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Flat Panel Vacuum Thermal Insulation

H. M. STRONG, F. P. BUNDY, AND H. P. BOVENKERK
General Electric Research Laboratory, Schenectady, New York

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Evacuated mats of glass fiber made up of fibers of proper size and orientation are capable of supporting a compressive mechanical loading of at least one atmosphere and yet maintain a thermal conductivity of less than 10 microcalories/cm°C sec. The use of such a glass fiber mat as a filler makes possible an evacuated flat-panel thermal insulation which is comparable to a Dewar flask in insulation efficiency. The rate of heat transfer through a Dewar flask wall was reduced several-fold at liquid nitrogen temperatures and below by adding a 2-cm-thick layer of orientated and evacuated glass fiber mat to the outer surface.

This investigation showed that in evacuated glass fiber mats, supporting external atmospheric loading, the fiber to fiber contact area is less than 10^{-4} the mat area, making the contact pressure about 15 000 kg/cm². The effective length of the thermal conduction paths along the fibers is about four times the mat thickness. The mean pore size for gas molecule motion in the mat was found to be about 54×10^{-4} cm and 2×10^{-4} cm for mean fiber sizes of 14×10^{-4} cm and 0.2×10^{-4} cm, respectively. The radiation mean free paths for the same fiber sizes were found to be 150×10^{-4} cm and 52×10^{-4} cm, respectively. The thermal diffusivity is about 10^{-4} cm²/sec, which is much smaller than any other insulating material.

I. INTRODUCTION

ONE of the most effective types of thermal insulation known is a wall space evacuated to less than micron pressure and having surfaces highly reflecto to thermal radiation. In the form of the familiar ar flask, this type of insulation has been in use for sixty years. However Dewar-type insulation is ted to cylindrical and spherical shaped vessels be- e of the necessity of supporting the atmospheric by the inner and outer walls without any mechanical ort in the evacuated space between. No insulation appeared in flat panel form that approaches the um type wall in insulation efficiency. Almost all of ther familiar insulations contain air, and regardless eir makeup have the conductivity of still air as lower limit of conductivity. Few of them reach lower limit and only the finest particle insulations as the silica aero-gel of Kistler[1] have conductivities valent to, or slightly lower than that of still air. lowest thermal conductivities can be reached only moval of air.

variation of the highly evacuated empty wall space he moderately evacuated wall space containing ly packed powders proposed by Smolukowski,[2] Langmuir,[3a] and Stanley[4] for cylindrical and spherical containers. While such a heat barrier is roughly equivalent to a Dewar-type wall, attempts to use powders to support flat evacuated walls[3,5,6] were not as successful because of the high thermal conductivity of the same powders when compacted by the atmospheric pressure load.

The possibility of discovering a supporting structure for flat evacuated walls that has great stress bearing capacity and exceedingly low thermal conductivity is very intriguing. The present report describes the authors' study of this and associated problems.

References of further interest in connection with this subject are text books on the kinetic theory of gases,[7,8] the early work of Smolukowski[9] and Knudsen[10] on the application of the kinetic theory of gases to explain

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