United States Patent

Kayser

[15] **3,640,072**

[45] **Feb. 8, 1972**

[54] **ROCKET ENGINE**

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[22] Filed: **Aug. 1, 1969**

[21] Appl. No.: **846,696**

[30] **Foreign Application Priority Data**

July 20, 1968 Germany ....P 17 51 740.7
June 11, 1969 Germany ....P 19 29 629.8
June 11, 1969 Germany ....P 19 29 628.7

[52] **U.S. Cl.** ....**60/258,** 60/39.74 A, 60/265
[51] **Int. Cl.** **F02k 9/02**
[58] **Field of Search** ....60/258, 265, 39.74, DIG. 8, 60/39.74 A; 431/9

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[57] **ABSTRACT**

A rocket engine has an internal combustion chamber provided with a front wall. An outlet nozzle is provided in the front wall. At least two injection conduits communicate with the chamber rearwardly of the front wall in such a manner as to inject into the chamber respective streams of reactive propellants in direction tangentially of the chamber walls thus providing a short heat conduction path from the nozzle throat to the injected but yet unburned propellants rotating at high speed along the chamber walls.

3 Claims, 13 Drawing Figures

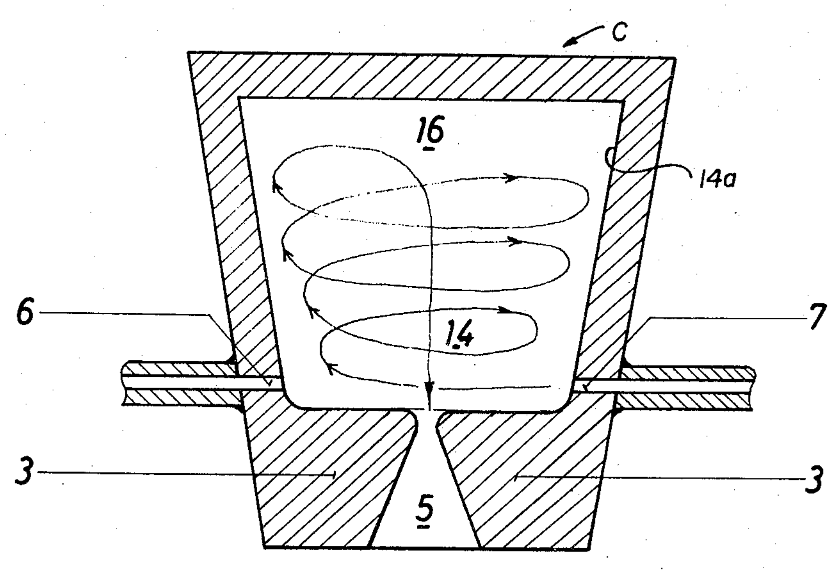


FIG.:1

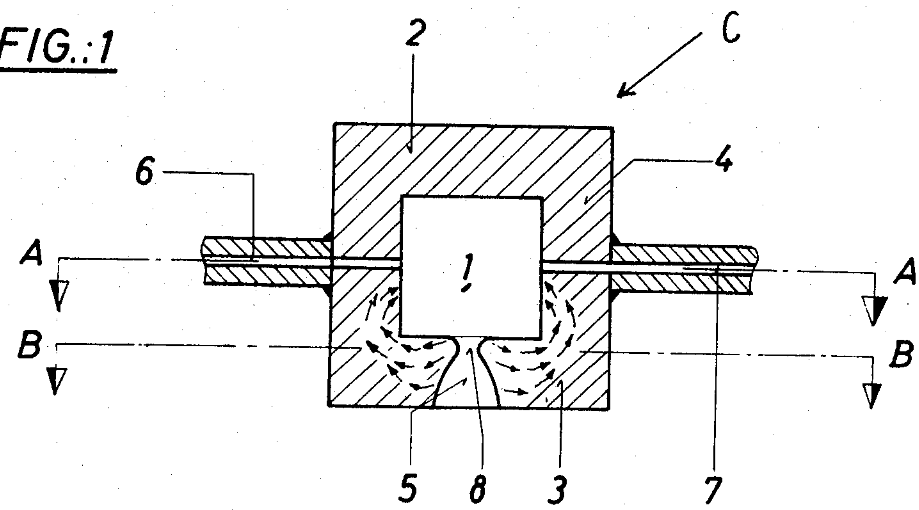


FIG.:2a

A-A

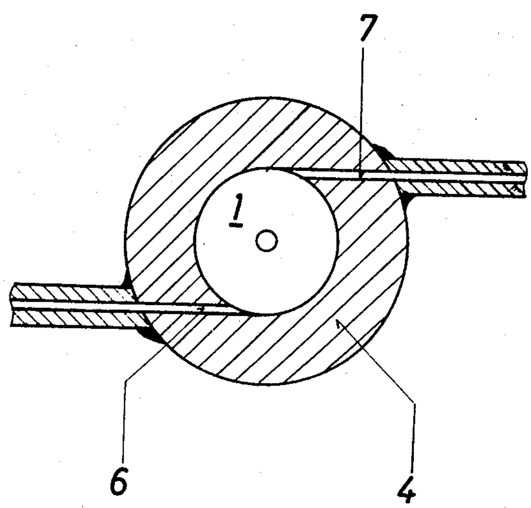
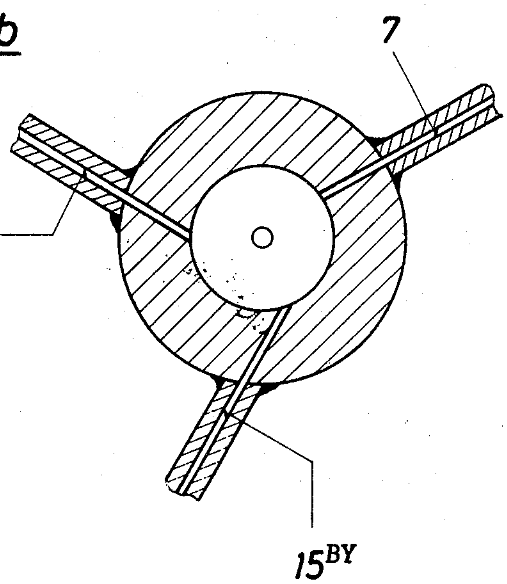


FIG.:2b



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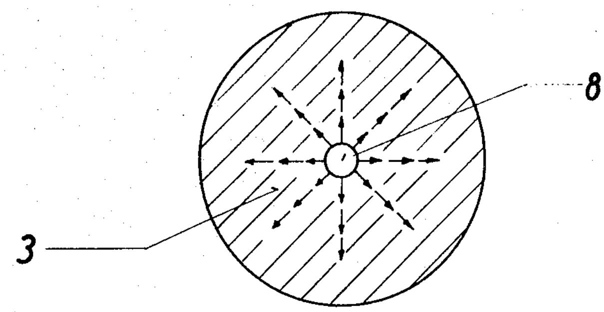

FIG.:3
B-B

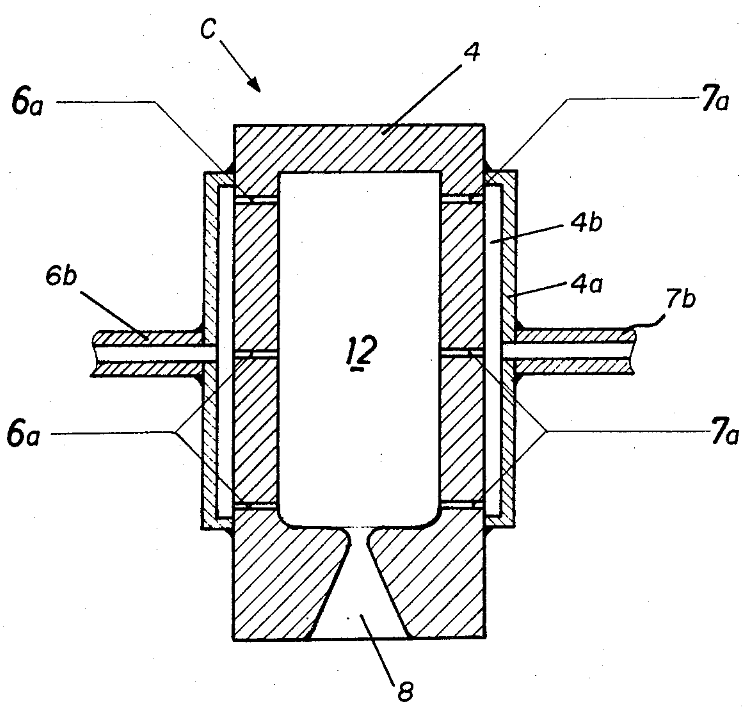

FIG.:4

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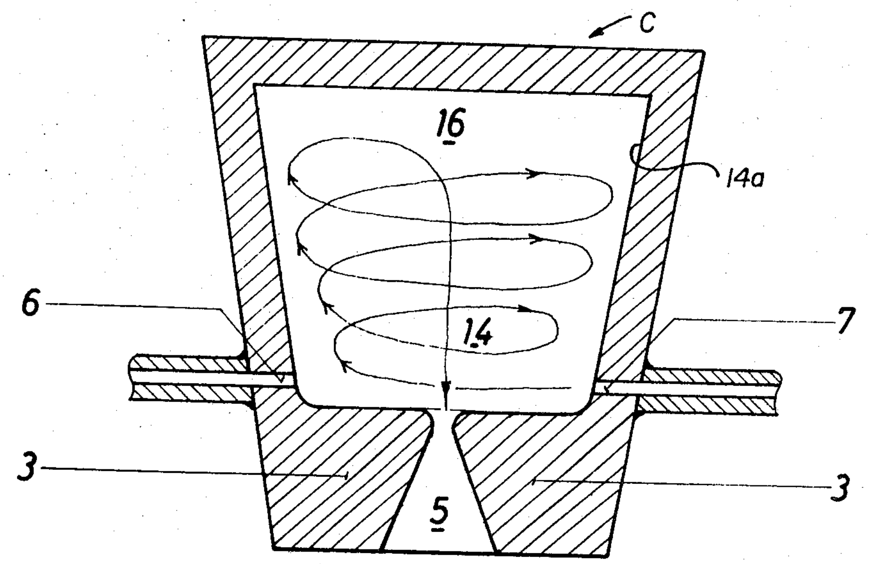

FIG.:5

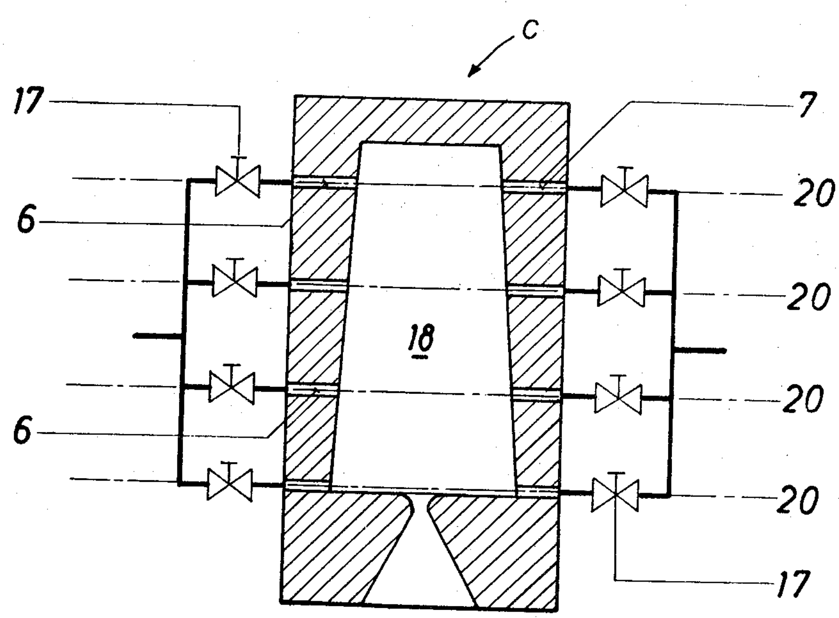

FIG.:6

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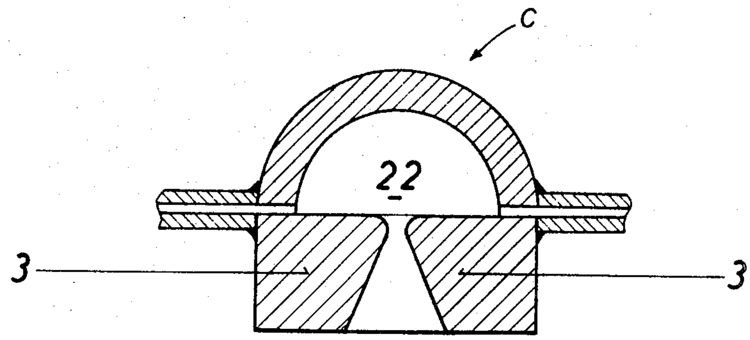

FIG.:7

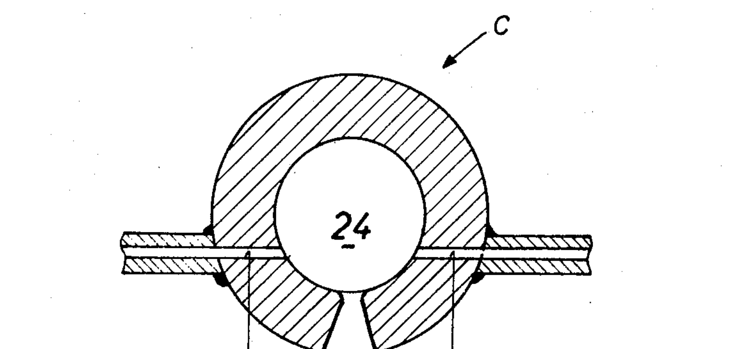

FIG.:8

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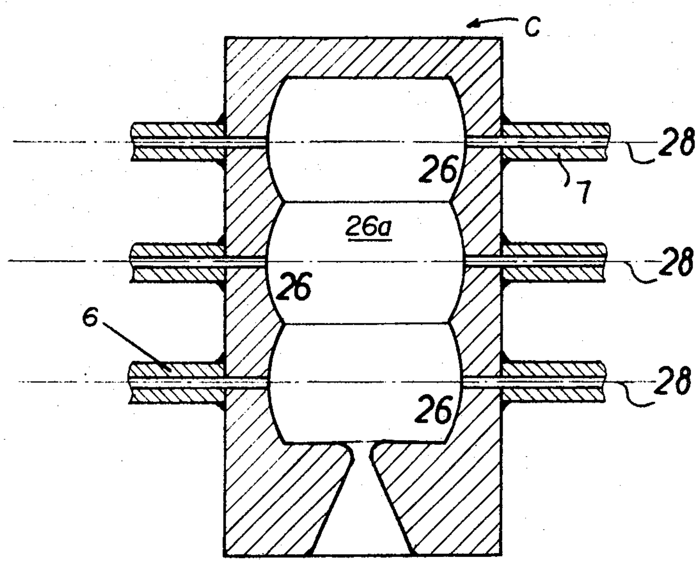

FIG.: 9

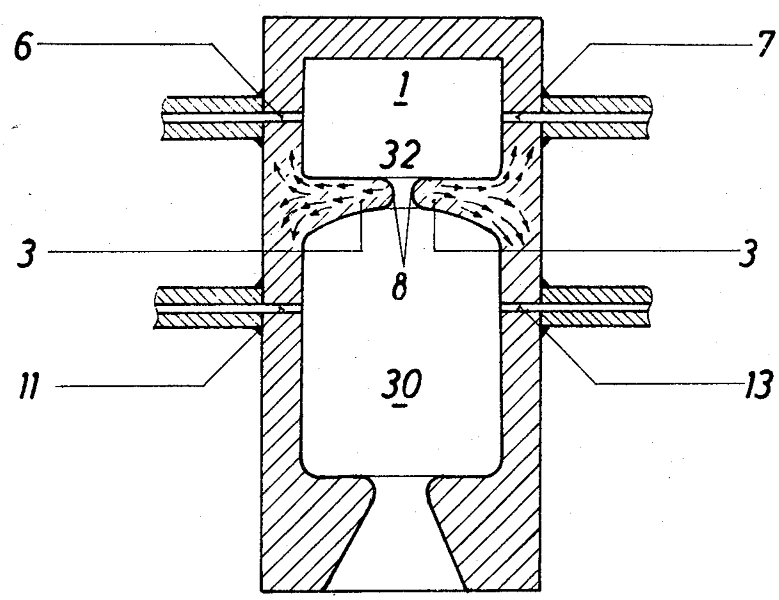

FIG.: 10

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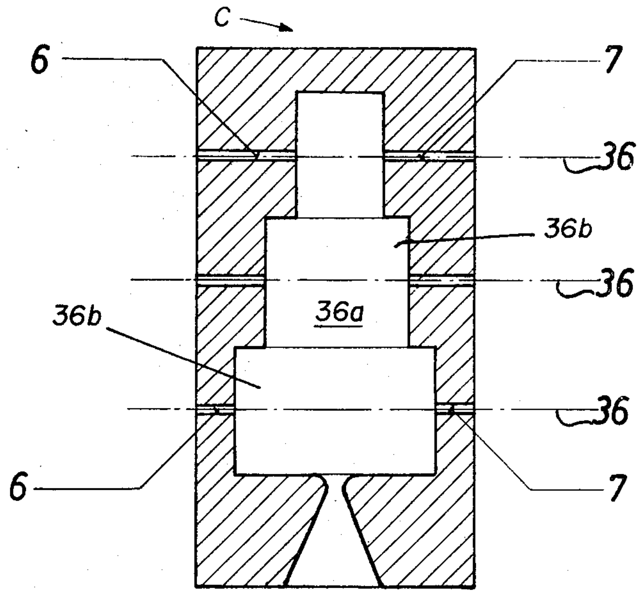

FIG.: 11

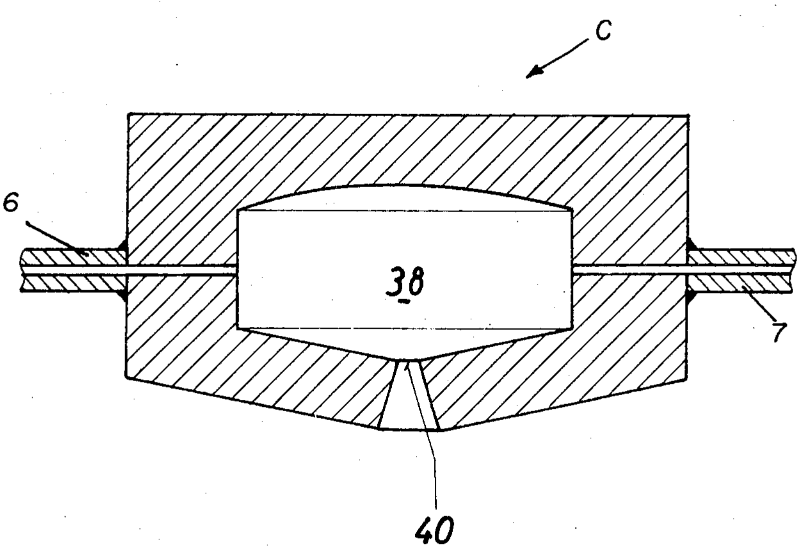

FIG.:12

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ROCKET ENGINE

BACKGROUND OF THE INVENTION

The present invention relates generally to a fuel-combusting device, and more particularly to a rocket engine. The invention also relates to a method of operating a rocket engine.

Rocket engines, and the operation thereof, are well known. The present invention is particularly concerned with small rocket engines wherein two or more liquid and/or gaseous fuel are injected for producing a gas stream. Such rocket engines are employed where small or very small amounts of thrust are needed, for instance as control thrusters of satellites, rocket-propelled aerospace vehicles and guided missiles. They are also used as the basic components of gas generators producing working gases such as are needed for the drive of turbines of auxiliary aggregates.

Rocket engines for these general purposes are of course already known. However, they suffer from various disadvantages, relating primarily to the problem of cooling the engines, providing proper propellant mixture ratio in the engine and operating the engine continuously. Particularly where small propellant quantities and small or very small thrusts below 7 pounds are involved, no properly operational rocket engines based on two or more component propellant systems are known, because it has been impossible to solve the cooling problem involved.

SUMMARY OF THE INVENTION

It is, accordingly, an object of the present invention to avoid the aforementioned disadvantages.

More particularly it is an object of the present invention ro provide a propellant-combusting device for rocket engines of low thrust such as used for the control of satellites, rocket-propelled aerospace vehicles and guided missiles, and also of the type which is used for gas production in gas generators.

A more particular object of the present invention is to provide such a device which provides for proper cooling, particularly in the region of the outlet nozzle.

An additional object of the invention is to provide a method of operating such a device.

In pursuance of the above objects, and others which will become apparent hereafter, one feature of my invention resides, briefly stated, in a propellant-combusting device which comprises wall means surrounding and defining an internal combustion chamber having a front wall portion. Outlet nozzle means is provided in the front wall portion and communicates with the chamber. Injecting means also communicates with the chamber and is operative for injecting into the same streams of reactive propellants in direction tangentially of the chamber, whereby the injected propellants initially sweep over and cool the wall means rearwardly of the front wall portion by taking off all heat conducted from the nozzle through the front wall radially outward simultaneously undergoing intimate mixture, prior to advancing towards and into the outlet nozzle means.

Because the rotation of the fuel streams resulting from the centrifugal forces acting upon them, and the resulting sweep of the fuel streams over the walls of the combustion chamber rearwardly of the front wall portion which is provided with the outlet nozzle, serves to cool these walls the present invention overcomes the cooling problem associated with the constructions known from the prior art. The flow of the fuel through the combustion chamber is radially inwardly from the outside towards the centrally located outlet nozzle and the maximum heat density is in the region of the throat of the outlet nozzle. According to the present invention the total cross-sectional area of the front wall portion in which the outlet nozzle is provided is a multiple of the cross-sectional area of the smallest radius of the throat of the outlet nozzle. In such a construction the heat transmitted to the outlet nozzle by the escaping hot gases is initially transmitted to the front wall portion surrounding the outlet nozzle, then radially outwardly conducted in this front wall portion, and then conducted rearwardly into the wall surrounding the combustion chamber rearwardly of the front wall portion into the region of the injecting means which injects the fuel components into the combustion chamber. In the region of injecting means the thus-conducted heat transmitted through the wall bounding the internal combustion chamber to the fuel which has been injected and which sweeps in a rotary motion over the inner surface of the wall under the influence of centrifugal force. It thus preheats the fuel which is desirable but is conducted away from and unable to damage the nozzle throat.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a somewhat diagrammatic axial section through a device according to the present invention in one embodiment;

FIG. **2a** is a section taken on the line A—A of FIG. **1**;

FIG. **2b** is a section analogous to FIG. **2a** of an embodiment utilizing three injection means instead of two as in FIGS. 1 and *2a;*

FIG. **3** is a section taken on the line B—B of FIG. **1**;

FIG. **4** is a view similar to FIG. **1** but showing a further embodiment of the invention;

FIG. **5** is a view similar to FIG. **4** but showing still another embodiment of the invention;

FIG. **6** is a view similar to FIG. **5** showing yet an additional embodiment of the invention;

FIG. **7** is a further axial sectional view through another embodiment of the invention;

FIG. **8** is a view analogous to FIG. **7** but showing still an additional embodiment of the invention;

FIG. **9** is another axial section through still a further embodiment of the invention;

FIG. **10** is an axial section through a gas generator embodying the invention;

FIG. **11** is a view similar to FIG. **9** showing still a further embodiment of the invention; and

FIG. **12** is a view similar to FIG. **11** but showing yet another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Discussing firstly the embodiment illustrated in FIGS. **1**, **2a** and **3**, it will be understood that reference character E identifies the engine in general which comprises an internal combustion chamber **1** bounded by a rear wall **2**, a front wall **3** and a circumferential wall **4**. The front wall **3** is provided with an outlet nozzle **5** which is illustrated diagrammatically and whose particular construction may be in accordance with the teachings of the prior art well known to those skilled in this field. However, the nozzle **5** is located centrally of the front wall **3** and, in accordance with the present invention, the smallest cross-sectional diameter **8** of the nozzle **5** at the throat or neck thereof, is considerably smaller than the cross-sectional area of the front wall **3**. This could also be stated, conversely, by saying that the cross-sectional area of the front wall **3** is a multiple of the cross-sectional area of the throat **8** of the nozzle **5**.

The circumferential wall **4** is provided in the embodiment of FIGS. **1**, **2a** and **3** with two oppositely located inlet bores **6** and **7** constituting injecting means for two reactive propellants or propellant components, and in accordance with the invention and as clearly visible in FIG. **2a**, bores **6** and **7** are so located that the streams of fuel injected into the combustion chamber **1** are injected tangentially to the periphery of the combustion chamber **1**. They are thus forced to sweep over the inner surface of the circumferential wall **4** bounding the combustion chamber **1** in a rotary motion and to cool the wall **4**, before they mix and react with one another. The bores 6 and 7 are located in the embodiment of FIGS. 1, 2*a* and 3 in a common plane normal to the axis of the combustion chamber 1, that is the axis extending through the nozzle 5. In the embodiment illustrated in FIG. 2*b*, which corresponds to that of FIGS. 1, 2*a* and 3 in most particulars, there are provided three inlet bores 6, 7 and 15 which each inject a stream of a propellant component. It is evident from FIG. 2*b* that the three bores 6, 7 and 15 may also be located in a common transverse plane.

FIGS. 1 and 3 shown the manner in which heat is conducted away from the nozzle 5 in operation of the engine E. The heat transmitted to the nozzle 5 by the escaping hot gases is conducted radially through the front wall portion 3 (see FIG. 3) and is then conducted rearwardly into the circumferential wall 4 to the region of the inlet bores 6 and 7 (and 15, in the case of FIG. 2*b*) where it is transmitted to the injected propellants which sweeps over the inner surface of the circumferential wall 4 prior to mixture. Because of the nonlinear radial temperature curve in the wall portion 3 which has a very large cross-sectional area by comparison with the cross-sectional area of the throat 8 of the nozzle 5, this manner of conducting heat away from the nozzle 5 is the more advantageous the smaller the cross-sectional area of the throat 8 of the nozzle 5 is, that is the smaller the thrust of the engine or the smaller the flow of fuel therethrough. By contrast to what is known from the art, the novel construction provides a cooling effect which is not only achieved in a most simple manner but which is extremely reliable and which is afforded in particular for the throat 8 of the nozzle 5, that is that portion of the engine which is subjected to the most heating and therefore susceptible of the most damage by having the fuel come in contact therewith, although in FIG. 5 the lines indicating the fuel flow are not shown in actual contact with this inner surface 14*a* for the sake of clarity.

Coming now to the embodiment shown in FIG. 6 it will be seen that here the configuration of the combustion chamber 18 is the reverse of that in FIG. 5, that is that the combustion chamber diverges conically in direction towards the outlet nozzle, rather than away therefrom. In this embodiment, also, there are provided a plurality of inlet bores 6 for one fuel component and inlet bores 7 for the other fuel component, with one bore 6 and one bore 7 always being located in one common transverse plane 20 extending transversely of the elongation of the chamber 18. Of course, the inlet bores 6 and 7 need not all be located on one side, and the construction could be modified so that on one plane 20 the inlet bore 6 is located at the left-hand side and on the next plane 20 the inlet bore 6 is located at the right-hand side of the illustration in FIG. 6. In any case, however, each of the inlet bores 6 and 7 is controlled by a separate control valve 17 but each inlet bore may be separately opened and closed, to thereby vary the throughput of fuel and the thrust in simple and highly effective manner by adding or taking away the output of individual ones of the bores 6 and 7. This control arrangement is the one which has been suggested in connection with the embodiment in FIG. 4, and can of course be employed in that embodiment.

In FIG. 7 I have illustrated a construction wherein the internal combustion chamber 22 is of semicircular configuration. All other features are the same as in the preceding embodiments, and like reference numerals identify like components. The heat flow from the nozzle is the same as identified in FIG. 3, and this is true in all embodiments already described and those still to be discussed. Also, the injection of the fuel fluids is always tangential, both in the embodiments which have been discussed here before and in those which are still to be described.

FIG. 8 shows a construction wherein the combustion chamber 24 is of spherical configuration and wherein the front wall portion 3 can be considered to extend from the region of the inlet bore 6 to the region of the inlet bore 7.

In the embodiment shown in FIG. 9 the combustion chamber 26*a* is composed of a series of substantially barrel-shaped sections 26, with the injection of fuel fluids taking place through the conduits or inlet bores 6 and 7 on three different transverse planes 28—each corresponding to one of the barrel-shaped sections 26 and bisecting the same at its greatest diameter. Each of the inlet bores 6 and 7 can of course be separately controlled in the same manner as discussed with respect to FIG. 6.

FIG. 10 shows a gas generator embodying the present invention. It comprises an internal combustion chamber 1 provided with the inlet bores 6 and 7 and corresponding to the embodiment illustrated in FIG. 1. Reference numeral 32 identifies the outlet nozzle whose downstream or outlet end communicates with a second internal combustion chamber 30 which again is provided with inlet bores 11 and 13 for two fuel fluids, both of which are also injected tangentially in the same manner as takes place in the chamber 1. As mentioned within the discussion of the embodiment in FIG. 1, the throat 8 of the outlet nozzle 32 is again so dimensioned that its cross-sectional area is much smaller than the cross-sectional area of the front wall portion 3 separating the chambers 1 and 30 from one another, with the flow of conducted heat being illustrated by the arrows in FIG. 9, from which it will be seen that the heat is here transmitted from the front wall portion 3 towards the inlet bores 6 and 7 as well as towards the inlet bores 11 and 13. The gases issuing through the nozzle 32 into the chamber 30 encounter additional fuel injected through the inlet bores 11 and 13 in a nonstoichiometric relationship, so that the hot gases issuing through the nozzle 32 into the chamber 30 are strongly cooled. In place of additional fuel, or in addition to such additional fuel, it is also possible to inject other means serving to cool the hot gases entering the chamber 30 from the chamber 1. However, the injection should always take place in the vicinity of the front wall portion 3 because this provides for additional cooling.

Finally, the embodiment illustrated in FIG. 12 shows an engine according to the present invention wherein the internal combustion chamber 38 is of substantially lenticular configuration and wherein the nozzle 40 is of the type known as a corner expansion nozzle. The injection of the propellants through the inlet bores 6 and 7 is of course again tangentially to the circumference of the chamber 38.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the types described above.

While the invention has been illustrated and described as embodied in a fuel combusting device such as a rocket engine, it is not intended to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

I claim:

1. A fuel-combusting device, comprising wall means surrounding and defining an internal combustion chamber having a front wall portion an inner surface of which faces the interior of said internal combustion chamber; outlet nozzle means provided in said front wall portion communicating with said chamber at said inner surface and having a longitudinal axis; and injecting means communicating with said chamber only adjacent said inner surface and being operative for injecting into said chamber at least two streams of reactive propellants in direction tangentially of said chamber only inwardly proximal to said inner surface of said front wall portion and only in one plane transverse of said longitudinal axis, said outlet nozzle means comprising an outlet passage diverging at least in part in direction away from said chamber, and having a predetermined smallest cross-sectional area, the cross-sectional area of said front wall portion being a multiple of said predetermined cross-sectional area, said chamber conically diverging in direction away from said front wall portion, whereby the injected propellants initially sweep over and cool said wall means rearwardly of said front wall portion, simultaneously undergoing intimate admixture, prior to advancing towards said outlet nozzle means.

2. A fuel-combusting device as defined in claim 1, wherein said plane is normal to the elongation of said chamber

3. A fuel-combusting device as defined in claim 1, wherein said injecting means is operative to inject two streams each composed of a different propellant.

* * * * *