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COOLED ROCKET NOZZLE

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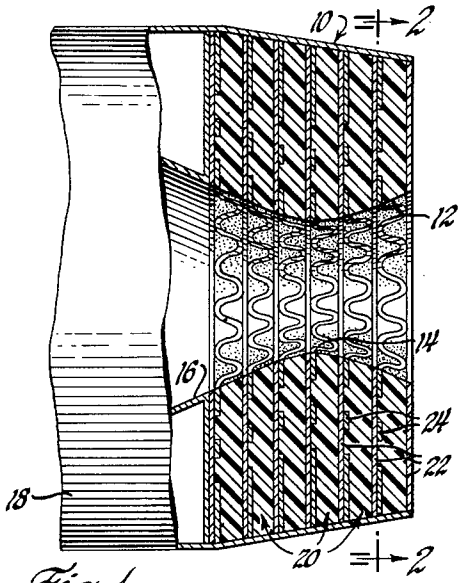


Fig. 1

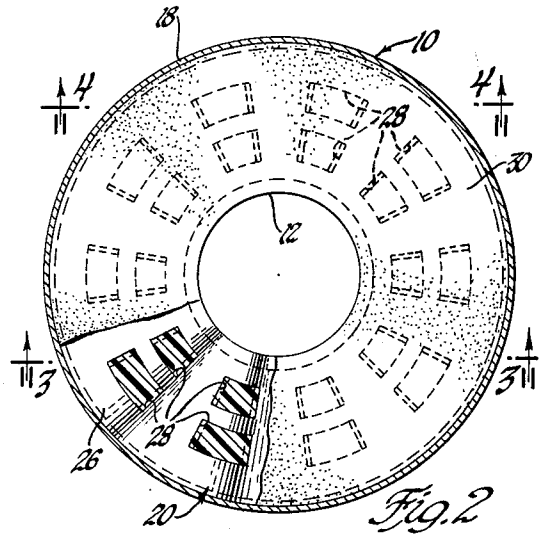


Fig. 2

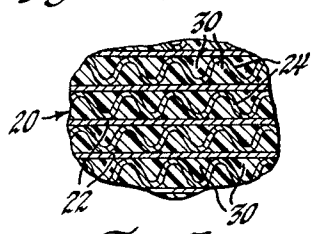


Fig. 3

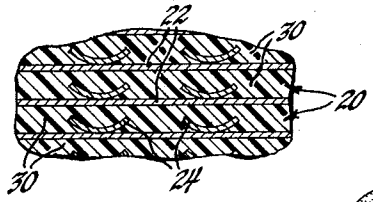


Fig. 4

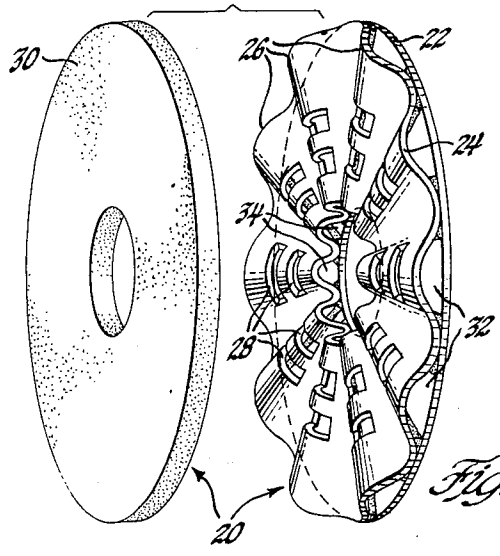


Fig. 5

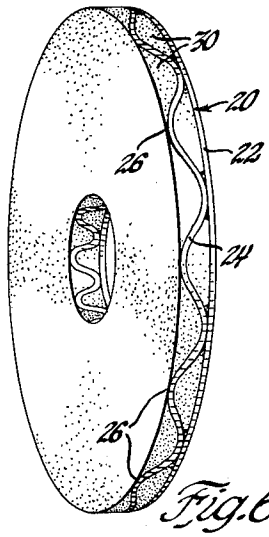


Fig. 6

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COOLED ROCKET NOZZLE

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This invention relates to a rocket nozzle construction and more particularly to a nozzle construction having a self-contained coolant.

Rocket nozzles frequently operate at temperatures considerably higher than the melting temperatures of the materials 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. Prior nozzle constructions utilizing coolants have generally been of the liquid coolant type requiring separate tanks for the coolant as well as control systems and additional hardware for injecting the coolant into the nozzle.

This invention eliminates the objections to prior cooled nozzles by providing a nozzle containing a solid cooling medium released by the heat of operation of the nozzle to flow out onto the nozzle surfaces to cool them.

More particularly, this invention relates to a cooled porous nozzle of the convergent-divergent type having a throat insert consisting of axially stacked units of annular refractory metal discs separated by corrugated annular refractory metal discs, all spaces between which are impregnated with a solid coolant, the coolant being fusible at temperatures lower than the normal nozzle operating temperatures to flow out onto the nozzle throat surface to insulate it against the exhaust gases passing through the nozzle.

It is an object of this invention to provide a cooled nozzle construction wherein the coolant forms an integral part of the nozzle construction and cools it automatically without the use of additional hardware or control mechanisms.

It is still a further object of this invention to provide a coolant fluid exhaust nozzle construction that is economical to manufacture due to the use of readily available refractory and material forms, one that is simple in construction and highly reliable, and one providing excellent heat transfer to the coolant without the use of complicated control systems.

Another object of this invention is to provide a cooled nozzle construction comprising a plurality of stacked thin annular sections enabling an easier replacement of parts and easy and highly accurate control of the porosity of the construction.

Other objects, features and advantages of the invention will be readily apparent upon reference to the succeeding detailed description of the invention and to the drawings illustrating the preferred embodiment thereof; wherein,

FIGURE 1 is a side elevational view in cross section showing the stacked units;

FIGURE 2 is a sectional view taken in the direction of arrows 2—2 in FIGURE 1;

FIGURE 3 is a partial sectional view taken in the direction of arrows 3—3 in FIGURE 2;

FIGURE 4 is a partial sectional view taken in the direction of arrows 4—4 in FIGURE 2;

FIGURE 5 is a view of an individual stacking unit before it is impregnated with the solid coolant; and

FIGURE 6 is a final complete view of an individual stacking unit including the solid coolant.

In general, the invention relates to a convergent-divergent nozzle construction having a throat portion made up of a number of axially stacked thin disc-like sections each containing a solid coolant. Each unit preferably consists of a flat annular disc of refractory material, such as tungsten, joined coaxially with a corrugated annular disc of refractory material, all spaces between which are impregnated under heat and pressure with a solid coolant. An interlocking of the units results from the flow of the coolant through apertures which are cut in the raised portions of the corrugations.

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

The nozzle is assembled by stacking the thin annular ring units **20**. Each individual stacking unit, as shown in FIGURES 5 and 6, comprises a flat annular disc of tungsten **22** to which is joined a corrugated annular disc of tungsten **24**. These discs are joined coaxially so that their center openings are aligned. Through the raised portions **26** of said corrugations **24** are cut apertures **28**. These apertures **28** allow the flow of the solid coolant **30** under heat and pressure to all open spaces **32** in the structure. The apertures **28** also perform an interlocking feature which results in the coolant being part of the final unit structure, as is shown in FIGURE 6.

The solid coolant **30** may be of material such as lithium or any well known synthetic polymeric amide, of which Nylon is an example. The coolant medium **30** is released as a vapor in a manner to be described to flow out onto the throat wall of the nozzle to cool it. Nylon is an excellent coolant since it degrades to a low molecular weight gas at a temperature, 2000° F. for example, below that at which an uncooled nozzle normally operates, which is approximately 6500° F.

In operation, the exhaust gases pass through the nozzle and are expanded out the exit portion **12**. In doing so, the heat is initially transferred through the flat annular discs **22** and the corrugated annular discs **24** to heat the coolant **30** in spaces **32**. Subsequently, as the throat becomes hotter, and using Nylon as an example, the Nylon degrades to a gas. Since the spaces **32** are effectively closed by being sealed at one end and having metered openings at the other ends, the expanding gas causes instantaneous pressure build up to occur in the spaces **32**. As a result, the coolant will boil out of the spaces **32** through the metered openings **34** onto the throat surface **14** to provide a thin layer of coolant between the exhaust gases and the nozzle wall.

It will be clear, of course, that the axial thickness of each section, as determined by the width of each corrugation, will be so chosen that the volume of coolant initially provided will upon vaporization produce a pressure great enough to overcome the exhaust pressure at that point in the throat opposite the section. The pressure differential, therefore, permits the coolant to boil out onto the throat surfaces and be carried aft by the exhaust stream.

As is seen in FIGURES 3 and 4, the corrugated portions **24** decrease in width from the outer periphery to the inner throat surface **14**, thus providing cone-like solid coolant holding compartments.

From the foregoing, it will be seen that this invention provides a nozzle construction containing a coolant in its solid state vaporized by the heat of operation of the nozzle to cool the nozzle. It will also be seen that the cooling system of this invention is highly reliable and eliminates the use of control systems, outside storage

tanks, and other additional hardware common to liquid cooled nozzle constructions. It will also be seen that the nozzle construction of this invention utilizes readily available refractory and material forms, such as tungsten, and affords an opportunity to vary coolant percentage loading to suit heat flux requirements by varying the depth of the corrugations. Finally, it will be seen that this construction provides a very light weight and economical design having an easily controlled porosity.

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 installations other than those illustrated and that many modifications and changes may be made thereto without departing from the scope of the invention.

What is claimed is:

1. A cooled nozzle for high temperature gases comprising, in combination, a plurality of coaxially stacked annular disc units, each unit comprising two coaxial annular discs, at least one disc being corrugated, spaces being defined in the units, and a body of solid coolant filling the said spaces and overlying one of the discs, the said overlaid disc having openings therein containing said solid coolant so as to interlock the coolant with said overlaid disc, and means retaining said discs in abutting relation with coolant overlying said one disc of one unit abutting and substantially conforming to the surface of the next adjacent disc unit.

2. A cooled nozzle for high temperature gases comprising, in combination, a plurality of coaxially stacked annular disc units, each unit comprising two coaxial discs, at least one disc being corrugated, spaces being defined between the discs, and a body of solid coolant filling the said spaces and overlying one of the discs, and means retaining said discs in abutting relation with coolant overlying said one disc of one unit abutting and substantially conforming to the surface of the next adjacent unit.

3. A cooled nozzle for high temperature gases comprising, in combination, a plurality of coaxially stacked annular disc units, each unit comprising two coaxial annular discs, at least one disc being corrugated, spaces being defined between the discs and a body of solid coolant filling the said spaces and overlying one of the discs, the said overlaid disc having openings therein containing said solid coolant so as to interlock the coolant with said overlaid disc.

4. A cooled nozzle for high temperature gases as described in claim 1 in which the said coaxial annular discs are made from a refractory material such as tungsten.

5. A cooled nozzle for high temperature gases as described in claim 1 in which the said solid coolant material is a synthetic polymeric amide such as Nylon.

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