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

Lt. Comdr. T. K. Treadwell, Plans and Policy Division, U. S. Navy Hydrographic Office, Washington, D. C.

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

needed to thaw numbed fingers and relax the chilled body.

The Navy Hydrographic Office realizes the difficulties of working in the arctic, and ordinarily employs a full survey group for a job. The standard group consists of one large, tender-type survey ship, and two smaller ships. These carry four to six sounding launches, amphibious trucks, numerous small boats and landing craft, assorted shore vehicles, and one or more helicopters. Seven hydrographic officer specialists, four civilian engineers, and ten to twenty enlisted CB surveyors are assigned to the technical work. These are in addition to the several hundred line officers and men necessary to carry out the routine work of ship operation, maintenance, and support of the survey. Unskilled and semi-skilled workmen for boat crews and construction parties are drawn as needed from the ship's company.

Each such survey group carries sufficient survey equipment and supplies for an extensive operation. The group is able to go into an area and make a complete charting survey. The preliminary work includes taking the necessary astronomical observations for position and azimuth, laying out a precise base-line, observing a second-order triangulation network, and carrying out essential field photography and photogrammetry. Thousands of miles of sounding lines are then run by ships and boats, using visual or electronic control, and the accessory tide, current and oceanographic observations are taken. The results are processed as the work proceeds, and if desired, a five-color field nautical chart can be printed on board ship for immediate use.

In the preparatory phase of the survey, the first technical difficulty to be encountered is that of obtaining the astronomical position and azimuth, due to the shortened periods of darkness and the erratic reception of radio time signals. This has been partially bypassed in some cases by the procedure of observing a series of accurate lines of position on the sun, using a theodolite. Magnetic observations for variation are difficult to obtain, due to the decreased horizontal magnetic component. Marking of permanent geodetic points presents a problem when they must be located on ice, snow or permafrost.

In the sounding operations, the hazards of ice and low visibility have already been mentioned. Carrying out a predetermined sounding pattern is further complicated by the fact that in high latitudes the magnetic compass, and to a lesser extent the gyro compass, become sluggish and erratic, making it difficult to hold a straight course. The actual soundings are taken by standard Navy recording fathometers, supplemented by hand lead soundings and wire dragging as necessary. The rocky nature of the bottom makes pinnacles and abrupt shoals common, and particular care must be exercised to insure that no danger to navigation is overlooked. The inshore soundings are taken by the launches, using three-point visual sextant fixes on shore objects. The offshore hydrography is developed by the larger ships, using electronic control. Radar beacons were formerly used, but are gradually being replaced by such systems as Shoran, EPI, and Lorac. Unfortunately, the performance of electronic positioning equipment in the arctic tends to be erratic and generally subnormal which somewhat lessens its utility.

To sum up, hydrography in the arctic is often difficult and hazardous. The challenges presented by the environment are disturbing principally because they are unfamiliar to the newcomer. Equally difficult problems, however, confront the hydrographer in all other areas. With careful preparation, technical ability, common sense, and experience, these uniquely arctic problems can be dealt with effectively, and one of the last frontiers of the world can be accurately charted.