Feb. 23, 1965 B. E. KRAMER 3,170,289

LIGHTWEIGHT REFRACTORY METAL STRUCTURE

Filed July 5, 1962

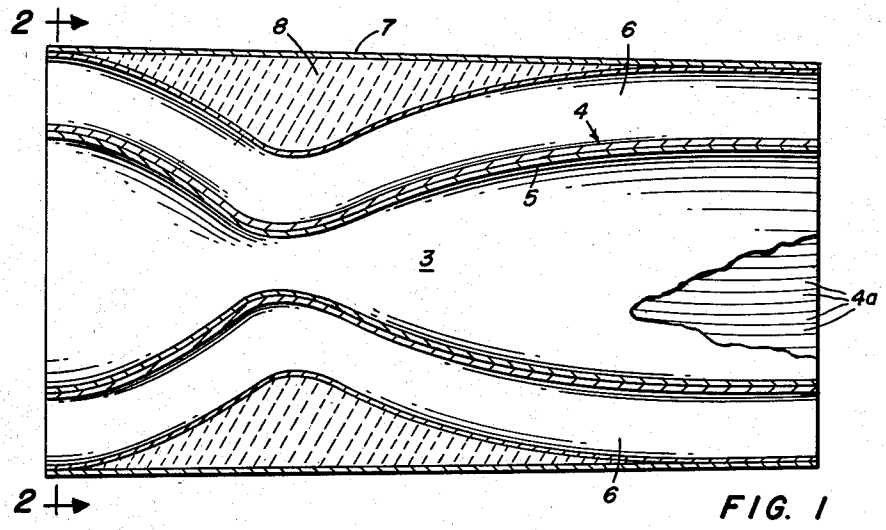


FIG. 1

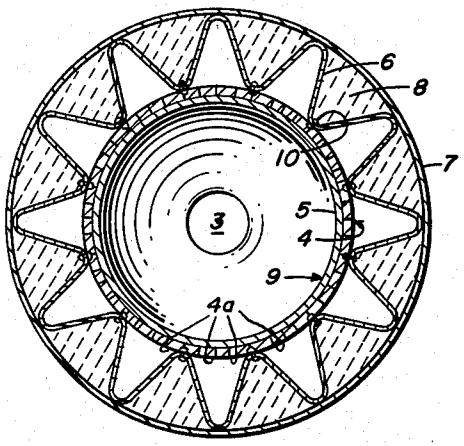


FIG. 2

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LIGHTWEIGHT REFRACTORY METAL STRUCTURE

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2 Claims. (Cl. 60—35.6)

The present invention relates to high temperature structural materials and methods of fabricating articles therefrom. More particularly, the invention relates to rocket nozzles formed entirely from refractory metal materials.

With the advent of solid propellant rocket engines, the extremely high temperatures and gas velocities generated have created a need for a temperature-resistant, erosion-resistant, high-strength, lightweight nozzle.

One of the prior art approaches to solve this problem is to construct the nozzle out of standard metals such as steel or aluminum and to circulate various coolants around the external surface. However, this nozzle has not proven satisfactory since it was too heavy, and demanded a complex system to circulate the coolant. The usual approach was to fabricate the body of the rocket nozzle out of light weight insulative material such as graphite or plastic. Such insulative material was then coated on its inside surface with a high melting material such as tungsten to resist the temperatures and forces of the expelled combustion products of the propellant reaction. Such nozzle systems have serious drawbacks and usually failed because there was little or no physical bond between the coating and insulative backup material, there was a mismatch between the coefficients of expansion of the materials and the insulative material was physically weak or broke down thermally.

Accordingly, it is an object of the present invention to provide a nozzle that is capable of use under extreme temperature conditions.

Another object is the provision of a nozzle that is not subject to failure in use due to mismatch of coefficients of expansion.

A further object is to provide a nozzle that will resist the eroding forces of the high velocity gas stream.

A further object is to provide a method of constructing a nozzle that is simple, reliable and relatively inexpensive.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like parts throughout the figures thereof and wherein:

FIG. 1 shows a sectional view of a preferred embodiment of the invention; and

FIG. 2 illustrates a section of the device taken on the line 2—2 of FIG. 1 looking in the direction of the arrows.

Referring now to the drawings there is shown in FIG. 1 a nozzle 3 constructed of an interior shell 4 composed of a series of longitudinal strips 4*a* of tungsten or tantalum. Since the circumference of the nozzle 3 is considerably reduced at the throat section, the width of longitudinal strips 4*a* must be correspondingly reduced at that point, as shown by Dalgleish in U.S. Patent No. 2,976,679. Said shell is covered with a coating 5 of erosion resistant material such as tungsten, tantalum carbide and hafnium carbide. The shell is supported by, surrounded by, and attached to a corrugated backup liner shown as corrugations 6 on FIG. 2. The corrugations can be joined to an outer liner 7 of suitable material and the spaces between the corrugation and the outside liner can be filled

with suitable heat resistant material 8 such as ceramics and plastics.

FIG. 2 illustrates more clearly the construction of the nozzle wherein a plurality of strips 9 of tungsten or tantalum are joined by tantalum rivets 10 or arc sprayed tungsten to the interior lands of the corrugations 6 to form the inner shell 4.

The following describes the fabrication process. Tungsten or tantalum sheet is hot rolled through a set of parallel gears with tapered teeth to provide a corrugated sheet which is then formed to the nozzle shape; the corrugations running in a longitudinal direction. The sheet is then joined by arc sprayed tungsten or by tantalum rivets, for example. Strips of sheet tungsten or tantalum are then joined to the interior lands of the corrugations. By longitudinally joining together the interior lands of the corrugation the inside liner of the nozzle is formed. The inside liner is then coated with arc sprayed tungsten, hafnium carbide or tantalum carbide which forms a coating of erosion resistant material and also joins together the strips of sheet metal. The sprayed coating may optionally be vacuum sintered. The outside corrugations may be filled with suitable ceramic or plastic to stiffen and provide insulation. The outer shell is attached to the corrugations and the inside diameter may then if desired be ground to a smoother surface.

The apparatus by which the above steps may be performed is not critical nor part of the present invention. The corrugator can be any one of those commonly available in the art such as one similar to the one disclosed by Pappelendam in U.S. Patent No. 2,746,139. The arc sprayed tungsten can be accomplished by electric arc furnaces commonly known or by a plasma stream apparatus such as that disclosed by Giannini in U.S. Patent No. 2,922,869. As is well known, tungsten melts at 6200° F. Though tantalum melts at 5400° F., 800° F. lower, it is more workable at room temperature and is thus easier to construct a nozzle out of this material. Of the spray coated materials, tungsten has proven most satisfactory and a 0.150 inch coating which was utilized in a solid propellant rocket engine did not come near its melting point. The liner is formed of 0.060 tungsten or tantalum sheet, but the corrugated sheet can be thinner. It should be understood that since the coefficients of expansion and melting points of these two metals are so similar that the liner or corrugated backing may be made of either interchangeably, tantalum being preferred for uses below 5400° F. and tungsten being required for heats above 5400° F.

Thus, it is readily obvious that the nozzle is constructed completely out of refractory materials of extremely high melting point and erosion resistance. The mismatch of coefficient of expansion is obviated since the materials have similar coefficients of expansion. Even the joining materials are refractory metals, i.e. tantalum rivets or arc sprayed tungsten. The arc sprayed tungsten can also be used to coat the inner surface of the liner and concomitantly this coating will weld the seams between the strips as it forms the smooth inner surface. It should be understood that although the corrugations have been shown to run longitudinally, it is also permissible to have the corrugations run horizontally and then join the longitudinal strips of refractory metal thereto.

Obviously many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A refractory metal rocket nozzle capable of withstanding temperatures and gas velocities generated dur-

ing ignition comprising in combination a plurality of strips of refractory metals arranged longitudinally to form an inner liner, coating means on said strips of refractory metal to provide erosion resistance and to form a continuous inner surface, an outer liner, corrugated means supporting said inner liner in spaced relation with said outer liner, insulating means between said inner and outer liners, and means attaching said inner liner to said corrugated supporting means.

2. A rocket nozzle constructed substantially from refractory metals such as tantalum and tungsten comprising in combination an inner liner composed of a plurality of longitudinal strips of one of said metals, a sprayed coating of a material selected from the group consisting of tungsten, hafnium carbide and tantalum carbide on said inner liner, corrugated refractory metal means supporting and insulating said inner liner and means attaching said inner liner to said corrugated support means.

References Cited by the Examiner

UNITED STATES PATENTS

2,217,193	10/40	Aronson	29—157
2,334,257	11/43	Egger et al.	29—157
2,548,485	4/51	Lubock	60—39.69
2,614,619	10/52	Fuller	60—35.6
2,658,332	11/53	Nicholson	60—35.6
2,699,036	1/55	Nicholson	60—35.6
2,751,188	6/56	Rath	60—39.69
2,849,860	9/58	Lowe	60—35.6
2,976,679	3/61	Dalgleish	60—35.6
3,082,601	3/63	Witt	60—39.69

OTHER REFERENCES

Rocket Refractories publication, Navord Report 4893, NOTS 1191, August 26, 1955, pp. 11–34.

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