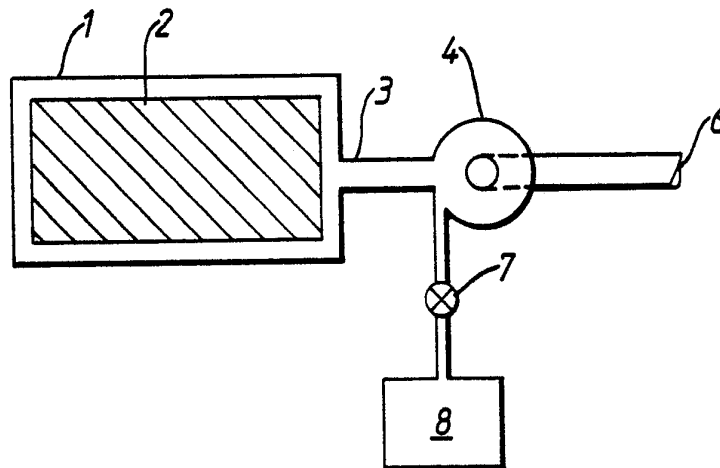




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(54) Title: SOLID PROPELLANT BURN RATE CONTROL DEVICE



(57) Abstract

In a power unit for a vehicle using a solid propellant fuel material which is burned within a combustion chamber (1), the chamber is provided with an outlet port (3) including an adjustable valve (4) arranged for controlling the rate of gas flow through said port, in which the valve (4) is a fluid flow valve capable of effecting control of the gas flow in the absence of a mechanically movable valve member. The valve (4) may be a fluidic vortex valve the flow through which is adjustable by controlling flow of a control fluid into the valve. This arrangement permits a build-up of gas pressure within the chamber (1) in order to increase the fuel burn rate at times when a high power output is demanded.

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SOLID PROPELLANT BURN RATE CONTROL DEVICE

This invention relates to a solid propellant burn rate control device. It relates particularly to a control device that may be used with a solid propellant gas generator for a vehicle and which will give effective control over the rate of burning of the propellant material.

In a power unit for a vehicle which relies on the use of a solid propellant fuel material, once ignition of the propellant material has been effected the material will continue to burn steadily within a gas generation chamber until the supply of the propellant material has been exhausted. In many applications, the flow rate of gas discharged from the gas generation chamber will need to be varied in response to changes in demand to meet needs such as thrust level changes or to effect actuator movements. However, the total mass of the solid propellant charge within the chamber will have to be adequate to meet the needs of any peak requirement that may arise. This implies that during a period of low demand the gas generation chamber will still continue to produce a supply of gas and it will then be necessary to bleed off this supply to the external atmosphere even though the gas discharged will be unable to serve any useful function.

For a gas generation chamber having an exhaust port

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with a fixed cross-sectional area, there is at present no way of influencing the propellant burn rate in response to external demands. It might be possible by a suitable selection of the propellant material composition and the charge geometry, to define a possible burn rate against elapsed time characteristic but, once established, this characteristic is unalterable and there is no possibility of adjusting it from time-to-time to cope with the transient variations that are needed.

It is a property of many solid propellant fuel materials that the burn rate is influenced by the pressure applied within the gas generation chamber. Between a significant range of pressure levels, the propellant burn rate tends to increase with pressure. One way of controlling the chamber pressure would be to vary the effective area of the exhaust port. An increase in the flow area would cause a reduction in both the chamber pressure and the propellant burn rate.

If an electro-mechanical valve was to be used at the chamber outlet port then problems might occur as a result of the high gas temperatures and velocities that are present. In addition, particulate contamination would be likely to have a detrimental effect on any mechanically movable part of a valve.

The present invention was devised to overcome some of

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these problems by providing alternative means of controlling the pressure within the gas generation chamber.

According to the invention, there is provided a power unit for a vehicle of the kind using a solid propellant fuel material which is burned within a combustion chamber, the chamber having an outlet port including an adjustable valve arranged for controlling the rate of gas flow through said port, in which the said valve is a fluid flow valve capable of effecting control of the gas flow in the absence of a mechanically movable valve member.

The fluid flow valve may be a fluidic vortex valve. The vortex valve may have a control port coupled through a control valve to a control fluid source.

Preferably, the said combustion chamber includes a gas pressure sensor capable of producing an output signal representative of the gas pressure within the chamber, the vehicle further including means responsive to the said signal and effective to control operation of said control valve.

By way of example, a particular embodiment of the invention will now be described with reference to the accompanying drawing, the single figure of which shows a power unit for a rocket vehicle.

As shown in the Figure, the power unit comprises a gas generation chamber 1 enclosing a mass of solid propellant

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fuel material 2. The chamber 1 has an outlet port 3 at which is fitted a vortex valve 4 which controls flow of the generated gases to a discharge port 6. The operation of the vortex valve 4 is controlled by a flow of a control fluid which passes through a control valve 7 from a control fluid reservoir 8.

The control valve 7 is operated in accordance with an electrical signal from a control unit (not shown) of the rocket vehicle. The control unit is arranged to respond to the output of a gas pressure sensor located in the gas generation chamber 1 and in addition, the control unit has an input responsive to the output power demanded from the propulsion unit in accordance with the operation of the vehicle.

In operation, after ignition of the fuel material 2 in the chamber 1, a flow of gas passes through the port 3 and the valve 4 to the discharge port 6. If only a minimum flow of gas is demanded from the discharge port 6, the resistance to the gas flow passing through the valve 4 is required to be low since this will produce low pressure in the chamber 1 and consequently a low burn rate. This result will be achieved therefore when the control valve 7 is closed and there is no flow of control fluid into the valve 4 from the fluid reservoir 8.

When the demanded gas flow rate from the discharge

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port 6 is required to be increased, the control valve 7 will open and this will allow control fluid from the reservoir 8 to pass into the valve 4. The fluid pressure within the valve 4 will thus increase and this will cause the pressure within the chamber 1 to rise with a consequent acceleration of the rate of burn of the fuel material 2. This will produce the required increase in flow from the discharge port 6.

The control valve 7 is operated by a control unit of the vehicle and this unit also has an input connected to a gas pressure sensor (not shown) located in the gas generation chamber 1. This arrangement allows closed loop control of the gas generation unit since under steady conditions the amount of opening of the control valve 7 will always correspond to a given pressure in the chamber 1.

The control unit of the vehicle will also have an input adjustable in response to the power output demanded from the propulsion unit at any time.

The burn rate control device of the invention has been found to be useful in practice since the rate of gas flow can be adjusted in response to the demands made on the vehicle propulsion unit and if the demand is low then the burn rate can be reduced to reduce wastage of the propellant material.

The foregoing description of an embodiment of the

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invention has been given by way of example only and a number of modifications may be made without departing from the scope of the invention as defined in the appended claims. For instance, it is not essential that the supply of control fluid should be derived from a control fluid reservoir. In a different embodiment, the control fluid might be derived from a suitable liquid supply, a pressurised cold gas supply or a separate gas generator. It will generally be necessary for the control fluid to be provided at a higher gas pressure than the pressure available in the chamber 1, but in some circumstances it might be possible for the control gas supply to be derived from the gas in the gas generation chamber.

It is also not essential that the power unit of the invention should be used only as the main thrust motor of a rocket vehicle. In a different embodiment, it might be used as a power source for attitude control in a vehicle having no motor, such as a projectile.

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CLAIMS:

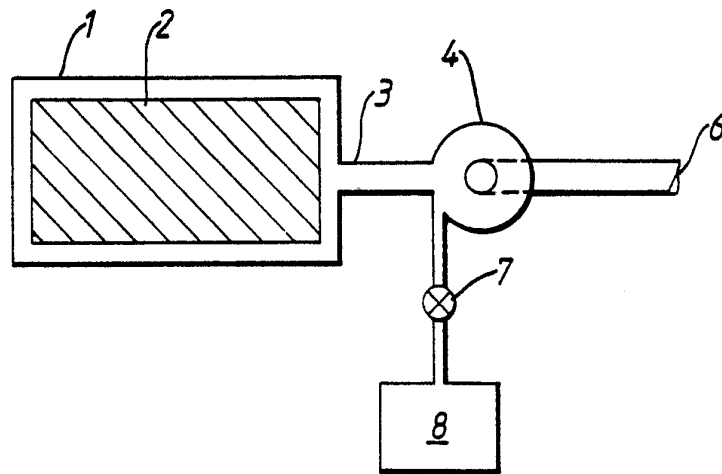
1. A power unit for a vehicle of the kind using a solid propellant fuel material which is burned within a combustion chamber, the chamber having an outlet port including an adjustable valve arranged for controlling the rate of gas flow through said port, in which the said valve is a fluid flow valve capable of effecting control of the gas flow in the absence of a mechanically movable valve member.
2. A power unit as claimed in Claim 1, in which the said valve is a fluidic vortex valve.
3. A power unit as claimed in Claim 2, in which the said vortex valve has a control port coupled through a control valve to a control fluid source.
4. A power unit as claimed in Claim 3, in which the said combustion chamber includes a gas pressure sensor capable of producing an output signal representative of the gas pressure within the chamber, the vehicle further including control means responsive to the said signal and effective to control operation of said control valve.

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5. A power unit as claimed in Claim 4, in which the said vehicle control means additionally has an input responsive to a power output requirement demanded from the vehicle power unit.

6. A power unit for a vehicle substantially as hereinbefore described, with reference to the accompanying drawing.

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INTERNATIONAL SEARCH REPORT

International Application No **PCT/GB 87/00354**

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁴ : F 02 K 9/80; F 02 K 9/86		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁴	F 02 K	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ⁹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	Journal of Spacecraft and Rockets, volume 7, no. 2, February 1970, (New York, US), A. Blatter et al.: "A vortex valve for flow modulation of 5500°F gas", see pages 169-174	1-6
X	Research Trends, volume 19, Winter 1971, N.A. Zarin: "Controlling the thrust of rocket engines", pages 4-7 see page 6	1,2

<p>¹⁰ Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"Δ" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
20th August 1987	24 SEP 1987	
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