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G. Frommann and K. Keck

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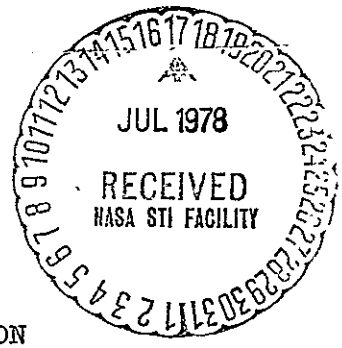

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16. Abstract

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A HELIUM ADSORPTION PUMP FOR TEMPERATURES BETWEEN 0.71 AND 1.2 K /258*

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The construction and method of working of a helium adsorption pump are described. The flux of helium-II film can be suppressed by an appropriate construction, which permits to reach temperatures down to 0.71 K. By total utilization of the pump's cross-section, temperatures from 1.2 K to 0.71 K remain constant for several hours with a precision of 10^{-3}K.

Introduction

One obtains He-bath temperatures of the maximum of 1.0 K using /259 vapor pressure reduction, and a He-bath using rotating vacuum pumps. At these temperatures and lower temperatures, the vaporization of the helium primarily no longer occurs at the liquid surface, but instead this occurs due to the presence of a He-film, which rises without friction to regions of higher temperature along the vessel walls of the cryostat.

This means that in this temperature range, substantially higher suction rates are required, which can be produced by adsorption pumps [1]. The active carbon used as the adsorption agent has the capability of the temperature of liquid helium, to adsorb a substantial amount of He-gas. Such a pump has been described by Eselson and Shvets [2]. Using a measurement chamber of 8 cm^2, and a temperature of 0.704 K, they were able to maintain it over a forty-minute interval. By using a small diaphragm, which was to prevent the propagation of the He-film, the suction performance of the adsorption carbon was substantially reduced.

In the following paper, we will describe an adsorption pump, in

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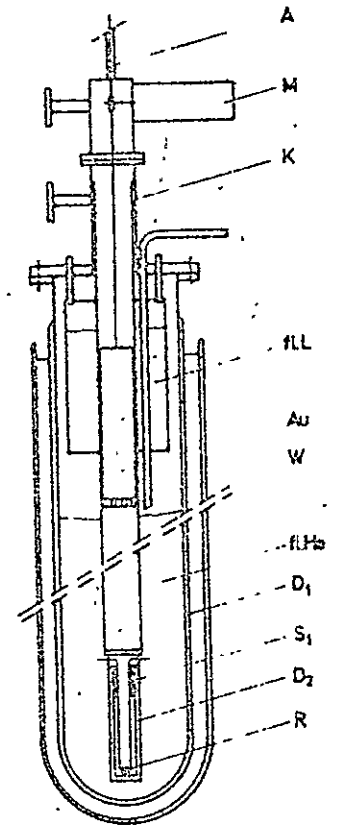


Figure 1: Cryostat. A- level indicator M- Motor K- stainless steel tube. Au- Lift W- Contact springs D_1- Helium Dewar D_2- Measurement Chamber S_1- tube enclosure R- measurement resistor.

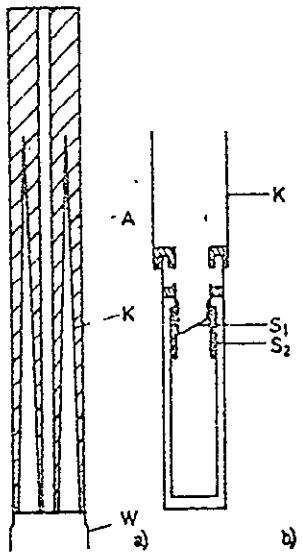
which the suction cross-section and therefore the adsorption capacity are completely avoided. This allows fast and convenient operation of the pump. Another advantage of this design is the fact that the temperature can be held constant within $\pm$ 2 x 10^{-3}K over several hours. Also, any temperature between 0.7 K and 1.2 K can be easily adjusted.

Cryostat, Design, and Operation

First we will describe the cryostat and the adsorption pump. (Figure 1). There is a pump in a thin-wall stainless steel tube K. The lower end of it is the measurement chamber D_2, in which the low temperature is to be created. The stainless steel tube (110 cm long, 3 cm inner diameter), is pre-cooled in a He-Dewar D_1 down to 1.2 K. At the upper edge of the tube K, there is an electrical motor M, which can move the vessel Au (called the lift in the following) with the

adsorption agent in the tube up and down. Molecular sieves (metal-alumino silicate) are used as adsorption agents.

The lift (Figure 2a) is inside a stainless steel tube 20 cm long, a cone K made of stainless steel mesh is soldered to the base of the tube, in order to obtain the maximum possible area for the 75 g of adsorption agent inside the lift. For better thermal contact with the tube K and for better control, there are bronze springs W on the lower



Figures 2a, 2b: 2a: Lift: A- adsorption medium K- cone made of wire mesh W- bronze springs

2b: Measurement chamber D_2: K- stainless steel tube, S_1- tube enclosure S_2- tear-off edge for helium film.

edge of the lift. The position of the lift above the measurement in the D_2 can be read off from a level indicator A (Figure 1).

The measurement chamber D_2 (Figure 2b) consists of a vessel which is isolated to the outside He-bath, with a content of 20 cm^3. In order to reduce heat transfer and avoid the He-film from leaving the measurement dewar, a tube enclosure S_1 with a tear-off edge S_2 has been installed. The He-film which is rising along the walls tears off at this point, and drops back into the He-bath in the form of drops.

The adsorption pump is operated as follows: the external He-bath in the dewar D_1 is brought to a temperature of 1.3 K and at the

same time a measured amount of He-gas is condensed in the measurement dewar D_2. After temperature equalization from the outer and inner He-bath, the lift, which has been pre-cooled with liquid air, is dropped /260 down to the upper edge of the dewar D_2 at a velocity of 2 mm/sec. There, the adsorption agent takes on the temperature of the external coolant because of the heat bridge W, and the adsorption process starts. The temperature in D_2 drops below 0.75 °K within five minutes (Figure 3).

When the adsorption agent is saturated with He-gas, or if the liquid He in D_2 is used up, then the lift is again raised into the temperature range of liquid air; there the He-gas is liberated and again condenses in the dewar D_2. After the very short regeneration of 10-15 minutes, the lift is lowered again and the adsorption process starts again. This cycle can be repeated until the external coolant in D_1 is consumed.

The temperature in D_2 was measured with a calibrated carbon resistor R. The low temperatures were calculated using a formula given by Quinnel [3]:

$$\ln R + \frac{K}{\ln R} = A + \frac{B}{T}$$

Here, T is the absolute temperature, R is the measured resistance, A, B, and K are constants. Using a germanium resistor calibrated with He^3, it was possible to control the temperature measurement. The deviations of both temperature measurements from one another was a maximum of only $\pm$ 3 x 10^{-3} K.

Measurement results

Figure 3 shows the time variation of the temperature in the measurement dewar D_2 and the lift with the adsorption agents directly above the dewar. The lowest achievable temperature of 0.71 K can be maintained to within 2 x 10^{-3} K over several hours. After 4.5 hours, the helium in the dewar D_2 is consumed for the geometric conditions used here, so that the regeneration process of the adsorption agent discussed above must be started. Of course, the time available for measurement at these temperatures depends on the heat which is introduced into the measurement dewar, by the supply lines. Of course, there is nothing against increasing the size of the measurement dewar.

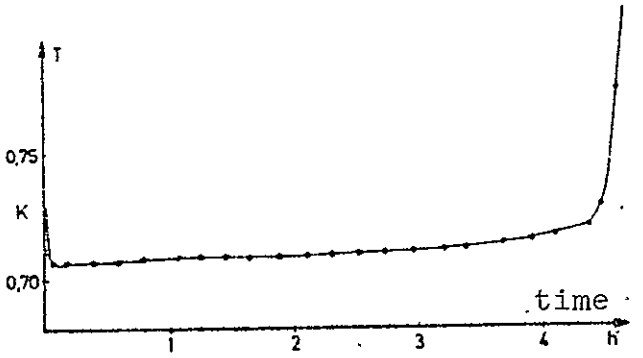


Figure 3: Time variation in the measurement chamber D_2

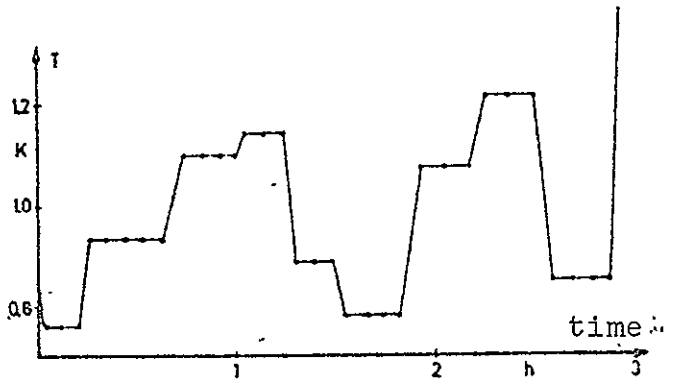


Figure 4: Temperature adjustment between 0.76 and 1.22 K.

The suction rate of the adsorption agent is reduced, if the lower end of the lift is a few cm above the measurement dewar. As Figure 4 shows, by changing the lift height above the measurement chamber, any temperature between 0.7 and 1.2 K can be adjusted, and can be maintained constant over a long period to within 1 x 10^{-3} K.

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