a caretaker keeps them charged through the winter. When all is secure, the men are returned home by plane. A small nucleus of men are retained in Seattle through the winter to work up the survey records and prepare for the coming season.

Charting Northern Seas and Harbors

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SYNOPSIS

The Canadian Arctic: Vast areas required to be accurately charted; immensity of the task.

Early charts: Discovery voyages and resultant sketch charts.

Need for modern charts: For defence, scientific investigation and commercial development; beneficial effect of charts on marine insurance rates.

Charting by Canadian Hydrographic Service: Provisional general and harbor charts; charting operations in Frobisher Bay, Ungava Bay, Hudson Strait and Hudson Bay; air-photographic coverage; cooperation with other surveys and Arctic navigators.

United States Hydrographic Office: A major contribution to Arctic charting.

Plans for charting development: Coastal triangulation network; photographic coverage required at both high and low water stages of tide; electronic method of fixing being investigated; new hydrographic ship projected.

Nautical charts of the Canadian Arctic play a vital role in scientific, economic and defence development. The purpose of this paper is to review the need for modern northern charts, to outline briefly what progress in charting has been made, and to indicate the general lines along which it is expected Canadian hydrographic surveys will advance.

A glance at the map shows the vast water areas that require accurate chart coverage. Of vital importance, and one of the most conspicuous features on the map of North America, is that great arm of the sea, Hudson Strait and Bay, which bites into the continent nearly as deeply as does the Gulf of Mexico. It provides some four months of ice-free navigation for the transportation of the products of the Canadian prairies to the markets of the world. Northward, in the Arctic archipelago, are some 10,000 linear miles of water passages. The charting of this vast ramification of interlocking channels presents to hydrographers a tremendous challenge.

As we heard in Dr. Nicholson's address this afternoon, the early history of Arctic charting unfolds a bleak picture of adventurous seamen who had caught a vision of a northern route to the Orient. As their tiny ships groped amongst the islands and along the misty northern margins of the continent they depicted the lay of the land as best they could, in many cases the line between fact and fancy being somewhat vague. Submerged dangers they located by laborious sounding with lead and line, or by the disastrous method of piling their ships on the rocks. Charting the ice-bound passages was, of necessity, a hit or miss affair and, for centuries, tales of shipwreck were common occurrence. Little wonder that most of the early charts, made from sketches and running surveys, have been found to be hopelessly inadequate for modern navigation.

From seaward, the Canadian Arctic presents a forbidding and barren appearance. Fortunate it is that the exposed coasts of the world are not always to be taken as an index of what is to be found within. The bleak coasts of the northern seas contain great mineral wealth, and it is expected that in the near future ore-carrying vessels will be an important factor in the northern water transportation picture. For this purpose, modern coastal charts and large-scale charts of prospective ore-shipping ports must be made available.

An important aspect of the need for nautical charts is their beneficial effect on northern marine insurance rates; the better the charts of a district, the less the risk of marine disaster and, consequently, the lower the cost of insurance which the carriers must pay. These charges, in turn, affect the costs of transportation and, eventually, will be reflected in the expansion or contraction of northern waterborne trade. A striking example of the relation between nautical charts and marine insurance was the case of the new Hudson Bay Route where, year after year as modern navigation charts were made available, shipping insurance rates were lowered.

Safety of ships that ply the northern

supply routes is a chief reason for subpolar charting, but there is also a trend today for hydrographic surveys for scientific and strategic purposes. Amongst such requirements are accurate bathymetric charts for fishery, oceanographic and geographic studies.

Of great interest to those concerned with problems of Arctic defence, is the fact that the submerged continental shelf which protrudes from the northern coast of North America is a part of the same plateau which surrounds the North Polar Basin. On it lie all the Arctic Islands of Canada, Greenland, Iceland and most of the islands north of Europe and Asia. A steep continental terrace borders the western side of the Canadian archipelago and constitutes one of the most striking features of the Polar regions. Soundings on this submerged northern threshold of the continent are too few to give a clear picture of its hydrographic relief. It is known, however, to be traversed by deep gullies, apparently cut by glaciers. These submarine valleys extend well in between the Arctic Islands and afford navigation routes for well-strengthened vessels.

Shipping in the Canadian Arctic has greatly increased in recent years. A considerable trade has been developed along the continental coast, and small vessels with the aid of only local knowledge and the hand-lead have made the complete passage from the Pacific to the Atlantic.

The production of provisional general charts covering nearly half of the Arctic Island area, and large-scale harbor charts of the principal harbors, has been made possible by the availability of air-photographic coverage. Coastline for these sheets was plotted by the Topographical Survey of Canada, and horizontal control was based mainly on astronomical observations by the Geodetic Survey of Canada and others. The charts are supplied to captains and hydrographers aboard northern vessels, with the understanding that additional soundings and related hydrographic information will be forthcoming as a result of their northern cruises.

By this cooperative method much useful data have been added to the charts, but the amount of new sounding contributed has been somewhat restricted by the understandable reluctance of ships' captains to venture into uncharted waters for the purpose of obtaining new depth information. Having once found a safe route it is extremely difficult to induce them to venture on uncharted courses.

The owner of a vessel bound for ports on the reef-infested Labrador coast, seeing the shoals breaking about him, and other dangers disclosed only by the green swirl of the sea above them, apprehensively said to his Pilot: "I suppose you know where all the shoals are?" "No, Sir, I don't, admitted the Pilot. "What!" exclaimed the startled owner, "Your are supposed to be guiding this ship and you don't know the shoals are?" "No," came back the answer, "I don't know where the shoals are, but I know where they are *not*, Sir, and that is where this ship is going."

This, unfortunately, illustrates the present condition of many Arctic charts. Areas to be surveyed are so great, and the field charting season so short, that in many cases soundings on the charts are limited to only the more or less established routes. Many years will elapse before the Canadian Arctic can be said to be adequately charted, but good progress is being made.

To this vast undertaking the well-equipped ships of the United States Navy have made a major contribution. Their welcome cooperation has enabled the more modest Atlantic flotilla of the Canadian Hydrographic Service to concentrate on urgent charting operations in Hudson Strait, Hudson Bay, Frobisher Bay and elsewhere, while technical development plans are being carried out. Amongst the latter might be mentioned a new hydrographic ship—now on the drawing boards. Electronic methods of fixing are being investigated, additional technical staff is being trained and arrangements are being made for establishing a comprehensive network of coastal triangulation for charting purposes.

For coastlining full use is made of special air photography. In Hudson Strait, where the tidal range is very great, it would be of advantage if two sets of photographs were available: one taken at the time of high-water Spring Tide to clearly delineate the high-water line; the other taken at low-water Springs for the purpose of locating the low-water line and also to show the character of the entire foreshore. The delineation of the three features, high water line, low-water line and foreshore are important objectives of hydrographic surveying.

Objectives of charting operations the world over are very similar. Dissimilarities are chiefly in the methods and equipment used, and in the physical conditions under which the actual surveying is carried on. At this Conference we look forward to hearing of the experience of the United States hydrographers in their charting of northern seas and harbors.

To sum up: The concept of all the Canadian Arctic waters being charted on an adequate scale, is one devoutly to be wished for, but one exceedingly difficult of accomplishment. The character of the coast, the severe climatic conditions, the strong tidal currents and dangers to surveying vessels from heavy ice and unknown reefs, all militate against rapid progress in nautical charting. Yet, it is these very reasons that add up to the necessity, and indeed the urgency, of hydrographic operations. As long as defence, economic and scientific development continue, the concept of adequately charted northern waters is not likely to be altered.

Hydrographic Surveying in the Arctic

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Hydrographic surveying may be roughly defined as the gathering of all necessary field information for the production of nautical charts. Due to the nature of the medium, hydrography in arctic and subarctic regions does not differ in principle from hydrography in temperate or tropical climates. If the water is not solidly frozen, the same methods of depth determination are used no matter where surveys are made. In the event that the water surface is completely solid, special techniques may be necessary such as breaking the ice, drilling holes to reach the water, or taking soundings through the ice itself. So many practical difficulties arise in making hydrographic surveys through a solid ice cover that it is almost never done on a large scale, but is limited to small areas or spot depth determinations made in connection with other scientific observations.

Even at the best, however, hydrography in the north presents some unique problems for men and materials. Though the surface may not be frozen solidly, it is rarely ice-free, and the floating ice is an ever-present and ever-changing hazard to the ships and boats taking soundings. Reinforcement of hulls, and modification of some engineering details is necessary, or else a certain calculated risk of damage must be accepted. Survey instruments must be specially lubricated and carefully handled to operate satisfactorily. The climate affects operations too by decreased visibility and poor working conditions brought on by snow, fog, rain and high winds. Much of the position fixing for sounding operations is now done electronically, and is therefore independent of visibility. It would be foolhardy, however to operate ships in ice-filled waters where the rocks and shoals are at best only imperfectly known.

An additional point is the comparative inhospitality and remoteness of the north. In warmer, more populated regions, an insured man ashore, a survey party in distress, or a grounded boat is almost always within range of friendly assistance from the local people. In the arctic, where the the nearest settlement may be hundreds of miles away, there is little possibility of getting local assistance or of buying emergency supplies from the nearest store. The detached survey party is on its own and must make do with what it has.

The purely psychological effect of the cold is considerable. There is the natural feeling in the back of one's mind that extra caution is necessary; that a mistake in judgment or a freak of nature may lead to discomfort, injury, or death. This feeling is bound to impede the progress of an operation which is exploratory by nature, and in which a good measure of calculated risk is ordinarily accepted. Added to this awareness of unusual hazard is the purely physical discomfort of low temperatures. Heavy protective clothing is almost a necessity for survival, although it greatly lessens personal efficiency. A balance must usually be struck between discomfort and the freedom of movement necessary to carry out the survey work. Even at best, proportionately longer rest periods are