B. N. Dostovalov, carried out a series of experiments in 1940 at Igarka on the lower Yenisey. Electro-magnetic waves had been used before in the U.S.S.R., by Petrovsky and others, in prospecting for minerals. As early as 1927 it had been possible to penetrate 120 m. of rock on wave-lengths varying from 50 to 250 m. The work at Igarka was the first attempt to penetrate permanently frozen soil. Working between an underground tunnel and the surface of the ground above, radio waves were successfully received through 10 m. of soil, of which 1 to 2 m. formed the upper thawed layer and the remainder was permanently frozen. The wave-lengths used were about 44 and 76 m., and it was noted that better results were obtained with the shorter wave-length.

The same two men have also explored the possibilities of using a radio method based on antenna impedance for measuring the depth of the interface between upper thawed and permanently frozen layers. A horizontal antenna is placed at varying heights above the ground to be examined, and the capacity of the antenna measured. In this way both the dielectric constant of each layer and the depth of the dividing line should be ascertainable. In 1939 and 1940 experiments were made at Moscow and Igarka, working on a wave-length of 142 m. It was established that for successful working of the method the dielectric constant of the upper layer must not exceed 15 e.s.u., and must be less than that of the lower layer. For this reason it proved possible to measure the thickness of ice lying on water (dielectric constant (ϵ) of ice $\simeq 4$ e.s.u., of water $\simeq 81$ e.s.u.) up to a thickness of 50 cm., and of frozen soil ($\epsilon \simeq 5$ e.s.u.) above thawed soil ($\epsilon \simeq 20$ e.s.u.), but not of thawed soil above frozen soil.

It is clear from the foregoing that the start that has been made on this problem promises well. It would appear that the direct current method should be developed for use in the southern parts of the permanently frozen soil zone since it cannot be used when the soil temperature falls below $-5°$ C. The radio methods are more appropriate for use in the north for establishing the thickness of the permanently frozen layer when there is no thawed layer lying above it. The direct current method is now, in the opinion of senior members of the V. A. Obruchev Institute, sufficiently developed for practical use; but clearly much work remains to be done on the other method. The war and Professor Petrovsky's death in 1942 combined to hold up work and to delay the publication of this volume of results for six years. Further advances along these lines may be expected in the near future. TERENCE ARMSTRONG

LOCATION OF ICEBERGS BY RADAR

[Based on "The transmission characteristics of micro-waves through advection fog and the reflection properties of floating ice" by Loren E. Brunner. Unpublished MS. supplied by the United States Coast Guard in November 1947.]

Lt.-Cdr. Loren E. Brunner of the United States Coast Guard has written a paper in which he considers the practical problem confronting the sailor on the look-out for icebergs, and gives some results obtained by recent experiments with radar in the region of the Grand Banks of Newfoundland.

The first task was to examine the reflection characteristics of an iceberg

regarded as a radar target. Both 3 cm. and 10 cm. radar sets were mounted on the same vessel with approximately the same antenna heights. Both sets were carefully tested and the constants of the test system determined. After trial observations on a number of icebergs it was found that they are relatively poor radar targets. Careful measurements of silhouette areas showed that an iceberg 500 ft. long and 180 ft. high gave approximately the same target strength as a vessel 240 ft. long with a 90 ft. mast, when both were within the portion of the radar range in which an inverse fourth power law is effectively obeyed.

The second problem was to determine the magnitude of the interference by reflection from the sea in various states of disturbance, and to find the point at which the iceberg's signal would be masked by this so-called "sea-clutter". Obviously it is essential to know whether or not an iceberg of sufficient size to do damage to a vessel would be observed in time to avoid collision. Information at present available (1947) shows that an iceberg 50 ft. long and 20 ft. high may be lost in the sea-clutter of a moderate sea. Work is going forward, however, on small icebergs in varying states of sea, and more accurate conclusions should be reached.

Thirdly, there is the question of fog and its effect on radar performance. Seven out of twelve test observations indicated subnormal range in fog. Two factors have a bearing on this: the signal is attenuated by the presence of water vapour and water particles, and the radiation is refracted upwards since the water vapour content increases with height.

Fourthly, there is the problem of rain. Heavy rain squalls are frequent in the Grand Banks area. The experiments showed that there is a very real danger of mistaking an iceberg in a rain squall for a heavy rain storm, since the echo becomes diffuse, though on the 10 cm. wave-length it was possible to distinguish large icebergs. Small icebergs would certainly be masked by the effect of rain, just as they are by sea-clutter.

The results of these experiments indicate that although the 3 cm. set will pick up icebergs at greater range, the 10 cm. equipment is more reliable when there is interference by sea or rain reflection, gives a stronger signal, and will still pick up anything that 3 cm. wave-length will pick up before the object gets nearer than is safe. Both sets were known to be operating at peak performance. Investigation is continuing, and it seems likely that it will become possible to establish the size of iceberg which may be masked by a particular state of sea or weather. The day has not yet arrived, however, when a vessel can steam through fog and rain in the ice area and presume that radar will detect ice in time to avoid a dangerous collision.

Mention is made in *Lloyds List* of 26 June 1947 of two developments in the use of radar in locating icebergs. The U.S. Coastguard cutter *Mendota*, during an ice observation cruise in 1947, was said to have shot metal targets into icebergs in order that they could subsequently be more easily picked up by radar. The *Mendota* was also said to have used the Loran long-range navigational system to determine the speed and direction of drifting icebergs. On neither of these points is more detailed information available. It seems likely that the experiments were made after Lt.-Cdr. Brunner had written his paper.