

INSTRUMENTS AND METHODS

IMPROVEMENTS IN THE MEASUREMENT OF A LAKE-ICE COVER

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ABSTRACT. A device is described which gives direct measurements of the rates of accretion of ice on both the top and the bottom of lake ice without the necessity for repeated drilling. A method for measuring the hydrostatic water level is also described.

RÉSUMÉ. *Amélioration des mesures de la couverture de glace d'un lac.* On décrit un appareillage qui permet la mesure directe sans forages répétés des valeurs de l'augmentation de la couverture de glace d'un lac à la fois à la surface supérieure et inférieure. On ajoute la description d'une méthode de mesure du niveau de la pression hydrostatique.

ZUSAMMENFASSUNG. *Verbesserungen in der Messung von Seeis-Decken.* Es wird eine Vorrichtung beschrieben, die direkte Messungen des Eiszuwachses sowohl auf der Ober- als auch auf der Unterseite einer Seeissschicht gestattet, ohne dass wiederholte Bohrungen notwendig würden. Des weiteren wird eine Methode zur Messung des hydrostatischen Wasserspiegels angegeben.

At the present time, the weekly survey of the ice cover of Knob Lake, Quebec, Canada, includes measurements of black-ice thickness, white-ice thickness, snow depth and of water level in relation to the upper surface of the ice sheet. The observer normally drills through the ice cover with a spoon drill (pausing *en route* to measure the amount of white ice visible in the hole) and measures total ice thickness with a specially designed tape (see Fletcher, 1962, plates 2-4, p. 54 and 62). He then measures the height to which water rises inside or above his drill hole with a wooden rule and obtains a snow depth by probing in the vicinity of the hole. He repeats these measurements at three sites.

All the measurements made are important in the study of lake ice. Black ice is the normal cover which results from the freezing of the surface layers of a lake and white ice is ice which forms on the surface of the black ice as a result of flooding. Snow cover retards ice growth by insulation and promotes it by depressing the ice sheet below the hydrostatic water level, allowing flooding. The weekly measurement of water level in relation to ice surface is an indication of the extent to which the ice sheet has been depressed and is liable to flooding, in the vicinity of the measuring site.

As the Knob Lake ice survey has become more intensive, the value of results obtained by the procedures outlined, which are quite standard in Canada, has been questioned. Drilling interferes with natural ice growth, in particular it promotes flooding and white-ice growth in areas of the ice sheet which are depressed. Also, measurements of white ice by inspection in a drill hole can cause an underestimation of the amount of white ice present as there are degrees of whiteness. The measurement of total ice thickness in a drill hole provides a value which may not even be representative for an area of a few metres radius around the measuring site. Both the upper and lower surfaces of the ice cover can be very irregular and mapping surveys (Adams and Shaw, 1964; Archer, in press) have demonstrated very large variations in quality and quantity of ice cover on Knob Lake at any one time. Large variations in thickness over short distances are usually due to differences in white ice which can form as very localized increments (Shaw, 1965). A large number of measurements, spread over the lake, is desirable to encompass these variations and, for a weekly survey, it is desirable to have some means of measurement which can be used repeatedly at exactly the same location on the ice sheet. Clearly it is not possible to obtain such measurements by drilling.

The following approach is suggested:

I. MEASUREMENT OF WHITE ICE AND SNOW DEPTH

As white ice thickens upwards from the original black-ice-white-ice interface, its development can be followed in relation to a fixed mark on a stake set in the ice early in the winter (this is comparable to the measurement of superimposed ice on a glacier surface). As only "white" ice grows upwards, the problem of differentiating black ice and white ice without coring is overcome by the use of this method. Depth of snow can be measured from the same

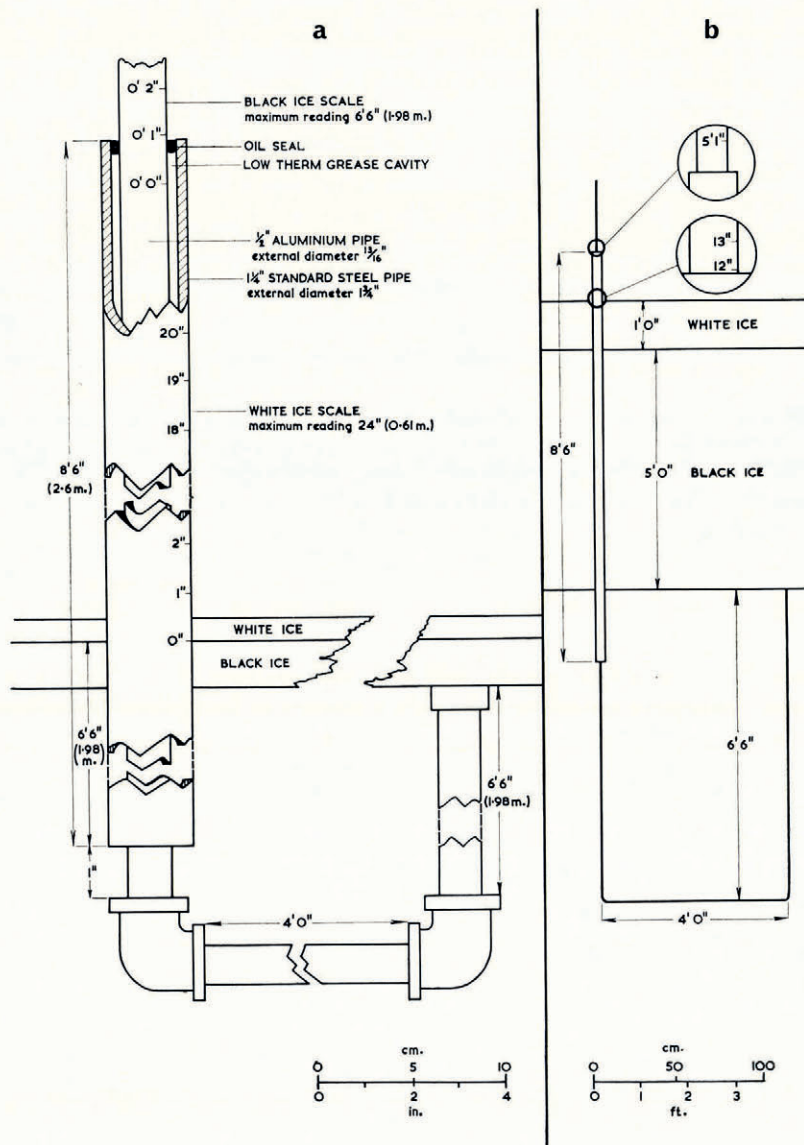


Fig. 1. Ice measuring device: (a) large-scale view of device shown measuring 1 in. of black ice and 1/2 in. of white ice, though the device would normally be installed when the ice is about 6 in. (15 cm.) thick; (b) fully assembled device reading 5 ft. black ice and 1 ft. white ice

stake. The considerable local variations of lake snow and white-ice cover can be encompassed by a network of such stakes.

2. MEASUREMENT OF BLACK ICE

In winter 1964–65, the device shown in Figure 1 was successfully used for the measurement of black ice on Knob Lake. It consists of a sealed tube, set in the ice, through which passes a movable rod. The black ice thickness is measured by raising the rod so that the point of the arm at its lower end touches the under-surface of the ice. The upper end of the rod is calibrated to read zero when the point of the arm is raised to the level of the original black-ice–white-ice interface—as black ice thickens downwards, the arm can be raised less as the winter proceeds. This simple but robust instrument greatly improves the black ice measurement, drilling is unnecessary and values can be obtained from a variety of points on the under-side of the ice, around the circumference of a circle radius the length of the measuring arm. These points are sufficiently far from the fixed part of the device to avoid complications in ice growth due to the presence of a steel tube. A spread of these devices over a lake allows rapid, accurate and repeatable black-ice measurements over the full range of variations in the ice cover.

The tube set in the ice can be calibrated (as shown in Figure 1) and used for the white-ice and snow measurements described above.

3. MEASUREMENTS OF THE HYDROSTATIC WATER LEVEL

Although using the method described above it is possible to follow the development of the components of a lake-ice–snow cover without drilling, it is still desirable to have some knowledge of the extent to which different parts of the ice sheet are being depressed below water level—for example, as a means of following the flooding–white-ice cycle. An attempt is being made to do this on Knob Lake by means of polythene tubes, containing light oil, set in the ice at the beginning of the winter. The variations in level of the oil can be simply related to the water level.

Again, a number of such tubes is required to encompass the range of variations within a lake-ice sheet, but each tube can be calibrated for the purposes of the white-ice and snow measurements.

Using these methods, a usefully large number of meaningful measurements of all facets of a lake-ice–snow cover can be obtained quickly. The length of time necessary for a weekly survey programme need be no longer than that required to make only a few, relatively inefficient, measurements by the conventional means.

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