Channel, on the east coast of Graham Land, becomes swamped with slushy snow and water every summer. This is due to the accumulated winter and spring thaw water not being drained away through the ice beneath, except where tide cracks and other rifts occur. Two seasons' observations have shown that these conditions extend over most of the Gustav Channel, covering an area of 500–1000 square miles (1300–2600 km.^{2}) at sea-level and lasting about two or three weeks.

E 2. *Local distribution of the pack ice*

All the F.I.D.S. bases have been keeping records of the distribution and type of sea ice in their neighbourhood. The eventual correlation of such observations will give a much better idea of conditions around Graham Land. When plotting the distribution of the sea ice it was found useful to indicate the amount of ice cover in tenths, in the same way as meteorologists indicate cloud cover. It is difficult of course to identify the types and distribution of sea ice near the horizon and to distinguish between light and heavy pack.

E 4. *Icebergs*

Observations of the speed and direction of the drift of icebergs were carried out in 1945–46 in Antarctic Sound at the northern end of Graham Land. An apparent seasonal change in the direction of the current was observed.

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II. Temperature Measurements in Polar Ice

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Abstract. Accurate measurements by electrical means of temperatures at various levels in shelf ice, glaciers or ice caps are of themselves insufficient; they must be accompanied by data on densities at the same levels and on incoming and outgoing radiation, as well as other things. Depths of measurements must be known accurately, and changes in them due to changes in surface level must be recorded. Levels chosen should be ½, 1, 2, 4, 8, 16, 32 and 64 m., and readings (if repeated to ensure accuracy) need be taken only once daily down to 4 m. and weekly or so at lower levels. Measurements should be free of external influences such as heat from buildings or deep drifts. Only when all other necessary data are available and all precautions observed will it be possible to explain the thermal structure of the ice sheet as shown by the sub-surface measurements of temperature.

Temperature measurements at various depths in Polar shelf ice, glaciers and ice caps need not be very intensive to be of value, but several precautions must be taken in their gathering, and certain allied data must be obtained concurrently, if the sub-surface temperature distribution is to be not only described but fully explained.

The following paragraphs have been written to amplify one point in the "Discussion on Glaciological Research in the Antarctic," held by the Society on 14 May 1947. They are based on intensive study and attempts at interpretation of the original observations of sub-surface temperature made at "Little America III" by Wade,[1, 2] and of reports of others who have measured sub-surface temperatures in snow and ice, chiefly Wegener,[3] Sorge,[4] Jülg [5] and Sverdrup.[6]

Suggestions for conduct of a program of temperature measurements are grouped under two headings: DIRECT, those pertaining to the measurements themselves; and COROLLARY, those pertaining to other measurements which must be made at the same time if the program is to have maximum value.

Direct

Method

Electrical means of determining temperatures at various depths below the surface of the firn are indubitably superior to readings of mercury or alcohol thermometers, either suspended in individual holes (Wegener [3]) or inserted into holes in the side of a shaft (Sorge [4]). These electrical elements may be dropped down to the required depths in holes drilled in the snow or ice for the purpose, and the holes filled in immediately; the elements are not recovered at the end of the program.

Instruments

Resistance thermometers (used by Wade [7]) may be more durable than thermocouples (used by Sverdrup [6] and Hughes and Seligman [8]) but may have larger errors due to the larger mass of the thermal element. Three wires are required in the leads of resistance thermometers, as opposed to two for thermocouples; this difference may be important when very long leads are planned. In formulating any future program of temperature measurements, the relative advantages of resistance thermometers and thermocouples must be carefully weighed.

Accuracy

Temperatures should be accurate to the nearest tenth of a degree centigrade, at all depths. Greater accuracy is probably not needed for over-all usefulness. The annual variation below 20 m. is so slight that it will not be shown clearly unless readings are truly accurate to the nearest hundredth of a degree centigrade, an accuracy which will probably be unattainable.

Location

The holes in which the thermal elements are dropped should be grouped very close together, and should be at least 50 m. from the nearest building or other drift-causing obstruction or source of heat. (In discussing their observations, both Wegener [3] and Jülg [5] were forced to study extensively the possible effects of heat from buildings on temperature measurements underneath them.)

Depths

Levels at which temperature measurements are to be made should not be spaced uniformly, but rather according to an exponential law. For practical purposes a geometric progression may be used, such as $\frac{1}{2}$, 1, 2, 4, 8, 16, 32 and 64 m. Readings at these levels will provide information adequate in detail for any analysis of the thermal structure and regime of a relatively homogeneous sheet of firn. Additional readings, for instance at 3 m. or 10 m., would not add materially to the information obtained; the suggested levels are sufficiently close together for satisfactory interpolation.

Accretion

The exact depth below the surface must be known, within 1 per cent. for each thermal element. Since the surface will change from day to day and probably will rise during the year, the height of the actual snow surface above the original surface level must be measured frequently. A series of vertical graduated poles, placed around the area of the holes, will provide the required information. Such sticks were used for measuring accretion at "Little America," [2] but were not originally related to the sub-surface temperature measurements. Naturally, the side for observing both temperatures and accretion must be free of unnatural drift; depending on the general location the 50 m. suggested above may not be enough to avoid artificial drifts, especially from large buildings.

Frequency

Readings need be made no more than once daily in the uppermost 5 m., and only every 5 to 10 days at greater depths. However, at each observation a series of three or even five readings, at intervals of three minutes or so, should be taken for each level, to ensure accuracy. (Wade's observations at first were made four times daily, later twice daily, and finally once daily.)

Duration

Measurements preferably should be continued for thirteen or fourteen months; observing a complete annual cycle with overlap will determine the presence of any year-to-year variation or secular change. However, much value can be obtained by careful measurements over a much shorter period. Even one day's readings of temperature at the lower levels (32 and 64 m., or 30 and 50 m.) can offer invaluable information, provided the disturbing effects of the drilling have disappeared by the time readings are taken. In such a short-term investigation, the holes will be drilled, the elements dropped in, the holes filled up as well as possible and readings taken frequently until equilibrium is attained. Since the annual variation is almost undiscernable at 32 m. (it is only about half a degree centigrade, at 16 m. at both "Little America" and "Eismitte"), temperatures at these lower levels will indicate the permanent thermal gradient and thus the direction and amount of heat flow.

Corollary

Density

Any computation of heat flow in shelf ice or glaciers involves both the thermal gradient and the thermal conductivity, which depends on the density. Consequently, determinations of density should be made at the same levels as those at which temperatures are measured. Admittedly, this is far more difficult than drilling a hole and dropping into it a wire with a resistance thermometer or thermocouple on the end. Nevertheless, without density values, the temperature readings merely describe conditions and cannot be used to explain them.

Crevasses

In some cases crevasses will be penetrated by the holes into which the thermal elements are to be dropped. Since they will affect the temperature regime markedly, they should be avoided if possible. If measurements must be made in a crevassed area, the exact depths and sizes of all crevasses or other cavities must be recorded.

Weather

Ordinary weather observations are almost certain to be made at the same camp as the sub-surface temperature readings, so they need not be mentioned in detail. Preferably, both air temperature and wind speed data should be available from two levels, such as 2 and 6 m. Barometric pressure, records of cloudiness and precipitation times and types may also be of value in interpreting the sub-surface temperatures; precipitation amounts probably cannot be obtained other than from the snow poles mentioned above.

Radiation

For a complete explanation of the temperatures observed in firn and ice, knowledge of the radiation balance is required. Intensity of solar radiation should be measured, and also the amount of outgoing ("nocturnal") radiation.

Surface

The temperature of the actual snow surface is of immense interest, but there are almost insuperable difficulties in obtaining it. Because of the low density at the very surface, even a fine thermocouple cannot be expected to measure the snow temperature unaffected by radiation. Some sort of radiometric measurement of the snow surface temperature may be feasible.

Thickness

The total thickness of the firn-ice sheet being investigated should be determined, by seismic or other means.

General

Other variables enter into a complete analysis of the internal temperatures of firn and ice, depending on the particular circumstance. For floating shelf ice, the temperature, salinity and currents of the underlying water are important. For glaciers, grounded shelf ice and ice caps the rate of motion and the nature of the underlying rock are important.

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FRICTIONAL ELECTRIFICATION OF SAND

An article by Mr. E. W. B. Gill in *Nature* (Vol. 162, No. 4119, 1948, p. 568–69) describes an experiment in which sand was allowed to fall about 1 m. on to the floor. An electrometer plate was placed about 3 m. away. While the sand was falling there was no effect on the electrometer, but soon afterwards it showed a deflexion which increased for three or four minutes, then decreased the needle coming to rest near its original zero position. The inference drawn by Mr. Gill after describing the experiment in detail, is that "the sand rubbing on itself must produce positive charges on the smallest particles and negative charges on the larger." He goes on to say, "When sand is blown about on a big scale, very large charges must be produced. . . ."

This raises the question as to what happens during the drifting of snow and whether any charge present on the flakes as they come to rest has an influence on wind-packing.*

* Mr. Robert Moss writes: "Some such mechanism may explain the powerful electric shocks which were sometimes experienced at the Central Ice Cap Station of the Oxford University Arctic Expedition, North East Land, 1935–36 when the aerial lead-in wire inside the tent was touched during periods of drifting snow. The aerial itself was often well above the drifting snow and thus it is difficult to attribute its electrification to direct friction between the snow particles and the aerial itself."