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LIAN-TONG WEN
HYPERSONIC COOLING DEVICE

3,129,667

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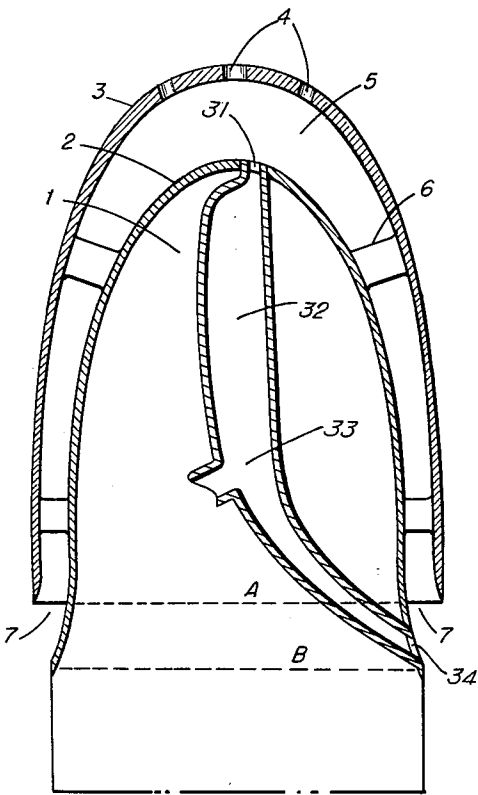


FIG. 1

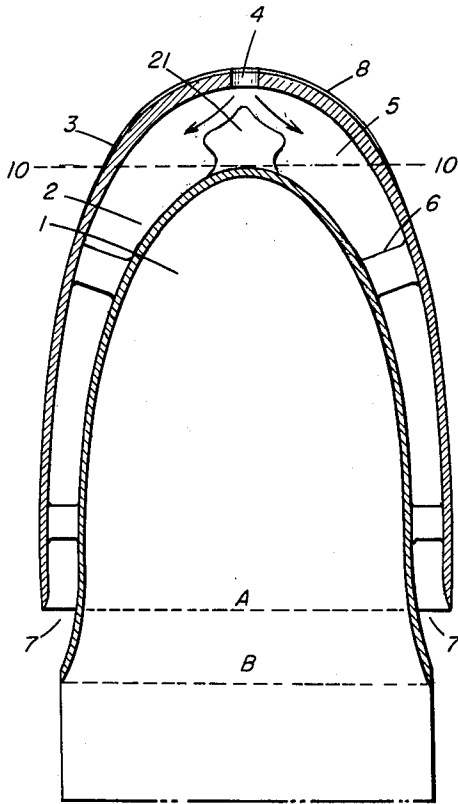


FIG. 2

1

2

3,129,667

HYPERSONIC COOLING DEVICE

Lian-Tong Wen, 601 W. 112th St., New York 25, N.Y.

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2 Claims. (Cl. 102-92.5)

The present invention relates to a cooling device for air vehicles and, more particularly, for hypersonic air vehicles such as missiles, aircraft and space vehicles.

The invention provides for a novel air cooling device, for the nose or leading portions of air vehicles, having no moving parts and affording fully automatic refrigeration with instantaneous reaction. The device is simple to construct and operate, lightweight and economical to manufacture.

The air cooling device is particularly effective for cooling the nose cones of missiles and the leading edges of hypersonic aircraft that attain high temperatures during flight.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction, combinations of elements, and arrangement of parts, which will be exemplified in the constructions hereinafter set forth, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a cross sectional view of a nose cone of a missile illustrating the cooling device; and

FIG. 2 is a cross sectional view of a nose cone of a missile illustrating a modification of the cooling device.

Referring to the drawings in which like numerals identify similar parts throughout, FIG. 1 illustrates a preferred embodiment of the cooling device. Missile 1 has a leading portion or nose cone 2 having a rearwardly extending outer surface. An outer shell or outer cone 3 has a rearwardly extending inner surface extending over said nose cone 2 substantially conforming to the contour of nose cone 2. The inner surface area of outer shell 3 is larger than the outer surface area of nose cone 2. There are attachment means 6 which may be suitable mechanical attachment means that fix or connect shell 3 to nose cone 2 and spatially separate the outer surface of nose cone 2 from the inner surface of shell 3 to provide a rearwardly extending channel or conduit 5 between the shell and nose cone that opens or exhausts to the atmosphere at port 7 positioned rearwardly of nose cone 2. Positioned in the leading or forward portion of shell 3 are a plurality of orifices 4, communicating air in front of the shell with a forward portion of said conduit. The orifices which are adapted to permit flow of air from the outer surface of the forward portion of the shell to the conduit are of small cross sectional area relative to the cross sectional area of the forward portion of conduit 5 at the forward portion of shell 3 and nose cone 2. There may also be at least one such orifice 4 positioned in the forward portion of shell 3, instead of a plurality of such orifices as illustrated in FIG. 1.

Dashed line A represents the diameter of outer shell 3 and dashed line B represents the diameter of nose cone 2. When A, the diameter of outer shell 3, is larger than B, the diameter of nose cone 2, more efficient expansion of air and speed of exhaust may be attained.

FIG. 2 illustrates a modification of the cooling device illustrated in FIG. 1 and has a single orifice 4. The arrows indicate the direction of flow of ram air. In combination with the device illustrated in FIG. 2 there is a generally conical deflector 21 attached to the forward portion of nose cone 2 and positioned in the forward portion of con-

duit 5. Deflector 21 is disposed with its apex positioned toward the outer shell 3 in the forward portion of the conduit. The deflector 21 may also be attached by suitable mechanical means to the forward portion of the inner surface of outer shell 3.

The efficiency of the cooling device may be further improved by increasing the rate of heat radiation of the heated compressed ram air by providing, in combination with the shell and nose cone, a heat radiating material or glow booster 8 on the forward portion of shell 3 that becomes highly incandescent when heated by the in-rushing compressed ram air and that radiates heat away from the shell to cool such portion. The heat radiating material may also be affixed to the forward portion of the nose cone. The heat radiating material or glow booster 8 may be made of material that becomes incandescent and highly reflective when heated, as for example, zirconia (ZrO_2), zircon ($ZrSiO_4$), thoria (ThO_2), lime (CaO), and the like. It is preferred that one or more of these substances be included in substantial amount to take advantage of their high radiation by incandescence at relatively low temperatures. The glow booster may be affixed to the outer surface of the forward portion of the shell by flame spraying, or by mechanical attachment or by any other suitable means. The shell or the nose cone, or both, may incorporate a substantial amount of such heat radiating material or even be constructed principally thereof.

The materials used in the construction of the cooling device may be the conventional heat resistant materials such as metal, ceramics, and the like that are employed in high speed air vehicles, missiles and the like.

The term "forward portion" of the conduit or channel as used herein means that portion of the conduit or channel that is intersected by a plane perpendicular to the central axis of the nose immediately forward of the point of the nose, the central axis being that longitudinal axis normal to the surface at the point of the nose or leading edge. The forward portion and the plane describing it are indicated at 10-10 in FIG. 2.

From the foregoing description it will be obvious to one skilled in the art that the cooling device may be adapted for the leading edges of wings and the like parts of aircraft and space vehicles. The orifice may also be in the form of a slot or a series of slots.

In practice the cooling device operates in the following manner. When missile 1 or a wing section constructed to utilize my invention rams through the air at hypersonic speed, air at the nose of the missile or wing is compressed and heat is developed. Some of the heat transfers to the forward portion of outer shell 3 and some of the heat radiates into the atmosphere in the form of light. This dissipates some of the heat that developed from compression of air. A portion of the hot compressed ram air enters orifice 4 which is of relatively small cross sectional area in relation to the cross sectional area of the forward portion of conduit 5. Upon entering the larger area of the forward portion of conduit 5 the heated compressed ram air expands and is thereby cooled. As the cooler expanded air passes rearwardly through conduit 5 and exhausts into the atmosphere at port 7 it absorbs heat from the outer surface of nose cone 2 and from the inner surface of outer shell 3, so that those surfaces heated by the compressed ram air are cooled, and the temperature of those surfaces is sufficiently reduced to avoid a critical harmful temperature. Thus, a means of avoiding destructive oxidation or burning of the nose cone is presented.

The rate and extent of cooling is dependent on the pressure differential between the forward portion of conduit 5 and the ram air on the exterior of the leading portion or nose of the shell 3 which in turn is dependent on the ratio of the cross sectional area of the forward portion of the conduit to the cross sectional area of the orifice or

orifices. It is preferred that this ratio be at least 15:1. Effective cooling may also be enhanced by deflecting the cooled expanded air against the outer shell as shown in FIG. 2.

To facilitate exhaust without unduly affecting ballistic properties it is preferred that the cross sectional area of the conduit at the point of exhaust be less than the cross sectional area of the forward portion of the conduit but that the cross sectional area at the point of exhaust be not less than about 10 times the cross sectional area of the orifice or orifices.

The cooling device is continuous in its action and starts automatically as the outer shell and nose cone begin to generate heat due to compression of air and the capacity of the device increases as the temperature rises from increased pressures. The instantaneous reaction of the cooling device to pressure changes makes it especially suitable for hypersonic air vehicles. Furthermore, no moving parts or complicated structure are necessary.

The modification of the cooling device illustrated in FIG. 2 operates in substantially the same manner as the device illustrated in FIG. 1. The employment of a highly reflective heat radiating material or glow booster on the outer surface of the forward portion of the outer shell radiates away some of the heat from the outer surface and further improves the cooling results. When the missile rams through the air at hypersonic speed and compressed air develops heat at the forward portion of the shell the intensity of glow from the highly reflective and incandescent heat radiating material increases and some of the heat is radiated away from the outer surface of the outer shell. The employment of the heat radiating material or glow booster in combination with the cooling device of the present invention achieves cooling of the heated nose or leading portion by radiation and by heat transfer and absorption.

The employment of the deflector in combination with the nose cone and outer shell deflects the cooled expanded air against outer shell 3 and deflects in-rushing heated compressed ram air away from the forward portion of nose 2 and such portion is maintained at a cooler temperature than when the path of heated compressed air hits it directly.

FIGURE 1 also shows another embodiment of the principle of my invention. In this embodiment the nose or leading portion of an air vehicle having a rearwardly extending outer surface may have an orifice 31 or orifices positioned in its forward extremity communicating air in front of the nose or leading portion with a rearwardly extending conduit 32 positioned in the interior of the nose or leading portion of the vehicle. The conduit has at least one exhaust opening 33 communicating with interior portions of the vehicle and with the atmosphere at 34 rearwardly of the leading portion. In this embodiment, the air is expanded in the conduit, and the cooled air passes through a conduit or conduits and serves to cool the interior portions, mechanisms and the like, of the vehicle.

It will thus be seen that the objects set forth above among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the features of the invention herein described, and all statements of the scope of the invention which might be said to fall therein.

This application is a continuation-in-part of application Serial No. 774,275, filed November 17, 1958, now abandoned.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. An air cooling device for the interior portion of an air vehicle which comprises in combination, a leading portion having a rearwardly extending outer surface, a rearwardly extending conduit positioned in the interior of said leading portion, said leading portion having at least one orifice positioned in the forward extremity of said leading portion communicating air in front of the leading portion to said conduit, said conduit having an exhaust opening communicating with the interior portion of the air vehicle and with the atmosphere rearwardly of said leading portion.

2. An air cooling device for the interior portion of an air vehicle which comprises in combination a leading portion having a rearwardly extending outer surface, a heat radiating material affixed to the outer surface of the leading portion, said heat radiating material comprising materials selected from the group consisting of zirconia, zircon, thoria and lime, a rearwardly extending conduit positioned in the interior of said leading portion, at least one orifice positioned in the forward extremity of said leading portion communicating air in front of the leading portion to said conduit, said conduit communicating with the interior portion of the air vehicle and being open to the atmosphere at a point of exhaust rearward of the leading portion.

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