United States Patent [19]

Butter et al.

[11] **3,782,118**

[45] **Jan. 1, 1974**

[54] **REGENERATIVELY COOLED THRUST GAS GENERATOR CONSTRUCTION AND METHOD OF MAKING SAME**

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[22] Filed: **Dec. 18, 1972**

[21] Appl. No.: **315,984**

Related U.S. Application Data

[63] Continuation of Ser. No. 62,448, Aug. 10, 1970, abandoned.

[52] **U.S. Cl.** **60/260**, 60/267

[51] **Int. Cl.** **F02k 11/02**

[58] **Field of Search** 60/267, 39.66, 260

[56] **References Cited**

UNITED STATES PATENTS

3,690,103	9/1972	Dederia et al.	60/267
3,190,070	6/1965	Neu	60/39.66
3,460,759	8/1969	Gregory et al.	60/260
3,022,230	2/1962	Fialkoff	60/39.66

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[57] **ABSTRACT**

A thrust gas generator includes combustion chamber and a thrust nozzle and has a plurality of longitudinally arranged and circumferentially spaced capillary tubes which form closed canals for the cooling medium, especially a liquid. A metallic layer particularly one which is applied by electroplating, joins the capillary tubes to form a pressure-tight combustion chamber. The electroplated metal is applied to positively embrace the capillary tubes at their radially outward portions or their radially inward portions to bridge the spaces between the tubes. The tubes are shaped so that they have a substantially constant cross section over major portion of their length and they may include a variable cross section in the thrust nozzle or neck portion.

9 Claims, 4 Drawing Figures

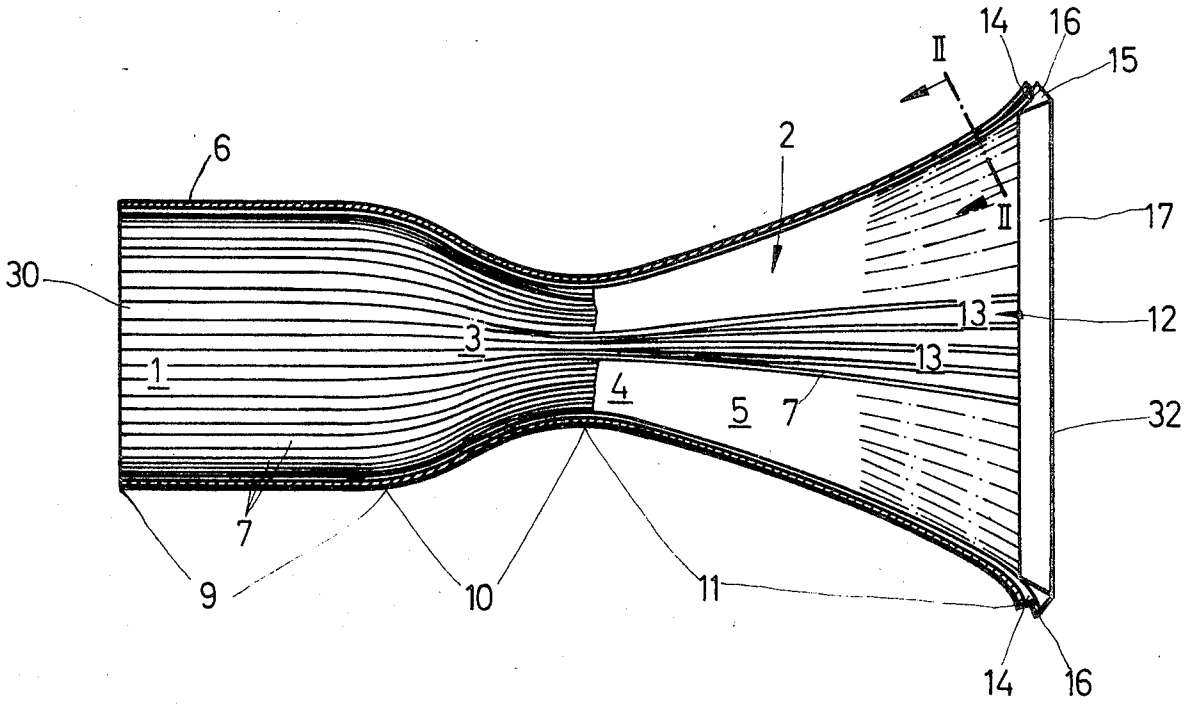


Fig. 1

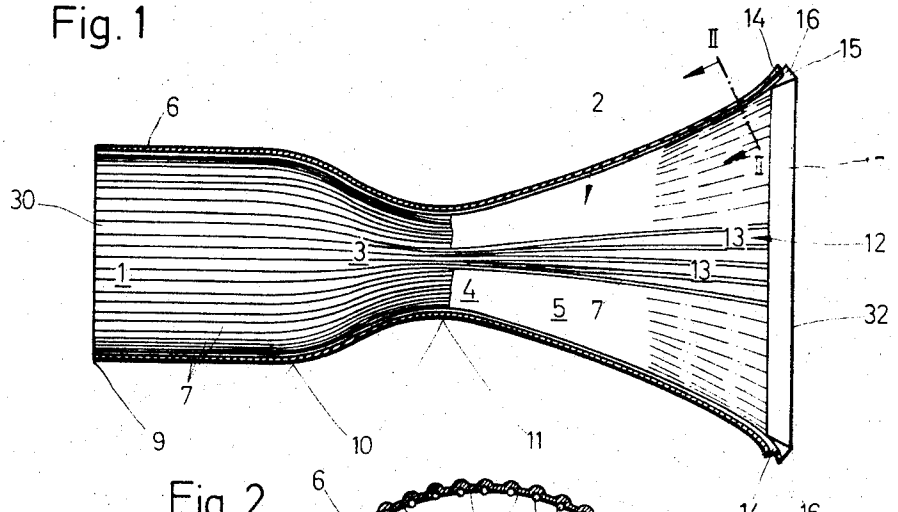


Fig. 2

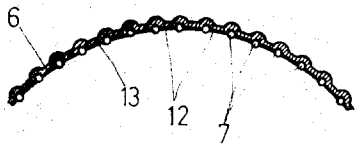


Fig. 3

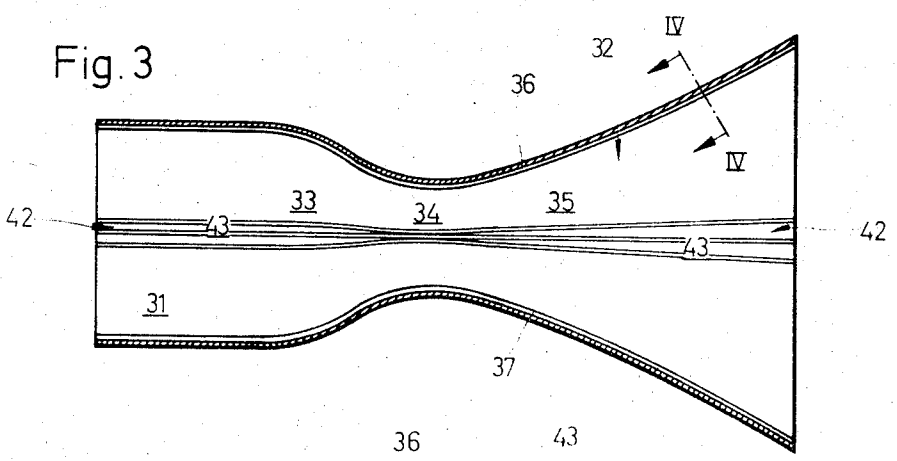
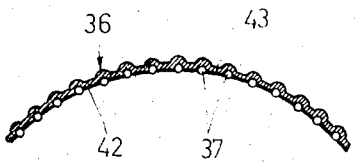


Fig. 4



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REGENERATIVELY COOLED THRUST GAS GENERATOR CONSTRUCTION AND METHOD OF MAKING SAME

This is a streamline continuation, of application Ser. No. 62,448 filed Aug. 10, 1970 now abandoned.

SUMMARY OF THE INVENTION

This invention relates in general to the construction and method of making combustion chambers, and in particular, to a new and useful regeneratively cooled thrust gas generator including a combustion chamber thrust nozzle having longitudinally arranged capillary tubes or similar tubular elements forming closed canals for the cooling medium especially for a liquid cooling medium and including a metallic layer which joins the capillary tubes together into a firm pressure-tight construction and which comprises an electroplated layer.

In a known design of combustion chamber and/or thrust gas generators of the regenerative type, the wall to be cooled comprises capillary tubes with different cross sections which also vary longitudinally in cross sections. These capillary tubes are dimensioned and arranged symmetrically about the longitudinal axis of the combustion chamber in such a manner that they touch each other laterally along their entire length. In this form of design, an electroplated layer making contact with the radial outer surface line of the capillary tubes provides the pressure-tight bonding of the tubes. However, undesirable deformations of the tubes tend to cause irrepairable leaks. Such conditions are due to locally present high temperatures which are produced during the soldering or welding of the tubes at their lateral points of contact. These disadvantages are prevented with certainity when using tube bonding methods which are carried out without heat being supplied. When the tubes are bonded by an electroplated metal layer, there is an increase of weight which, as compared with the known soldered or welded form of construction, is maintained within economically justified limits by leaving the gaps defined by the peripheral regions between the radial outer surface lines and the lateral (linear) point of contact of each two adjacent tubes free of the layer material when the electroplated layer is applied. To this end, the gaps are levelled off prior to the application of the electroplated layer with a low melting filling material which is electrically conductive at its exposed surface. The filling material is applied so that there is only line-shaped bonds which are therefore prone to produce cracks between the capillary tubes on the one hand and the electroplated layer on the other hand.

The invention is therefore based on the task of developing the combustion chamber and/or thrust nozzle which is inexpensive to manufacture, and is characterized by greater static and dynamic strength against the forces arising from the internal pressure of the combustion chamber due to the occurring temperature differences in manufacture or operation, and which is lighter in weight than the known designs. According to the invention, it is solved by arranging the capillary tubes around the longitudinally extending combustion chamber axis and/or thrust nozzle axis with spacings therebetween being uniformly maintained either over the entire length of the thrust generator, or at least in defined sections thereof. A metallic layer, particularly a layer which is applied by electroplating is arranged to positively embrace the tubes either at their radially outer or

radially inner peripheral regions and also to bridge the gaps therebetween.

In another form of the inventive construction of combustion chamber or thrust nozzle which is particularly inexpensive and light in weight the capillary tubes or tubular elements are formed with constant cross sections over substantially their entire length and are dimensioned so that the tubes lie next to each other and without any spacing therebetween only at the narrowest cross sections of the thrust nozzle. With such an arrangement not only is the circumference of the diverging part of the thrust nozzle covered by the capillary tubes and by the parts of the metallic layer which is applied by electroplating to bridge the spaces between them but also the circumference of the combustion chamber and the convergent part of the thrust nozzle with the exception of the neck portion thereof.

Because of the intimate bond, which extends over a relatively large area between the metallic layer and the capillary tubes and the comparitively high flow velocities of the cooling medium resulting from the fact that the tubes remain substantially constant in cross section from the neck of the thrust nozzle to the rear end of the thrust nozzle, a sufficient cooling is assured in both forms of construction of the invention.

In accordance with a further feature of the invention, the tubular elements located at the discharge end of the thrust nozzle are bent outwardly and are imbedded in the radial outer zone of a stiff nozzle ring which is electroplated into position when the metallic layer is applied by electroplating. The radial inner surface of the ring is not profiled and it is flush with the parts of the metallic layer which lie within the region of the inner nozzle contour between the tubular elements. This design brings about two advantages: First the nozzle terminating ring serves to provide a stiffening element for the discharge end of the thrust nozzle or combustion chamber. Secondly, it permits a smooth and even discharge flow from the combustion chamber or nozzle.

The invention provides also an improved method for manufacturing the combustion chamber and/or the thrust nozzle, which comprises providing a combustion chamber and/or thrust nozzle core with an electrically conductive surface which determines the inner contour of the combustion chamber and/or thrust nozzle, machining out the core surface particularly by milling continuous longitudinal grooves which are separated from one another at least in sections by bridging portions or lands, inserting suitably formed and shaped capillary tubes into the grooves between the lands, and applying by electroplating a metallic layer on the outwardly pointing peripheral regions of the capillary tubes or shapes and on the surfaces of the core lands located between the tubular shapes.

Accordingly, it is an object of the invention to provide an improved method for forming a combustion chamber and/or a thrust nozzle which comprises forming a core which determines the inner contour, machinging out the core surface to form longitudinally extending grooves, inserting individual tubular elements forming closed longitudinally extending cooling channels within the grooves and applying electroplating a metallic layer on the outward peripheral regions of the capillary tubes and the spaces between the tubes over the core.

A further object of the invention is to provide an improved combustion chamber construction which in-

cludes a wall formed by longitudinally extending spaced tubular elements forming cooling medium conduits which are firmly held together in a pressure-tight manner by a layer of an electroplated metal material which positively embraces the tubes at their radially inner portions or radial outward portions, and wherein the tubes are made of substantially uniform cross sections through out the length and are either maintained in spaced relationship throughout their lengths, or are arranged in contacting relationship only at the narrowest cross section.

A further object of the invention is to provide a combustion chamber or nozzle construction which is simple in design, rugged in construction, and economical to manufacture.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is an axial sectional view of a combustion chamber constructed in accordance with the invention;

FIG. 2 is a partial section taken along the line II—II of FIG. 1; and

FIG. 3 is a section similar to FIG. 1 of another embodiment of the invention; and

FIG. 4 is a section taken along the line IV—IV of FIG. 3.

GENERAL DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings in particular, the invention embodied therein, in FIGS. 1 and 2, comprises a thrust nozzle device or thrust gas generating device having a combustion chamber portion 1, a thrust nozzle portion 2 with a convergent part which is designated 3 and a neck portion 4 having a divergent part 5. The entire device is formed by a plurality of longitudinally arranged capillary tubes 7 which are spaced apart circumferentially and held in a fixed position by a metallic layer 6 which surrounds the outwardly extending portions of each tube over a portion of their peripheries. The layer 6 is applied by electroplating to form a firm and unified structure.

The capillary tube 7 includes a first portion 9 which is of substantially constant cross section and extends from the front end or closed end 30 to the beginning of the converging portion of the nozzle 4. A second longitudinal section 10 having a cross section which varies in dimension extends from the converging portion 3 to the neck portion 4. A further portion 11 extends from the neck portion 4 to the discharge or open end 32. The tubes 7 have a cross section in the section 11 which is substantially constant throughout the length of the section. From the end 30 of the combustion chamber 1 to the thrust nozzle neck 4, the capillary tubes 7 touch each other laterally. From the thrust nozzle neck 4 to the discharge end 32 of the thrust nozzle 2, they are separated from each other by spaces 12 which, because of the fact that the tube section remains constant, increases rapidly in width with increasing nozzle diameter. These spacings 12 are bridged in a pressure-tight manner by parts 13 of the metallic layer which lie within the contour of the nozzles.

The ends 14 of the capillary tubes 7 at the discharge end 32 are bent outwardly and are embedded in longitudinal grooves 16 of a radial outer portion of a stiff nozzle terminating ring 15. The ring 15 is electroplated together with the metallic layer 6 which is also applied by electroplating. The nozzle terminating ring 15 has an inner surface 17 which is flush with the part 13 of the metallic layer 6 which is located between the tubes within the inner nozzle contour.

In the embodiment shown in FIGS. 3 and 4, there is provided a combustion chamber or thrust gas generator having a combustion chamber 31 and a thrust nozzle 32. The thrust nozzle 32 includes a convergent part 33, a neck 34, and a divergent part 35. The thrust nozzle according to the embodiments of FIGS. 3 and 4, similar to that of FIGS. 1 and 2, and comprises a plurality of longitudinally extending capillary tubes 37 and a metallic layer 36 which is positively engaged around a portion of the outer periphery of each tube and which is applied by electroplating. The construction of FIGS. 3 and 4 differ from that of FIGS. 1 and 2 in respect to the capillary tubes 37 which have cross sections which are constant over the entire length thereof. The tubes 37 touch each other in the region of the thrust nozzle neck 34 are separated from each other in the divergent thrust nozzle part 35 as well as in the convergent thrust nozzle 33 and the region of the combustion chamber 31 by interspaces 42. The interspaces 42 are also bridged by the parts 43 of the metallic layer 36 which is located within the region of the inner nozzle contour. The ends of the capillary tubes 37 are located at their rear end of the thrust nozzle 37 and they can be embedded in the outer region of a stiff nozzle terminating ring similar to that of FIGS. 1 and 2 or as indicated in FIG. 3.

The thrust generator according to the invention can be constructed with less weight than the known types using the capillary tube construction, because in contrast to the latter, only the thermally highly stressed sections of the combustion chamber and/or thrust nozzle are peripherally covered exclusively by capillary tubes while the remaining thermally less stressed sections in order to reduce the weight are peripherally covered only partly by capillary tubes the interspaces being covered by the metallic layer, particularly a layer applied by electroplating. As a further advantage is added that the metallic layer, especially the layer applied by electroplating, makes contact not only with the radially outer surface lines of the capillar tubes or shapes, as in the known case, but surrounds a portion of their peripheries so that at all mutual points of contact reliable area bonds are assured between the metallic layer on the one hand and the capillary tubes or shapes on the other hand.

In the development of the invention, it is proposed to use capillary tubes or shapes with cross sections which are constant over the entire length or at least a large part of same. Due to their lower machining and labor cost, such capillary tubes or shapes are cheaper in production than the capillary tubes or shapes used for the construction of the known combustion chambers and/or thrust nozzles, which for geometric reasons must have variable cross sections over the entire length or over a large part of same. This fact has an extremely

positive effect on the manufacturing casts of a combustion chamber and/or thrust nozzle, and such costs are substantially influenced by the prices of the capillary tubes or shapes, respectively.

What is claimed is:

1. A regeneratively cooled thrust gas generator comprising a hollow tubular wall defining a combustion chamber and a thrust nozzle having a narrow diameter portion and a diverging portion terminating in a thrust gas discharge, said hollow tubular wall being made up of a plurality of longitudinally extending tubes, each tube forming a closed cooling channel for the flow of a cooling medium therethrough, and a metallic layer extending between said tubes at least in the diverging portion of said nozzle and extending over a portion of the periphery of each tube and bonded thereto, said metallic layer comprising an electroplated layer positively embracing the capillary tubes and forming, at least in a section in the diverging portion of said nozzle, circumferentially extending wall portions between said tubes of a circumferential extent at least as great as the diameter of said tubes.

2. A regeneratively cooled thrust gas generator, according to claim 1, wherein said tubes are of substantially constant cross-section over their entire lengths.

3. A regeneratively cooled thrust gas generator, according to claim 1, wherein said tubes are of substantially constant cross-section over at least a major portion of their lengths.

4. A regeneratively cooled thrust gas generator, according to claim 1, wherein said tubes are in substantially abutting contact at said narrow diameter portion of said thrust nozzle.

5. A regeneratively cooled thrust gas generator, according to claim 1, including a hollow terminating ring arranged at the discharge end, said tubes having inturned end portions at said discharge extending into and sealed with said terminating ring, said ring being electroplated with said layer.

6. A regeneratively cooled thrust gas generator, according to claim 1, wherein said tubes are distributed around said nozzle circumference in said divergent wall portion with the spacing therebetween increasing with the increasing nozzle diameter toward said thrust discharge, the spacing between said tubes being exclusively bridged by electroplated material joining said tubes together.

7. A regeneratively cooled thrust gas generator, comprising a hollow tubular wall defining a combustion chamber and a thrust nozzle having a narrow diameter portion and a diverging portion terminating in a thrust gas discharge, said hollow tubular wall being made up of a plurality of longitudinally extending circumferentially arranged tubes with each tube forming a closed cooling channel for the flow of a cooling medium therethrough, a circumferentially extending electroplated metallic layer extending over a portion of the periphery of said tubes along their lengths and bonded to said tubes, said electroplated layer with said tubes comprising said hollow tubular wall and with the electroplated layer extending between said tubes in the area defining said diverging portion and defining the only interior wall surface between said tubes at such location.

8. A regeneratively cooled thrust gas generator, according to claim 7, wherein said tubes are in abutting contact in the area defining said combustion chamber and said thrust nozzle narrow diameter portion and wherein at such locations, said electroplated layer extends around the exterior periphery of said tubes.

9. A regeneratively cooled thrust gas generator, according to claim 7, wherein said tubes are spaced apart in the area defining said combustion chamber and wherein said electroplated layer forms the interior wall between the tubes in this area.

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