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A SUPERFLUID PLUG FOR SPACE*

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INTRODUCTION

This experiment is concerned with the problem of containing liquid helium in space. On earth, one maintains cryogenic equipment at 4°K by immersing it in liquid helium and utilizing the latent heat of the liquid to dissipate any heat input. Gravitational phase separation allows the boil-off gas to be withdrawn at the top of the dewar. Two major problems arise in a zero-g environment. First, we no longer may have an open gas-evacuation line because liquid will also be withdrawn. Second, there may not always be enough liquid in contact with the equipment to dissipate the entire heat input; consequently, the temperature of the system will rise.

In order to overcome these difficulties without spinning or using cumbersome electrostatic techniques, the use of a high thermal-conductivity porous plug is proposed which will operate in the superfluid regime. Liquid will flow through the plug in a controlled manner as discussed below. The exit channel will be evacuated in order to evaporate the liquid at its outer surface. With a plug of high thermal conductivity, the major portion of the heat needed to evaporate the liquid will be conducted from inside the chamber, while the high effective thermal conductivity of the superfluid film, which coats all inner surfaces, establishes thermal equilibrium throughout the dewar. Preliminary calculations suggest that this film will be several orders of magnitude thicker in space than on earth, thereby conducting ample amounts of liquid to the plug and providing adequate liquid contact with the equipment. (On earth, a wick must be used to provide the plug with enough fluid).

THEORY

Equations for describing superfluid flow through the plug may be derived from the equation of motion [1]

$$\frac{dv_s}{dt} = -\nabla G \tag{1}$$

or

$$\frac{dv_s}{dt} = S\nabla T - \frac{\nabla P}{\rho} + \frac{\rho_n}{2\rho}\nabla(v_n - v_s)^2 \tag{2}$$

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