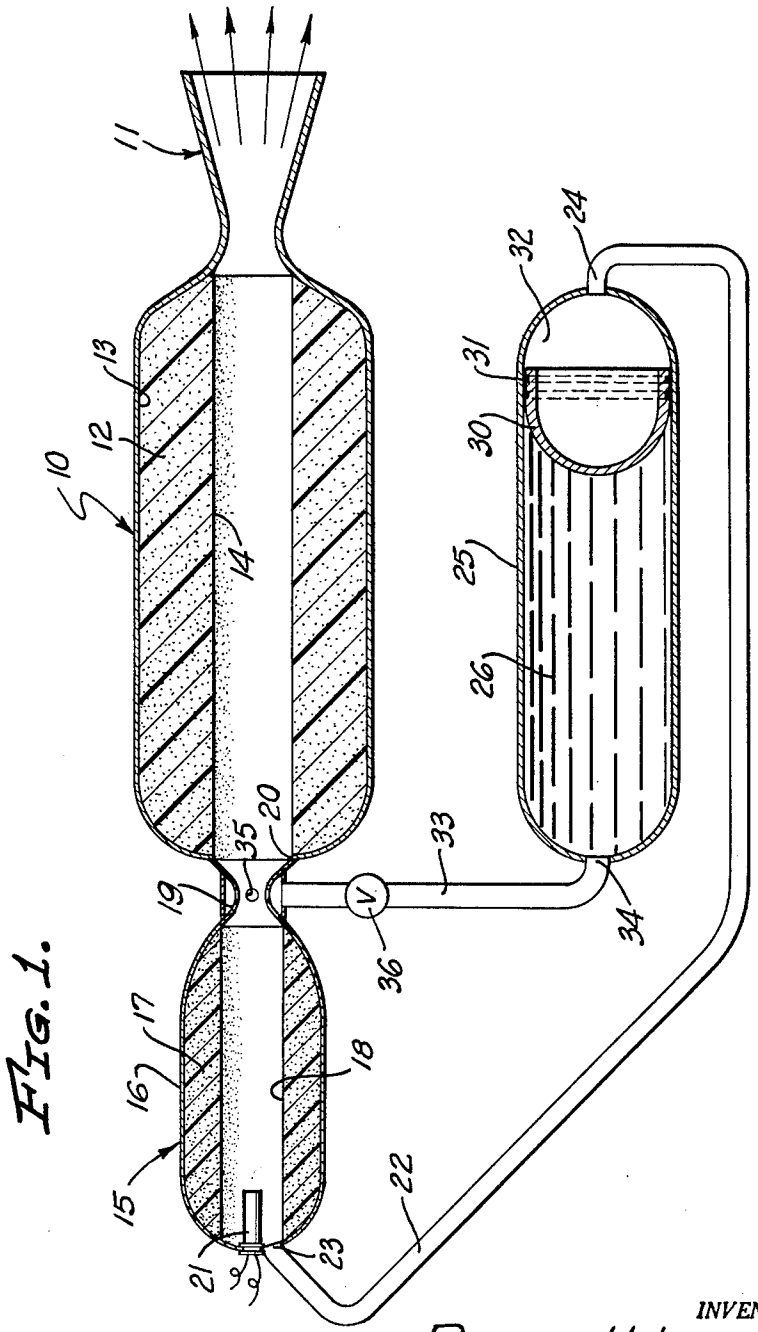


FIG. 1.

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HYBRID ROCKET ENGINE

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This invention relates generally to hybrid rocket motors, which term is used to describe rocket motors that use separate fuel and oxidizer components, one of which is liquid and the other solid. More particularly, the invention is concerned with a rocket motor of this class which vaporizes and heats a liquid oxidizer to a high temperature before contact with the solid fuel.

One of the main objects of the invention is to provide a solid propellant ignition heater and gas generator that pressurizes a liquid oxidizer and vaporizes the same as the heater exhausts through an underexpanded flow nozzle upon the reaction surface of the solid fuel.

Another object of the invention is to provide an ignition heater that pressurizes a liquid oxidizer and vaporizes the same at a flow nozzle for high temperature diffusion over the solid fuel reactive surface.

Still another object of the invention is to provide an igniter that pressurizes, vaporizes and heats a liquid oxidizer to high temperature before contact with the solid fuel.

A further object of the invention is to provide an ignition heater for hybrid rocket engines, which vaporizes and heats a liquid oxidizer before the latter contacts a solid fuel, and thus permits the use of various combinations of solid fuel and liquid oxidizer, that are not normally reactive when the oxidizer is in the liquid phase.

A still further object of the invention is to provide an ignition heater, the high temperature combustion products of which change a liquid oxidizer to a gaseous condition and also break down the fuel composition to make it more reactive.

Yet another object of the invention is to provide an ignition heater and gas generator which vaporizes and preheats a liquid component, so that many combinations of liquid and solid fuel and oxidizer may be used.

Still another object of the invention is to provide a relatively simple and low cost type of injector that insures hot gas phase reaction and high burning rate and at the same time has capability of on and off operation during heater operation.

The foregoing and other objects and advantages of this invention will be clear to those skilled in the art upon consideration of the following detailed specification of one illustrative embodiment thereof, reference being had to the accompanying drawing, in which:

FIGURE 1 is a schematic view of a hybrid rocket engine, showing a preferred form of the invention.

Referring to the drawing, which is more or less schematic, it will be noted that the various elements are not shown in complete structural detail. This has not been deemed necessary because it is believed that a profusion of drawings would merely complicate the disclosure of fundamental elements and the combination thereof. The prior art recognizes certain essential elements and obviates the necessity of engineering detail.

A solid fuel rocket motor casing **10** of conventional design has the usual exhaust nozzle **11** at the rear end thereof. Bonded to the inner surface **13** of the casing **10** is a body **12** of solid fuel which may, if desired, have some oxidizer incorporated therein. The body **12** of solid fuel has a central, longitudinally extending bore **14** which forms the burning surface. The bore **14** may be of circular cross-section, or it may take any other configuration. The elements heretofore recited are entirely conventional.

Mounted on the front end of the motor casing **10** is an auxiliary gas generator **15** comprising a casing **16** loaded with a grain of solid propellant **17**. The solid propellant **17** differs from the solid fuel **12** of the motor casing **10** in one important respect, and that is that it comprises a fuel and oxidizer mixture in proportions for stoichiometric combustion, whereas the fuel **12** is either completely without oxidizer, or with a substantial deficiency of oxidizer, whereby combustion of the fuel **12** cannot be supported without additional oxidizer. The solid propellant **17** is provided with a central longitudinally extending bore **18** from one end of the casing **16** to the other, the rear end of said bore opening into an under-expanded nozzle **19**. The nozzle **19** is attached to the front end of the motor casing **10** around the marginal edges of an aperture **20**, and the nozzle **19** thus discharges directly into the bore **14**. An igniter **21** is mounted on the front end of the casing **16**, and serves to ignite the solid propellant **17** when fired. The combustion gases from the auxiliary gas generator **15** are exhausted through the nozzle **19** into the rocket engine and upon the reaction surface **14** of the fuel **12**.

A pressure tube **22** is connected at **23** to the auxiliary gas generator **15**, and at **24** to a container **25** filled with highly reactive liquid oxidizer **26**, such as chlorine trifluoride (ClF_3) for example. A conventional piston **30** with standard sealing rings **31** is disposed in the pressure end **32** of the casing **15**. One end of a supply tube **33** is connected at **34** to the container **25**, and its other end communicates with a plurality of ports, or discharge openings **35**, in the throat of the nozzle **19**. A valve **36** is provided in the supply tube **33** for controlling the flow of liquid oxidizer, and thereby controlling the rate of combustion of the fuel **12**, which has the effect of controlling the propulsive thrust of the rocket motor **10**. Maximum rate of combustion of the fuel **12** for maximum thrust is obtained when the quantity of oxidizer **26** discharged into the bore **14** is exactly equal to the requirement for stoichiometric combustion. The thrust of the rocket motor **10** may be programmed in any desired manner by merely operating the valve **36** to restrict the flow of oxidizer. If desired, combustion of the fuel **12** may be stopped by closing the valve **36**, and even restarted by opening the valve again, provided the auxiliary gas generator **15** is still operating.

Operation of the invention is effected by firing the igniter **21**, which ignites the small solid propellant **17** in the auxiliary gas generator **15**. The combustion gases of the auxiliary gas generator are discharged through the under-expanded flow nozzle **19** into the bore **14**. Thus the nozzle **19** effectively becomes a heater nozzle due to the hot gases passing therethrough. At the same time, the combustion gases of the generator **15** pressurize the liquid oxidizer through the tube **22**, acting against the piston **30**. The liquid oxidizer **26** controlled by the valve **36**, is forced through the throat holes **35** in the heater nozzle **19**. The heater nozzle gas flow vaporizes and heats the liquid oxidizer to high temperature before contact with the solid fuel **12**. The vaporized liquid oxidizer is diffused completely within the rocket engine and over the reactive surface. The invention is characterized by insensitivity to scaling, high burning rate, and high mass ratio. There is also an insensitivity of specific impulse to ratio of fuel and oxidizer. The rocket engine is rendered flexible and enables the use of combinations of fuel and oxidizer that are not normally reactive when the oxidizer is in a liquid state. The hot gaseous condition of the oxidizer tends to break down the fuel composition to make it more reactive. Various combinations of con-

ventional solid fuels, oxidized and slightly oxidized, or solid fuels alone may be used.

In addition to the solid fuel and liquid oxidizer combination described herein, the present invention contemplates the use of combinations of solid oxidizers such as ammonium nitrate, for example, and liquid fuel, such as gasoline or kerosene. In this instance, the solid oxidizer would be loaded in the motor case **10**, and the liquid fuel would be carried in the container **25**.

While I have shown and described in considerable detail what I believe to be the preferred form of my invention, it will be understood by those skilled in the art that various changes may be made in the shape and arrangement of the several parts without departing from the broad scope of the invention as defined in the following claims.

I claim:

1. A hybrid rocket engine utilizing a fuel component and an oxidizer component, one of said components being solid and the other being liquid, said engine comprising a motor case loaded with said solid component and having a rearwardly directed nozzle through which combustion products are discharged, a container in which said liquid component is contained, an auxiliary gas generator mounted on the front end of the motor case and having a nozzle discharging into said motor case, means for pressurizing said container with gas generated by said auxiliary gas generator, means for conveying said liquid component under pressure from said container to said last-named nozzle and means including said last-named nozzle for mixing said liquid component with the hot combustion gases discharged by said auxiliary gas generator, whereby the said liquid component is vaporized as it is discharged into said motor case for reaction with said solid component.

2. A hybrid rocket engine comprising a motor case having a rearwardly directed exhaust nozzle, a body of solid fuel contained within said motor case, said body of solid fuel defining a combustion port opening at one end into said exhaust nozzle, an auxiliary gas generator having a nozzle discharging into said combustion port at the other end thereof, a container of liquid oxidizer, a conduit opening at one end into said container and at the other end into said last-named nozzle, and a second conduit connecting said auxiliary gas generator with said container, whereby gas pressure developed in said generator is applied to said container, and forces said liquid oxidizer into said last-named nozzle where it is vaporized before being discharged into said combustion port.

3. A hybrid rocket engine as defined in claim 2, wherein said auxiliary gas generator comprises a second case loaded with solid propellant, and means for igniting said solid propellant.

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