Sept. 17, 1963 J. C. McLAUCHLAN 3,103,885

SWEAT COOLED ARTICLES

Filed Aug. 31, 1959

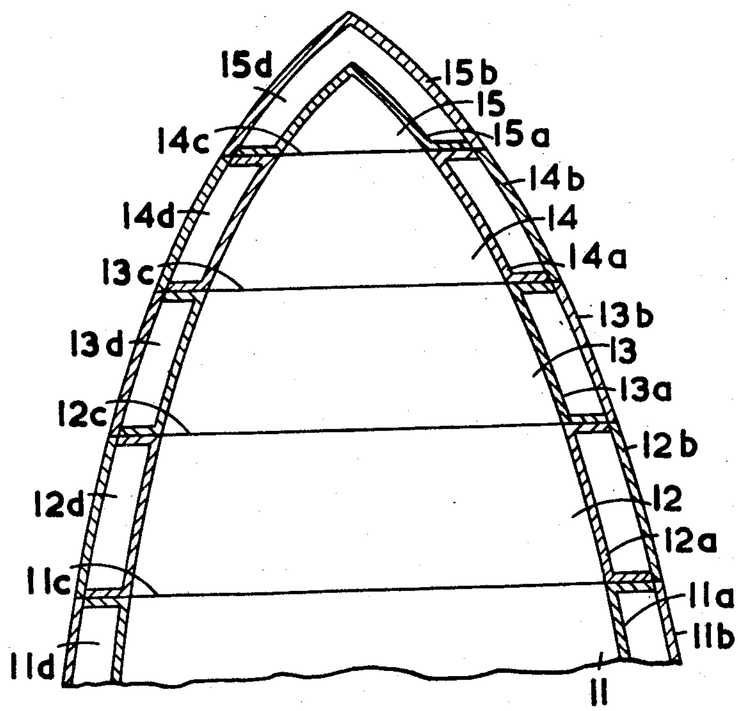

FIG. 1

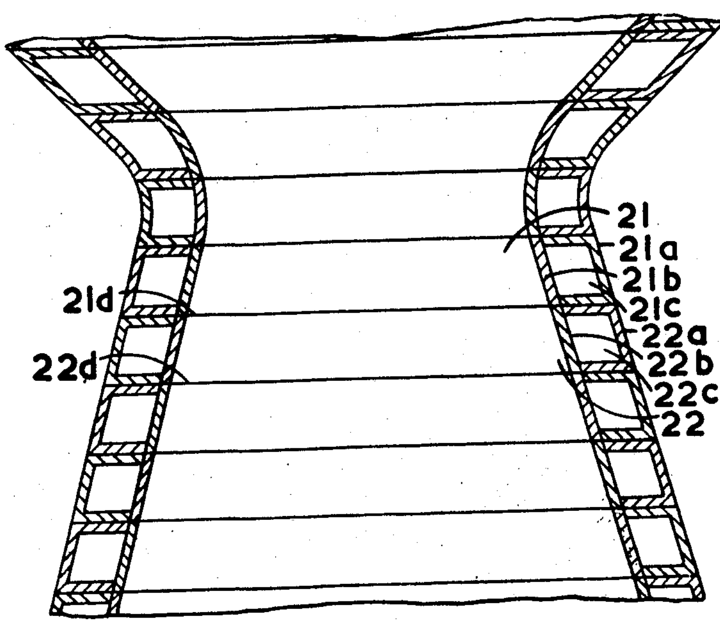

FIG. 2

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United States Patent Office

3,103,885
Patented Sept. 17, 1963

3,103,885

SWEAT COOLED ARTICLES

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Filed Aug. 31, 1959, Ser. No. 837,277
2 Claims. (Cl. 102—49)

This invention relates to sweat cooled articles.

In the sweat cooling process which is also known as diffusion or transpiration cooling a cooling fluid is forced under pressure through a porous wall or member which is exposed to heat and the fluid protects the wall by absorbing heat from it and by so affecting the boundary layer as to reduce the heat flux that would otherwise reach the wall. A pump or other pressurising device is required to pressurise the fluid and some means of flow regulation must be provided if the rate of cooling is to be controlled. In general the use of a liquid as coolant in such a way that it does not vaporise before leaving the wall leads to overcooling and the use of a liquid which vaporises during its passage through the wall leads to instability and makes the control of the pressurising device even more difficult. The use of a gas as a coolant requires not only the provision of special pressure control devices but also of high pressure containers.

The present invention is concerned with the provision of sweat cooled articles in which the coolant is self pressurising and the rate of cooling varies with existing heating conditions.

A sweat cooled article according to the invention comprises a wall, part at least of which is porous, the wall enclosing a chamber or space for containing volatile cooling liquid which vaporises when the wall is heated, the vapour forcing itself through the porous portion under its own pressure to act as a coolant and protect the wall.

The rate of coolant flow will vary with the amount of heat present, a high rate of heating increasing the rate of vaporisation and hence the rate of flow of cooling vapour through the porous portion.

For storage of the cooling liquid the porous portion may be sealed for example with a wax or resin to prevent the leakage thereof, the wax or resin being melted and burnt upon the application of heat.

The cooling liquid may comprise a mixture of several liquids having different volatility, the more volatile liquids vaporising at first to provide cooling and as heat conditions become more severe the less volatile liquids in turn vaporise to effect protection at a higher wall temperature.

For example, ether, ethyl alcohol, methyl alcohol and water may be used as coolants.

Two preferred arrangements in accordance with the invention are illustrated by the accompanying diagrammatic drawings which are sectional elevations of which:

FIGURE 1 illustrates a sweat cooled article in this case the nose portion of a rocket, and

FIGURE 2 illustrates a part of a jet reaction rocket motor combustion chamber.

Referring first to FIGURE 1, the wall of the rocket comprises separate sections of which four hollow annular sections are shown at **11**, **12**, **13** and **14**, and a nose section at **15**. Each of the annular sections **11–14** comprises an annular channel section liquid impermeable inner portion **11*a*–14*a*** and an outer skin portion **11*b*–14*b***, respectively, of porous material. Similarly, the nose section **15** has a liquid impermeable inner portion **15*a*** and a porous outer skin portion **15*b***. The adjacent separate sections are formed by dividing the coolant space into axially separate annular zones. Separate chambers **11*d*–15*d***, are thus formed in the separate sections **11–15**, respectively.

In operation a volatile cooling liquid is contained in each of the chambers **11*d*–15*d***, the porous portions **11*b*–15*b*** being sealed with a wax which is melted as a result of aerodynamic heating due to the rocket's high velocity through the atmosphere and the liquid vaporises, the vapor forcing itself through the porous outer skin portions **11*b*–15*b*** under its own pressure to act as a coolant.

Referring now to FIGURE 2, the throat section shown of a venturi form rocket motor combustion chamber is formed by a number of hollow annular members as at **21**, **22**. Each member comprises a channel section liquid impermeable outer portion as at **21*a***, **22*a***, and a porous inner skin portion **21*b***, **22*b*** which enclose a corresponding annular chamber **21*c***, **22*c*** respectively. The adjacent separate sections are formed by dividing the coolant space into axially separate annular zones. The inner skin portions are sealed with wax and a volatile liquid is contained within each chamber **21*c***, **22*c***.

In operation the heat of the gas in the combustion chamber melts the wax and the liquid in the chambers **21*c***, **22*c***, vaporises, the vapor forcing itself through the porous inner portions under its own pressure to act as a coolant.

The pressure and temperature within a rocket motor combustion chamber varies axially of the chamber and it is for the reason that the separate coolant chambers are provided to prevent overcooling of a low pressure zone. Also the porosity of the various inner skin portions may be varied, those in a high pressure and or high temperature zone being made more porous than those in a low pressure and or low temperature zone to provide the desirable variable rate of cooling.

The invention is of particular use in jet reaction rocket motors in which the severity of the heating conditions necessitate cooling of part at least of the motor wall. For example, where it is required to cool the wall of the combustion chamber the combustion chamber is made with double walls of which part at least of the inner wall is porous and cooling liquid is retained in the hollow space between the walls, the porous wall being sealed for storage of the cooling liquid by the application of a wax or resin which is burnt off when combustion takes place. The advantage of this arrangement is that the cooling liquid may be selected on its suitability as a coolant instead of using one of the motor propellants as coolant which may not be so satisfactory.

The pressure within a rocket motor varies according to the axial position and the coolant would tend to emerge at a low pressure region which would result in overcooling of that region and under cooling of other high pressure regions. It is therefore proposed to divide the coolant space between the combustion chamber walls into axially separate annular zones each of which supplies cooling liquid for a corresponding region of the combustion chamber. Also the degree of porosity of the inner wall may be varied the wall being more porous in a high pressure and/or higher temperature zone and less porous in a low pressure and/or low temperature zone.

The invention is also of use for cooling a missile against heat generated at re-entry into the more dense regions of the atmosphere. In this case that part of the missile to be cooled is formed with a double wall, the outer wall being porous and cooling liquid is retained in the space between the walls until heating takes place when the liquid vaporises and passes out through the porous wall acting as a coolant and protective agent.

In articles according to the invention the rate of cooling is self regulating in that decrease in vapour flow results in a greater heating of the porous wall which in turn results in more rapid vaporisation and/or vaporisation of the less volatile cooling liquids and hence an increased rate of cooling and a greater measure of protection; and conversely, an excess of vapour flow will result in a reduced heating of the porous wall and hence a reduced rate of vaporisation. An equilibrium state is thus provided and any departures from that state are self-correcting.

I claim:

1. A jet reaction motor having a combustion chamber comprising a jacketed wall enclosing a combustion space and defining a gas ejection orifice, said wall consisting of closed cooling compartments divided into axially disposed separate annular zones having a porous wall adjacent the heat zone, said porous wall sealed with a material of low melting point, the porous wall adjacent the heat zones of higher temperatures having greater porosity for an increased cooling at those points, a vaporizable cooling medium sealed within each zone by the closed porous wall to form separate self-sufficient individual cooling units in each zone, said cooling medium being a mixture of several liquids of different volatility with the more volatile liquids vaporizing at lower wall temperatures for cooling and the less volatile liquids vaporizing for protection at higher wall temperatures, the coolant mixture of each zone vaporized by the heat at the corresponding porous wall of that zone to melt the storage seal and each zone exuding the vaporized coolant from its respective cooling mixture by its own vapor pressure through its porous wall at a rate individually governed by the heat and the porosity of that particular wall to provide a separate and self-regulated cooling equilibrium for each zone.

2. In a missile comprising a jet reaction motor and a nose cone, a jacketed wall for cooling both the motor and cone, said wall consisting of closed cooling compartments divided into axially disposed separate annular zones, said separate annular zones having a porous wall

adjacent to the heat zone interiorly for the motor and exteriorly for the nose cone, said porous wall sealed with a material of low melting point, the porous walls adjacent the heat zones of higher temperatures having a greater porosity for an increased rate of cooling at those points, a vaporizable cooling medium sealed within each zone by the closed porous wall to form separate self-sufficient individual cooling units in each zone, said cooling medium being a mixture of several liquids of different volatility with the more volatile liquids vaporizing at lower wall temperatures for cooling and the less volatile liquids vaporizing for protection at higher wall temperatures, the coolant mixture of each zone vaporized by the heat at the corresponding porous wall of that zone to melt the storage seal and each zone exuding the vaporized coolant from its respective cooling unit by its own vapor pressure through its porous wall at a rate individually governed by the heat and the porosity of that particular wall, to provide a separate and self-regulated cooling equilibrium for each zone whereby the motor on ascent and the nose cone on reentry are sufficiently cooled.

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