

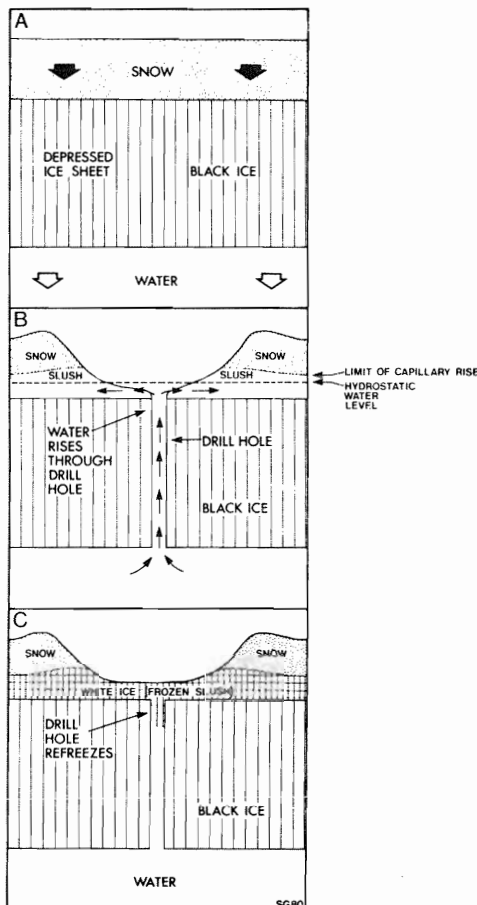
OBSERVATIONS ON THE USE OF A MECHANICAL DEVICE  
FOR MEASURING THE THICKNESS OF LAKE ICE

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The most common method of obtaining measurements of lake ice thickness in Canada and the United States involves drilling a hole in the ice sheet (see, for example, Canada 1969, Michel 1970). This is generally a fairly simple procedure but it has the great disadvantage, in regions where the ice sheet may be depressed below the hydrostatic water level by its snowcover, of artificially modifying ice growth by promoting slushing. This situation is illustrated in Figure 1.

Figure 1. Effect of drilling on a snow covered lake ice sheet.



The sequence shown envisages 1A, frozen lake water (black ice) depressed below the hydrostatic water level by an overlying snowcover; 1B, slushing of the disturbed snowcover in the vicinity of a drill hole; and 1C, a new layer of ice (frozen slush or white ice) on top of the original layer of ice. A sequence of events such as this might occur several times during a winter as the 'new' ice sheet in 1C becomes re-covered with snow and is subjected to further drilling.

It should be noted that the sequence portrayed in Figure 1 can, with the exception of the alteration of the snowcover which is necessary for the drilling operation, be viewed as being essentially the same as the natural sequence of events which occurs when cracks occur in a snow-loaded ice sheet (see, for example, Shaw 1965, Fig. 6). In regions where an appreciable snowcover develops on lakes, the snow-slushing process is important in the growth and decay of the lake cover (Adams 1976a, b). It is a process which greatly influences the pattern of evolution of ice and snow on lakes, the forms of ice and snow on lakes and the roles (biological, hydrological, geomorphological etc.) of these forms.

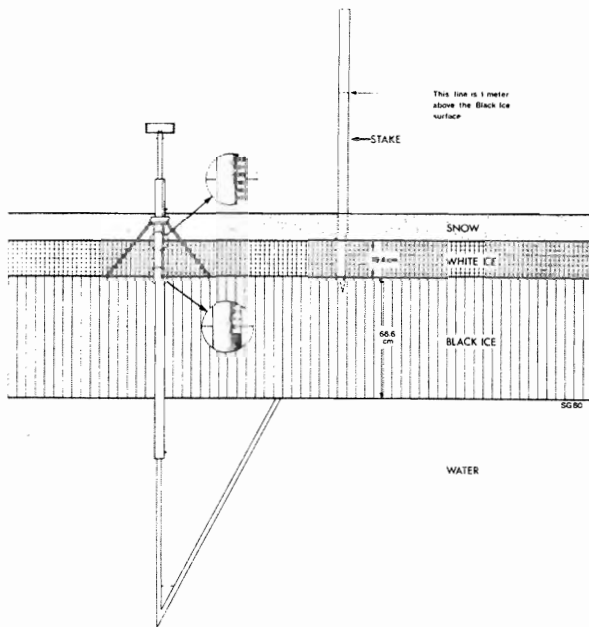
An example of the ramifications of the slushing process in modifying the evolution of the ice sheet is the fact that slushing (which can clearly be seen to modify snowcover and add white ice to the ice sheet in

Figure 1) also affects black ice growth both during and after the slushing phase. While slush is present on top of the black ice, there is no temperature gradient in it so that no growth can occur, indeed a reduction in thickness is quite common as a result of thermal-mechanical erosion at the base of the ice sheet. After the white ice layer has formed, ice growth is stimulated by the absence of the snowcover which previously insulated the sheet. Different combinations of white ice and black ice and different thicknesses and qualities of snow (the role of slushing in the evolution of snow on lakes is considered in Adams and Prowse 1978) have wide implications in terms of the lake ecosystems as a whole. An example of this which has obviously wide ramifications is the influence of different snow and ice covers on the quality and quantity of light entering the lake (e.g., Roulet 1979).

Thus drilling which induces slushing may change the timing and magnitude of a process which is of great significance in the evolution of a lake cover and in determining diverse roles of that cover within the whole lake system. Modifications induced by the drilling may be lake-wide in scope or may be quite localized. In the latter case, a site which is used for regular ice measurements may become quite anomalous as far as the entire lake cover is concerned.

Various methods of measuring ice thickness are available but they are often too complicated and too delicate for regular field use. The device shown in Figures 2 and 3 has the advantage of being simple to operate and extremely robust so that it can be used in an unprotected field situation. The device, which is a modification of that described by Adams and Shaw (1966), consists of a sealed metal tube, set in the ice, through which passes a rod connected to an arm located in the water beneath the ice. To make a measurement, the tip of the arm is raised to the under-side of the ice sheet. The thickness is read off the handle of the rod. One advantage of the device is that a series of measurements, on the circumference of a circle described by the arm, can be made by turning the handle. This encompasses local variations in ice thickness. Measurements are made some distance from the main device which may, by its presence, complicate ice growth.

Figure 2. Installation of device to show measurement of 66.6 cm of black ice and 19.4 cm of white ice for a total thickness of 86 cm. The use of a stake to measure white ice (and snow) thickness is also shown.

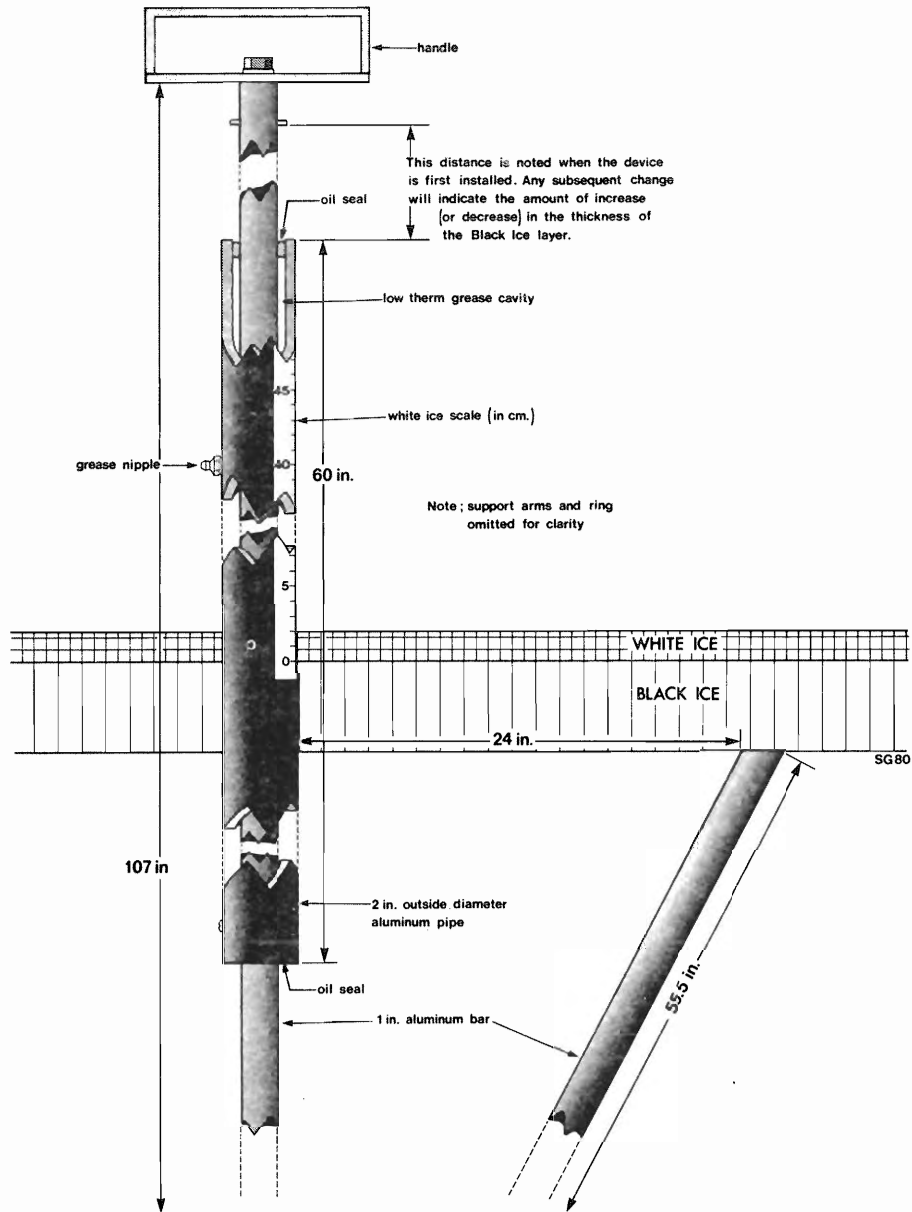


The device is installed through a rectangular slot in the ice, ideally at a time when the ice sheet is still thin. It is set so that black ice and white ice (see below) measurements are made with reference to the black ice/white ice interface (Figure 3). Between observations, the handle is depressed to its fullest extent so that the device, which is rather large\*, presents a very low profile when it is installed. Removal of the device at the end of the winter is something of a struggle where the ice is thick but the use of a chain or cross cut saw to produce a rectangular slot simplifies matters.

Figures 2 and 3 illustrate the fact that the device can also be used to measure the thickness of white ice (and snow) by means of a scale on the side of the tube. These same functions can be accomplished through the use of a stake set in the ice and similarly marked (Figure 2). In this case, it should be borne in mind that the white ice does not in fact grow upwards. Each layer of slush freezes from the surface downwards so that at any particular time there may be lenses of slush "within" the ice sheet. These can be detected by drill holes which only extend down to the black ice/white ice interface (or to the interface between the most recently formed white ice layer and its predecessor).

\* the proportions of the device have to be adjusted for the expected ice thickness, the example shown here measures up to one metre of black ice, the Adams and Shaw 1966 device could measure up to 1.5 metres.

Figure 3. Detail of device and installation.



Such holes do not induce flooding of the lake cover. It is important, when measuring white ice by the means shown in Figure 2, to carefully check that the stake or tube do not change position after being installed.

In conclusion, it should be noted that a device such as the one presented here also has the advantage of greatly speeding up ice measurements so that it becomes more feasible to make more than one measurement on a lake. The great variability of most lake covers, in the spatial sense, makes it highly desirable that a series of measurements be obtained from varied locations on the lake (see Adams 1977) rather than relying on measurements from a single point. Studies which demonstrate this include Prowse (1978) and Wolfe (1979.) A lake cover equivalent of the snow course which is now the accepted basis of snow surveys on land, is a useful objective.

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