REPORT ON THE USE OF RAYDIST FOR HYDROGRAPHIC SURVEY IN GREENLAND

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Owing to a demand for the hydrographic survey of certain parts of Greenland's inshore waterways possessing great economic interest, and due to the fact that the relatively large area had to be surveyed in a short time, often during stormy weather and poor visibility, the Royal Danish Hydrographic Office decided to procure Raydist equipment for position fixing.

1. General Remarks

In the spring of 1959, therefore, Raydist equipment of the two-dimensional type DM transistor system was bought from the firm at Hampton, Virginia.

This system has not been described in IHB Special Publication 39, but a description can be found in the Instruction Manual published by the makers (*). As no detailed information can be given without permission from the latter, suffice it to say that the equipment works with two shore-based relay stations and one shipborne station — the so-called Navigator (**) — on which the distance from the relay stations is registered as a number of lanes according to the frequency used.

Position lines are thus distance circles centred on the relay stations.

It is the first time that the Royal Danish Hydrographic Office has endeavoured to survey by means of this equipment, and accordingly a certain amount of beginners' difficulties were met with owing primarily to lack of training and very adverse conditions in the area.

In the following an account will be given of the experiences gained during the summer's work.

The equipment was standard equipment as there was no time to have it strengthened and made to naval specifications.

This proved to be inadequate, as the equipment had to be used under

(*) *IHB Note* — A detailed description by the Hastings Co. will appear in the revised edition of Special Publication 39.

(**) The *Navigator* equipment is shipborne, and supplies measurements in convenient form for navigational purposes.

difficult, at times even severe, conditions as regards placing the gear on board ship where vibrations from the motors could be felt, climate, and transport ashore on rocky islands devoid of roads of any kind.

The construction of the equipment was not sufficiently robust for this kind of handling, and consequently breakdowns occurred in places where they ought not to have happened.

It must, however, be mentioned that the weather conditions were at times so severe that the whip antennas and nylon stays were broken and the shelter tents completely destroyed.

2. Frequencies

The Raydist chain works on four different frequencies, two of which must be interproportional. These four frequencies must be undisturbed by other stations in order that the chain can work faultlessly. Consequently before the equipment was ordered a lot of thought had been given as to what frequencies could be expected to remain free from disturbances. As an extra safeguard a set of crystals using different frequencies had been bought.

In the field, however, this proved to be insufficient as some of the many fishing vessels working in Greenland waters were disturbing the survey frequencies when using their radio telephones.

Even if was possible to stop these disturbances to some extent by requesting the fishing vessels to alter their frequencies, difficulties of this kind continued during the summer. One transmitting frequency was changed to the reserve frequency without adequate results.

This shows the importance of having this problem studied very thoroughly before a chain is put to use.

3. The Navigator

The equipment bought was supplied with two Navigators, the plan being either to wire-drag and survey in the same area simultaneously or to wire-drag with Navigators in both towboats, and then survey with two launches working independently.

The frequencies used by the two Navigators working on the same shore-based relay stations are extremely close to each other, so that it is possible to use the mean value of the lanes obtained as distance for both Navigators without any practical influence on the positioning.

The use of two Navigators on the same shore-based stations has, however, the severe drawback that it restricts the movement of the launches relative to the stations and to each other.

If one launch approaches one shore-based station while the other is further away, the Navigator in the far launch will not register as it will not receive the right signal from the station near which the other launch is working. This can be explained as follows :

Each launch transmits a signal to a receiver at the shore-based stations from which it is returned to the launches for phase comparison in the Navigator. If however one launch approaches a shore station, its signal becomes so strong that it influences the automatic amplification control protecting the receiver against distortion. This means that the sensibility of the receiver is lowered, which consequently is unable to receive the signal from the far launch if this is much further away than the other.

The ratio of the distance at which the two launches can operate depends to some extent on the terrain, but is somewhere between 1 : 5 to 1 : 10.

In the field this condition proved so inconvenient that it has been decided to use only one Navigator with each system in the future. In this way the torque in the lane counters will be much stronger and the possible errors reduced accordingly.

With two Navigators the lesser torque means that the other antennas, stays, etc. will often be in the way, especially if they are in a direct line between transmitters and receivers.

4. Antennas

12-m whip antennas were used on the shore stations, but in order to augment the transmitting energy these will be replaced by 20-m whips in the future.

The 12-m whips used on the launches will be retained owing to the size of these launches, but experience shows that every effort must be made to place these free of and higher than other conducting elements.

5. Power supply

The stations are operated on 12-volt batteries. Owing to local conditions it often proved difficult to have these changed and charged. It is therefore deemed necessary to have the survey launches equipped with charging units.

In order to save the batteries while the survey was stopped, these were disconnected either by means of automatic clockwork switches, or by sending the launches to the stations.

Neither system proved ideal, partly on account of the time spent sending a launch, and partly because the automatic switches did not always fit weather and other survey conditions.

In order to have the equipment operate correctly a couple of hours warming up is necessary.

During the summer the chain was used from four different locations, at the last of which it was possible to connect one station to the local electric supply system. By means of a rectifier unit it was thus possible to keep this station supplied constantly, which proved to be nearly ideal as the station operated without break or error during the whole of a period of two weeks.

6. Check points

Apart from the two coordinated points used for the transmitting antennas a third fixed point is needed for lining up and checking the Navigator lane counter. It often proved difficult to obtain this third fix with sufficient accuracy. In principle it must be of the same order as the antenna fixes, as the entire Raydist survey hinges on this check point.

It is hardly possible theoretically to obtain sufficiently accurate check points in an area of isolated islands where mooring facilities are nonexistent, and where the trig points are few and far between.

It is, however, possible to find certain places among the islands where a launch can tie up, but then other difficulties are met with. The launch antenna has to be coordinated through sights to trig points which are difficult if not impossible to see. No close-lying high land must come between the antenna and the relay station, as the radio waves will be blotted out in such cases. If the launch is tied up so that she has a clear line of sight to the relay station, reflections from the mountain sides can disturb reception.

The best check point was obtained by erecting two sets of in-line signals that intersected about 200 m offshore.

This intersection was measured very thoroughly during fine weather conditions with a sextant and computed after a normal horizon adjustment had been made. When computed, the distances from the intersection to the relay stations were converted into numbers of lanes.

It was relatively easy to keep the launches at this intersection while checking, as it had been placed where there was good shelter and no current.

By means of this well-determined check point other auxiliary check points were established near the area to be surveyed, in order to make the frequent daily controls less time consuming.

On account of the recurrent instability it was necessary to check the system every two hours during operations, but it is hoped that with better knowledge this interval can be lengthened considerably next season.

7. Accuracy

The dial of the equipment reads to 1/100 lane, but this accuracy is beyond that which can be utilized in practical surveying.

The long series of inaccuracies entering into hydrographic surveying, well known to the readers of this review, shall not be discussed here. It must be mentioned, however, that the lane counter could oscillate up to 3/10 lane while the launch was stopped for checking, presumably owing mainly to vibrations of the whips. Accordingly a checking error of ± 5 m had to be reckoned with.

8. Operations

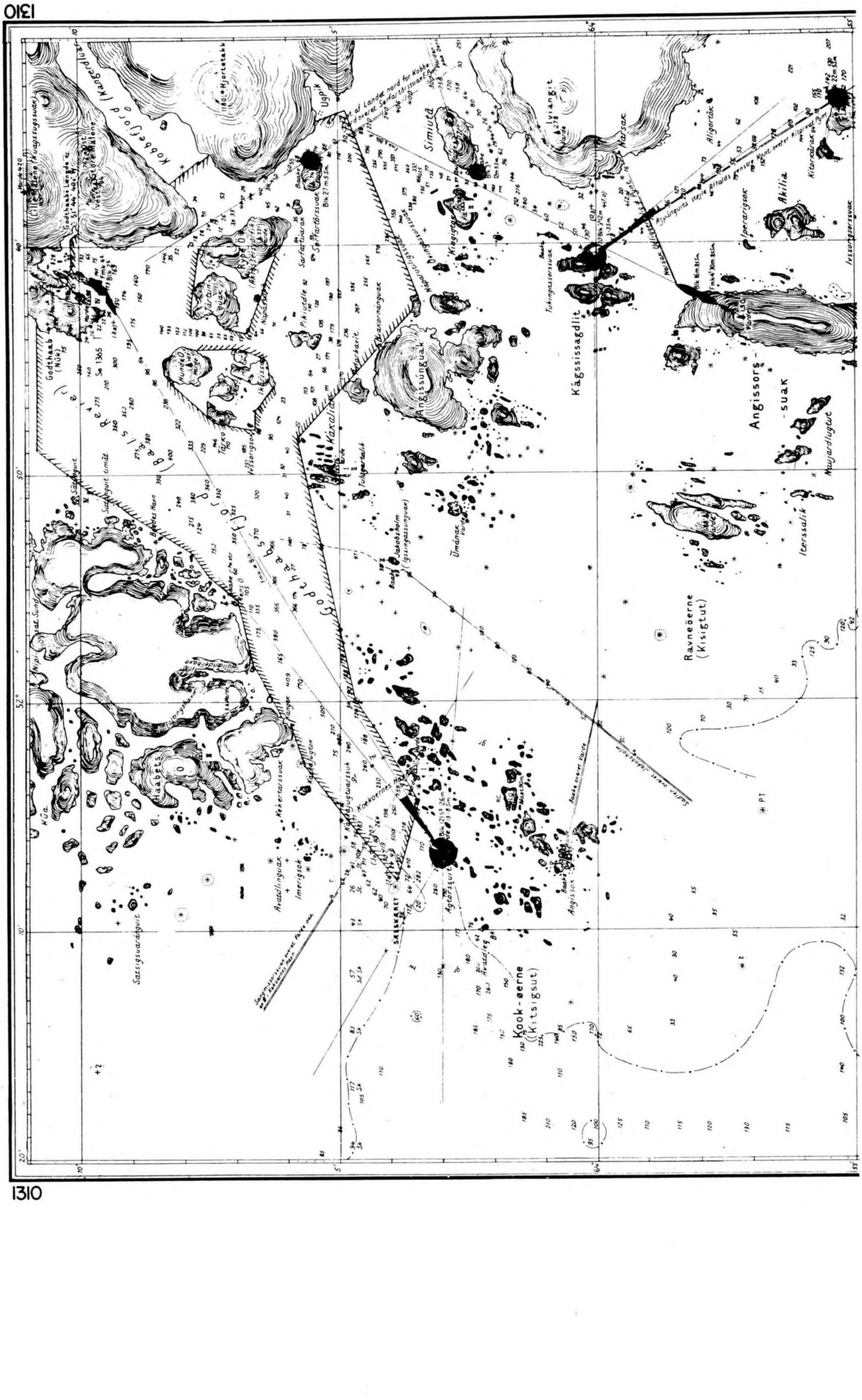
By means of the Raydist the area shown in plate 1 was surveyed. As mentioned above, four different locations were used for the chain in order to have one location for each rough sheet used (scale 1/10 000).

In case the antenna positions are placed outside the rough sheet in use, special computations and the drawing of distance circles are necessary, and plotting becomes more difficult.

The survey was carried out by having the launch follow the least curved of the two distance-circle systems.

It proved very easy for the helmsman to follow the lane pointer, as this moved slowly and steadily while under way. After a short training period he was able to stay within ± 3/10 lane.

The distances were plotted on the rough sheets by means of long rulers made of translucent plastic marked with the distances. Zero point was placed at the antenna positions so the actual plotting was extremely easy.



Pl. 1. — Limits of area surveyed are shown by hachures.

9. Rough sheets

For the last fifty years, a rough sheet on the Mercator projection has been used in Denmark, so that the draughtsman should have no projection difficulties computing the actual charts.

Accordingly the rough sheets for this seasonal work had been constructed on the Mercator projection. But owing to the fact that the area to be surveyed lies around 64° N, the problem as to the curvature of the distance circles when transferred to Mercator had to be studied thoroughly by the computing division of the Hydrographic Office.

The sheets were computed for 66° N, and for a number of lanes the equivalent coordinate values naturally had to be computed for every station of each chain location, as was the case for the corresponding rulers.

The result of this study showed that if the Raydist was not used outside a distance of 10 - 11 000 m, the use of circles would be sufficiently accurate provided their centre was moved northward as the number of lanes grew larger. The greatest displacement was 2 mm on the chart (1/10 000) at a distance of 300 lanes.

Continuous displacement of the centre is, however, not possible while working, as the zero of the ruler was fixed with a needle, but had to be done by jumps tolerating errors not exceeding 3/4 mm on the charts, corresponding to 7.5 m on earth in a N-S direction.

The above-mentioned result was obtained using the following expression, which gives polar coordinates (r, θ) in the Mercator plane for the lane curve :

$$r = a_1K + a_2\cos\theta K^2 + (a_3\cos^2\theta + b_3\sin^2\theta)K^3 + (a_4\cos^3\theta + b_4\cos\theta\sin^2\theta)K^4 + ...$$

the pole being placed in the relay antenna position, with the axis oriented north (see fig. I).

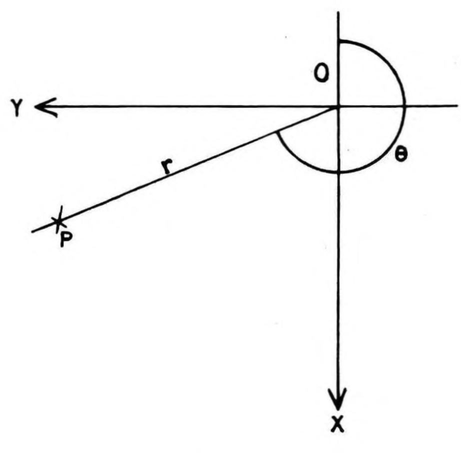
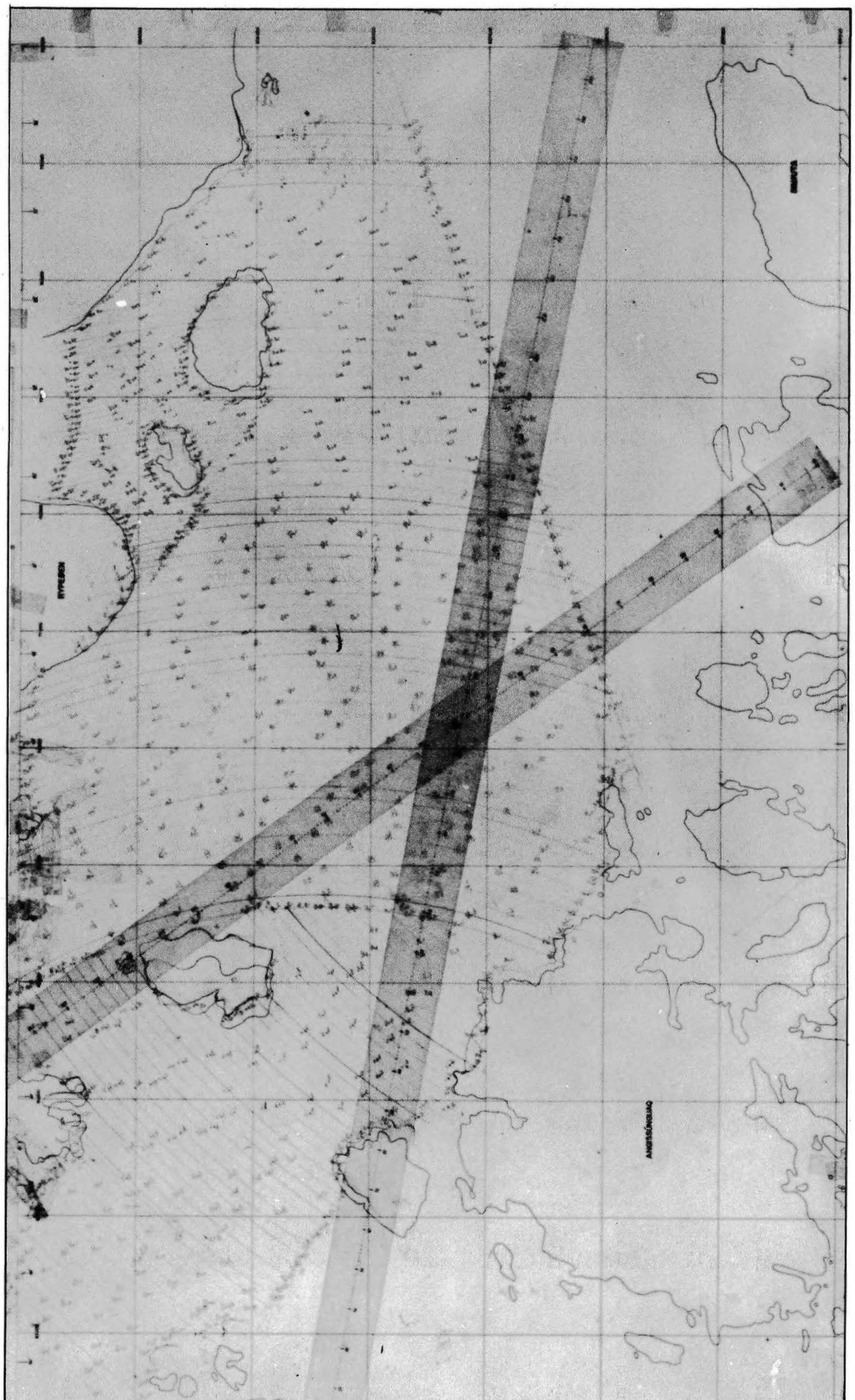


FIGURE 1

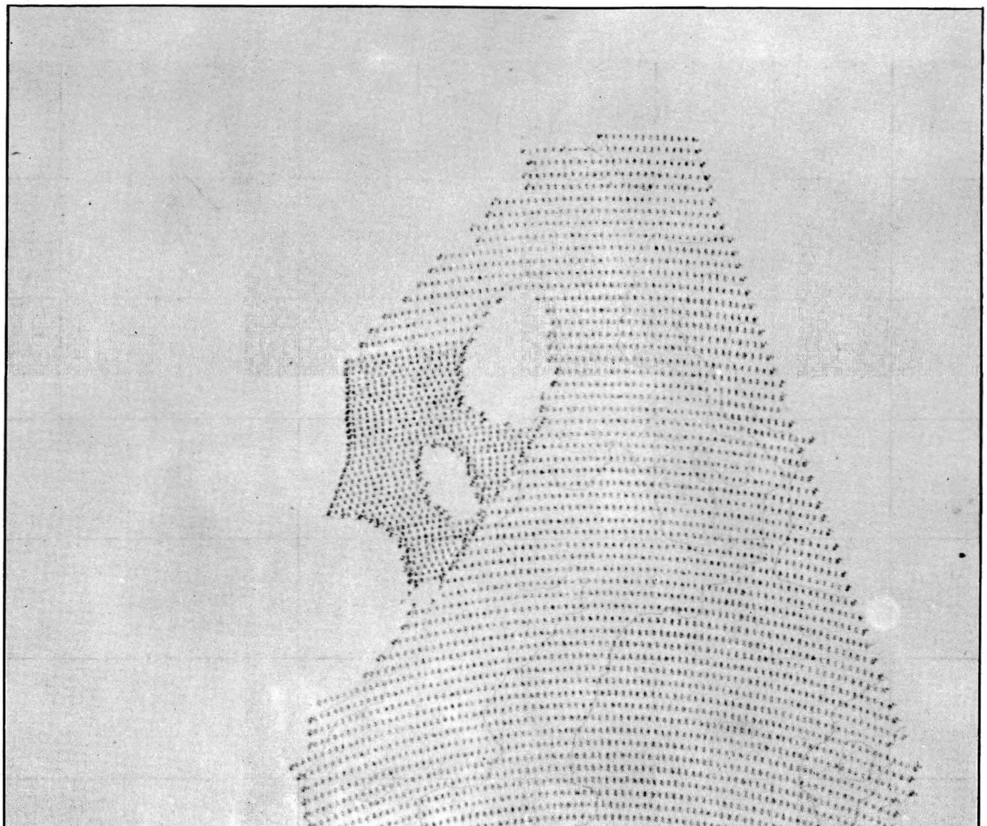
K is the distance on earth, (a_i, b_i) are constants dependent on the eccentricity of the ellipsoid, radius of the equator and local latitude.

The expression can be made as accurate as desired over hundreds of kilometres by adding a sufficient number of terms.

When r is calculated within a distance of about 11 000 m the third term corresponds to 7 cm.



Pl. 2. — Rough Sheet.



PL. 3. — Smooth Sheet.

The result on 64°00′38″ N is :

$$r = 0.928270\,K + 0.14886 \cos\theta \frac{K^2}{10^6}, \text{ when K is given in metres.}$$

The curves on the Mercator plane resulting from this expression can be replaced without tangible loss of accuracy by circles with a radius of 0.928 ... K and a displacement northward of the centre of $0.148 \ldots \frac{K^2}{10^6}$.

Example (see fig. 2) :

$$\varphi = 64°02' \text{N} \qquad K = 10\,000 \text{ m} \qquad \theta = 90°$$

gives r = 9 290.3 m, and a displacement of the centre of 14.9 m.

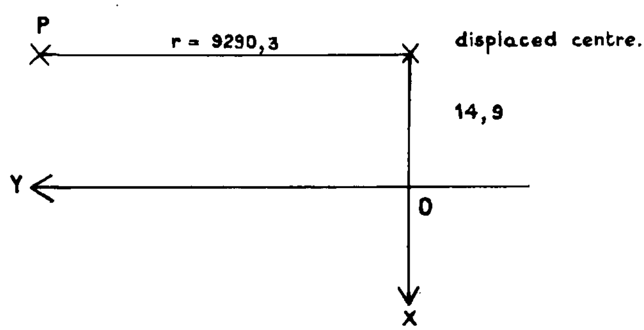


FIG. 2.

By a reverse calculation of the distance OP on the earth, using the polar coordinates (—14.9 + 9290.3), K results in 10 000.00 m, which shows that the accuracy of the circles lies within 1 cm.

The shortened expression for r can thus be approximated by a circle, as the resultant inaccuracy for the whole approximation will be less than 10 cm.

The use of Raydist makes it doubtful whether it will be worthwhile to continue using the Mercator projection for hydrographic surveying in this area, and the Royal Danish Hydrographic Office therefore contemplates changing to the projection used by the Geodetic Institute, which is the usual conical orthomorphic projection and in which the distance circles can be used direct.

Conclusion

In spite of all the difficulties met with owing to an extremely bad summer with many days of poor visibility, it was possible to complete the desired survey. When the smooth sheets were drawn, the overlappings between the different chain locations proved exceedingly accurate, even when some time had elapsed between the various surveys.

It is the considered opinion of the Hydrographic Office that by having the equipment strengthened, using higher whip antennas and only one receiver per system, the Raydist system will prove very valuable indeed for the survey of Greenland's inshore waterways, even for distances greater than the ones used this season, as the system can easily be operated up to 20-25 miles.