COMMENTS ON THE PAPER OF PROFESSOR ARAKAWA ON THE GROWTH OF ICE CRYSTALS IN WATER

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The beautiful photographs obtained by Professor Arakawa show clearly how ice crystals develop from the liquid, and in particular how the dendrites start. I would like to suggest another reason why the growth is initially in the form of a disc and only subsequently in the form of dendrites. There are two different factors that can determine the shape of growing crystals; one is the surface energy of the crystal, and the other is the ease with which heat can flow from the water to allow it to freeze onto the crystal. The first process tends to make crystals equiaxed and dominates when the rate of growth is small, the second promotes dendritic growth and occurs when the rate of growth is large. It seems from the photographs of Arakawa that, in the initial stages of growth, a disc-shaped crystal forms because, while the crystal properties of ice dictate a planar form, they do not dictate any preferred directions in this plane. At this stage no difficulty is experienced in getting rid of the latent heat. In fact the disc may be thought of as rather similar to the tip of the dendrite subsequently formed. When the disc has grown to such a stage that its radius of curvature is large compared to a length determined by the rate of growth and the thermal conductivity of the melt, the heat flow term begins to dominate, and any small irregularities in the circular form of the disc tend to be enlarged as dendrites, despite the increased surface energy involved, because they stick out and can therefore dispose of the latent heat more easily. This would account for the "notched crystal." Finally, the dendrites in the direction in which growth is easiest grow faster than their neighbours to give the stellar shape.

This explanation differs from Arakawa's in that it does not depend on any internal stresses to account for the branching out of dendrites. His explanation is probably true in the case of the crystals whose branches had different crystallographic orientations from the mother needles, but it would seem to be unnecessary where, as in the case of the stellar crystals, no orientation difference is present.

THE INSTITUTE OF LOW TEMPERATURE SCIENCE HOKKAIDO UNIVERSITY, JAPAN

The Institute of Low Temperature Science of the Hokkaido University, Japan, was established in 1941 for the purpose of making researches on those natural phenomena which are caused by the winter cold experienced in Japan. It has six cold chambers for experimental work. These can be cooled as low as $-57°$ C., five of them having a floor area 4 m. $\times$ 4 m. The fifth, which is four times as large as the others, is equipped with a wind tunnel.

The Institute comprises six research sections. Four are physics sections and the other two are biological and medical. The total number of research workers is twenty-eight.

The members of the physics sections are occupied mainly with investigations on the physical properties of snow and ice. After having carried out general research for the last eight years on various properties of ice and snow such as the thermal, mechanical and electrical aspects, most of the staff is now studying the mechanical properties of deposited snow from a rheological point of view. Physical researches have also been conducted for the last several years on the sea ice field on the north-east coast of Hokkaido.

The eastern coast of Hokkaido is invaded by dense sea fog in spring and summer. Although this fog is not directly related to winter cold members of the Institute have been engaged for the last four summers in studying the problem of the influence of forests planted along the sea coast in preventing fog.

Members of the biological section have been engaged in studying how plant bodies freeze. They have taken a large number of freezing curves of food plants such as potato or turnip, and have found

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