Oct. 20, 1964 J. C. PROSSER 3,153,320

COOLED ROCKET NOZZLE DESIGN

Filed Nov. 8, 1962

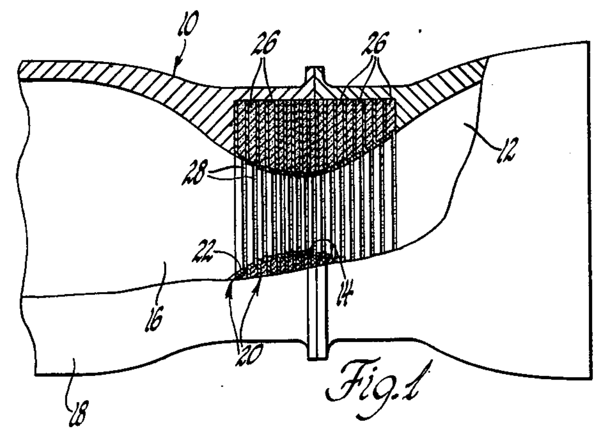

Fig. 1

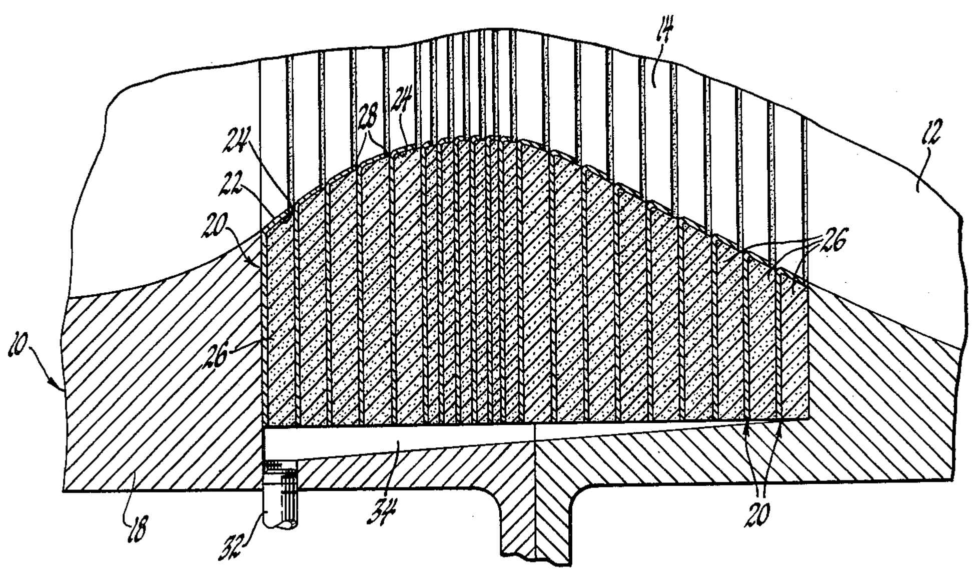

Fig. 2

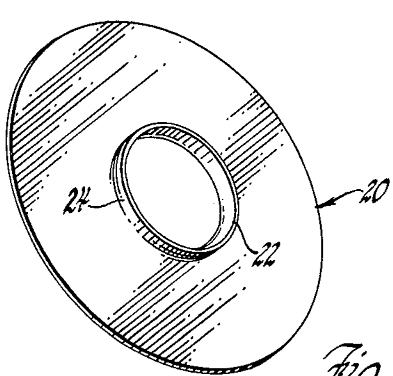

Fig. 3

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3,153,320

Patented Oct. 20, 1964

3,153,320

COOLED ROCKET NOZZLE DESIGN

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Filed Nov. 8, 1962, Ser. No. 236,228

4 Claims. (Cl. 60—35.6)

This invention relates to a rocket nozzle construction and more particularly to a nozzle construction facilitating transpiration cooling.

Rocket nozzles frequently operate at temperatures considerably higher than the melting temperatures of the material with which the nozzle is lined. Some form of cooling system must, therefore, be provided to prevent the liner from burning out before the termination of the operation of the nozzle. Present and past attempts to build satisfactory high perfomance cooled rocket nozzles have had limited success due to the basic problems in refractory metals, formability and brittleness, porous material characteristics, pressure distribution in the nozzle and nozzle weights. Many designs which have evolved are quite complex or heavy and require fabrication procedures which exceed the state of the art for materials which can be used. In addition, many configurations do not have adequate strength and shock resistance to withstand the initial firing shock.

The object of this invention is to provide a relatively lightweight rocket nozzle which is inherently rugged and will be capable of operating at motive fluid temperatures in excess of the melting point of its refractory metal liner by virtue of coolant provisions in the design. A further object of the invention is to construct a nozzle containing porous members contacted by a coolant for effusion of the coolant through the porous members. It is still a further object of this invention to circumferentially surround the throat section of a porous convergent-divergent type nozzle with cooling medium manifolds to cool the higher temperature portions of the nozzle by the effusion of the coolant through the porous material.

Other objects, advantages and features of the invention will become apparent upon reference to the succeeding detailed description of the preferred embodiment of the invention, and to the drawings thereof, wherein:

FIGURE 1 is a side elevation view, with parts broken away and in section, of a nozzle embodying the invention;

FIGURE 2 is an enlarged sectional view of the nozzle construction as shown in FIGURE 1; and

FIGURE 3 is a perspective view of a single flanged annular disc construction unit.

In general, the invention relates to a convergent-divergent nozzle for high-temperature gases, cooled by transpiration-type cooling means, having a throat portion made of a number of axially stacked thin disc-like sections. Each section includes an annular disc having a flange portion on its inner margin, said flange forming a segment of the throat surface of the nozzle, and a porous spacer ring abutting the annular flanged disc and extending radially inward to the flanges. The porous spacer rings lie between adjacent discs and provide the medium through which flows the coolant material.

More specifically, FIGURE 1 shows a fixed nozzle 10 of the convergent-divergent type. It has a diverging conical exhaust gas exit port 12, annular throat or venturi portion 14, and a converging conical inlet portion 16 connected to the aft end of annular casing 18. Casing 18 may constitute a portion of a rocket engine chamber or may be the aft end of any other suitable reaction motor duct. The throat and exit portions may be formed integral with the converging portions, or may be secured thereto by any suitable means.

Casing 18 is the nozzle throat supporting structure and

can be constructed by any other common techniques which are well known and it is not a feature of this invention. Suggested materials are molten Fiberglas insulation in combination with steel supporting structure.

The basic unit or module in the nozzle is an annular disc of refractory metal 20. It has a flange portion 22 spun or drawn on the inside margin to form a relatively short segment of the nozzle wall. The thickness and choice of refractory metal can be varied to suit the operating environment of the nozzle. The flange angle 24 may be varied with each successive ring to form the desired contour of the nozzle surface. As in this case, a convergent-divergent configuration is attained. The length of the flange section will depend upon the relative formability of the material and the pressure distribution desired in each coolant space between the washers. Variable spacing and flange length is shown on the drawings to illustrate this feature.

Located coaxially adjacent to and between the annular flanged discs, and extending radially inward to the flanges, are porous spacer rings 26. These porous spacer rings 26 form the medium through which flows the coolant material. Depending upon operating conditions the porous spacer rings may be made from a high temperature porous ceramic, porous graphite, or a refractory metal honeycomb. The outside diameter and relative porosity of these spacers may be varied to help control the coolant flow and distribution. In addition, a secondary, reserve type of coolant may be incorporated in the porous spacers and be released by the heat of operation near the end of the firing time. The primary function of the spacer 26 then is to maintain the axial position of the refractory washers, support pressure loads, and aid coolant distribution.

Since the flange portions 22 of the annular discs 20 are less extensive in the direction axially of the nozzle than the width of the porous spacer rings 26, small circumferential passages 28 are formed through which flows the coolant from the porous spacer rings 26 out onto the throat surface 14. As a result, the circumferential slots 28 are formed thereby affording the throat surface with a good distribution of coolant. The width and configuration of these slots may be varied to aid coolant flow control and pressure distribution in the coolant chamber. As is seen in FIGURE 2, the width of the porous spacer rings may be varied thereby permitting a greater concentration of circumferential coolant openings where desired.

As is shown in FIGURE 2, an inlet manifold 32 is provided for the coolant. This inlet manifold 32 leads into tapered manifold chambers 34. The number of inlet manifolds 32 and chambers 34 may be selected to suit the amount of coolant required as determined by the operating temperature and time. The manifold chambers 34 taper toward the exit of the nozzle to aid control of coolant flow by pressure drop. Some of the refractory metal annular discs 20 could extend out farther into chambers 34 to form various size orifices to further control coolant flow if desired.

In operation, the primary coolant, which would be a suitable gas or liquid, will flow through the inlet manifolds 32 into the manifold chambers 34, from which it will effuse through the porous spacer rings 26 towards the throat surface 14. When it reaches the flange portion 22 it will pass through the openings 28 and flow out onto the nozzle throat surface 14. This, then is a novel way to provide transpiration coolant to a rocket nozzle throat surface.

This invention embodies many advantages over previous configurations. The relatively large percentage of light-weight porous material in the nozzle will result in a very light-weight nozzle. The invention uses forms of refractory metal which are readily available. The relatively weak and thermally shock sensitive porous divider material is divided into less shock sensitive sizes and cracking of the spacer material would be of little consequence. The flexibility of the design will enable the nozzle to use coolant effectively by adjusting the flow to suit requirements. The thin refractory metal flange will facilitate heat transfer. The division of the liner into small segments will aid thermal expansion problems. The porosity of the spacers can be varied at will to control the coolant flow. Quality control and fabrication will be good because each component can be inspected individually prior to assembly. The thickness of the refractory metal can be varied from disc to disc to compensate for erosion and thereby produce a minimum weight design. And finally, the nozzle is inherently rugged and will function as a heat sink after exhaustion of coolant for added firing time.

While the invention has been illustrated for use in connection with a rocket motor casing, it will be clear that it would have use in any installation other than those illustrated, and that many modifications and changes may be made thereto without departing from the scope of the invention.

I claim:

1. A nozzle, cooled by a transpiration-type cooling means, for high temperature gases comprising, in combination, a coaxial stack of a plurality of annular discs each having a flange portion on its inside margin, said flange forming a segment of the throat surface of the nozzle, and porous spacer rings located coaxial with, adjacent to, and between said annular flanged discs and extending radially inward to said flanges, said porous spacer rings forming the medium through which the coolant material flows.

2. A nozzle as described in claim 1 with said flange portion slightly less extensive in the direction axially of the nozzle than the width of the porous spacer rings thereby forming a narrow coolant passage around the circumference of the throat through which the coolant flows from said porous spacer rings out onto the throat surface.

3. A nozzle as described in claim 1 with said flange portions of the annular rings having a varying flange angle with their parent annular rings thus enabling the formation of any desired contour for the throat portion of the nozzle.

4. A nozzle as described in claim 1 in which the intensity of the transpiration cooling at various locations along the nozzle surface can be controlled by varying the width of the porous spacer rings thereby regulating the distance between the annular flanged rings and the concentration of circumferential coolant passages.

References Cited in the file of this patent

UNITED STATES PATENTS

3,026,806	Runton et al.	Mar. 27, 1962
3,048,972	Barlow	Aug. 14, 1962
3,069,847	Vest	Dec. 25, 1962
3,103,885	McLauchlan	Sept. 17, 1963