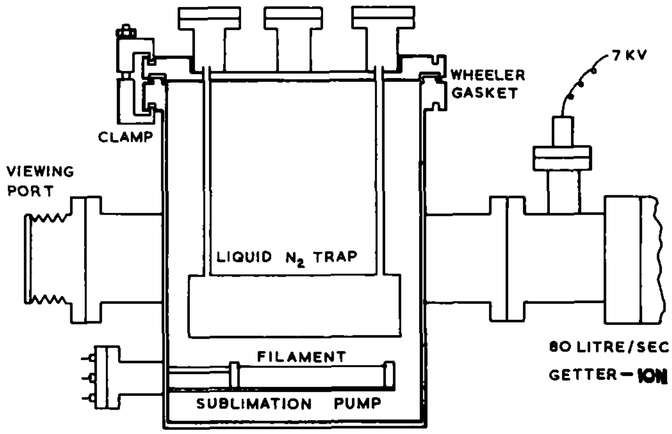
Short communications

Charge build-up in ice layers condensing on liquid nitrogen traps

When normal atmospheric air is admitted to a vacuum system containing a filled or part-filled liquid nitrogen trap then the condensed ice layer may contain a considerable charge. This phenomenon has been repeatedly observed when admitting air to the UHV system shown in the diagram. Sparks up to 2 cm long have been observed when the lid and trap assembly is lowered towards an earthed surface. To eliminate the risk of electric shock the lid is always earthed by a flexible lead; however, the discharge still occurs. Discharges through the thin ice film have been observed by rocking the trap on a perspex sheet, although arcs from the surface of the ice to an earthed plane through the air is the usual method of discharge. As many as four separate discharges over a space of 10 min have been observed. The mechanism of this charged layer is believed to arise from dissociation of some of the water molecules on condensation. Latham and Mason (1961)[1] have proposed a mechanism for the production of an electrostatic dipole in ice, as part of the mechanism accounting for the charge in thunderclouds. If a temperature gradient exists across a block of ice then there is a greater concentration of H^+ and OH^- at the warmer rather than the cooler end due to thermodynamic dissociation. The more mobile proton diffuses to the cooler end producing an electrostatic dipole. A temperature gradient $\Delta T(K)$ produces a voltage of $2\Delta T(mV)$. This mechanism has been verified by Latham (1963)[2] in experiments performed by asymmetrically rubbing one block of ice on another.

In this phenomenon temperature gradient across the ice film would account for less than ½V. However, if the rapid condensation of the water vapour results in a large degree of dissociation of the water molecule, then very much higher potentials could be achieved. The observations at present would tend to rule out a charging mechanism due to friction as the air flows through the inlet pipe, but it is difficult to be certain at this stage. In the production of thin films by vacuum condensation the maximum degree of disorder is created by rapid deposition on cold substrates. This is the situation here and if this disorder is taken up by the dissociation of about one in every 10^5 of the water molecules initially condensing then the subsequent proton diffusion could produce voltages in excess of 50 kV.



UHV System

It is important for users of vacuum equipment containing liquid nitrogen traps to note that the liquid must be allowed to boil off before admitting atmospheric air. Otherwise one runs the risk of electric shock. Also in some systems there may be a fire risk if volatile inflammable vapours happen to be present.

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References

[1] J Latham and B J Mason, *Proc RS A*260, 1961, 537.
[2] J Latham, *Brit J Appl Phys*, **14**, 1963, 488-90.