THE USE OF DECCA AS AN AID TO THE HYDROGRAPHIC SURVEY OF NETHERLANDS NEW GUINEA

by Commander Ir. W. LANGERAAR, Royal Netherlands Navy.

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The Arafura Sea, situated between Netherlands New Guinea and the north coast of Australia, covers the continental shelf connecting both countries. Consequently this sea is not very deep, and especially to the north its bottom rises very gently to chart datum. Though the dense woods of New Guinea end abruptly at the seashore, there are parts where the water is so shallow as to prevent medium-draught ships from nearing the coast sufficiently to see the coastline.

The normal techniques of hydrographic surveying are therefore of little value in this region, as a triangulation along the coast is only barely visible from surveyable parts of the sea. Extension of this triangulation by means of floating beacons is not feasible because of the enormous area to be covered and the resulting serious accumulation of errors.

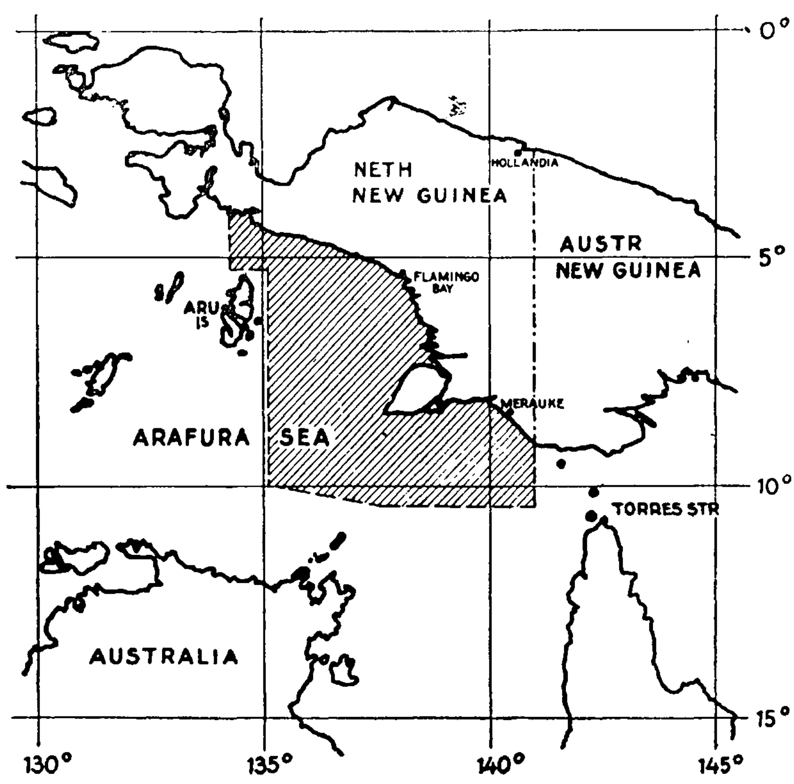

Fig. 1.

Density of shipping through Torres Strait and the Arafura Sea is far from negligible, and traffic to and from New Guinea will no doubt increase gradually, as this country is developing. Not only is the hydrographic survey of the Arafura Sea one of the responsibilities of the Netherlands Hydrographic Office, but a systematic survey is also necessary to meet the demands of the above-mentioned increase in traffic. Among these demands is the necessity of an uninterrupted survey of the area considered, and the desirability of such a survey being carried out with modern equipment, to a level of accuracy not to be surpassed by the mariner using the charts based on it. Moreover it may be expected that future shipping in the Arafura Sea, after a systematic survey has taken place, will be subject to a considerable increase, as the shortest route from Torres Strait to Manila, for instance, is through this sea.

Most of the present charts of the Arafura Sea are compiled from old surveys, and some from running surveys that were not based on a continuous triangulation along the coast. The use of echo-sounding equipment has scarcely begun and these charts therefore do not come up to modern standards. The main reason, however, for the apparent reluctance, until recently, to begin a systematic survey of this area has been the impossibility of applying normal surveying techniques.

The introduction of electronic aids to navigation after the war, together with the growing importance of Netherlands New Guinea and the seas around it, furnished the answer to the increasing necessity of a systematic survey of the Arafura Sea and its northern coasts.

Though unnecessary in this audience, it may be mentioned that the paramount importance of electronic aids lies in the fact that such aids are largely independent of visibility, greatly reduce the harmful influence of any accumulation of errors, and lastly permit the surveyor to perform a systematic and evenly distributed search for submerged features and obstacles.

In 1955 the Netherlands Government decided to buy a Decca Survey chain for use in New Guinea. No particular reasons will be given as to why the Decca system was chosen, except that this system was expected to be most easily adaptable, in view of the difficulties to be encountered in the primeval forests of a country devoid of manpower.

In December 1955 this chain and auxiliary equipment arrived at Merauke, New Guinea. One of our surveying vessels, HNMS *Snellius*, in the meantime had been specially adapted to this method of surveying and arrived at Merauke during the same month. One of the major problems to be tackled in the beginning was the fact that suitable sites had to be found for the three transmitters. Such a position had to meet several requirements, such as conductive properties of the soil, baselines between transmitters preferably over sea, an open space in the woods ; and last but by no means least, the transmitter had to be accessible under all circumstances. This last requirement appeared to be decisive and could not be decreased because of the risks involved. Whatever the weather conditions in both monsoons might be, a repair party had to be able to reach the transmitter, or a possible stretcher-case be transported to a hospital.

The best way to meet the electronic requirements would be to have the Master transmitter at Merauke and the two Slave stations at Delivrance Is. and Habeke Is, but an investigation on the spot soon revealed that Delivrance Is. as well as Habeke Is. would provide insurmountable difficulties for a landing party because of the very extensive submerged reefs surrounding both islands. During an air reconnaissance two other apparently promising places were seen and visited shortly afterwards by boat. These positions indeed were satisfactory from the point of view of logistics and also met some, but not all, of the electronic requirements. For instance the village of Erambo, the proposed site for the Red Slave, had the disadvantage that the baseline as well as its extension lay completely in a wooded region. The village of Kimaan on Frederic Henry Is. had another disadvantage as the possible site for the Green Slave. Its distance from the Master at Merauke was 180 km and therefore longer than was deemed advisable regarding the problem of synchronization. After the Master at Merauke had been erected, however, field-strength measurements made at sea, beyond the village of Kimaan, proved the electro-magnetic field to be of sufficient strength to guarantee a satisfactory operation of the chain as a whole. It was decided therefore to build the Green Slave at Kimaan.

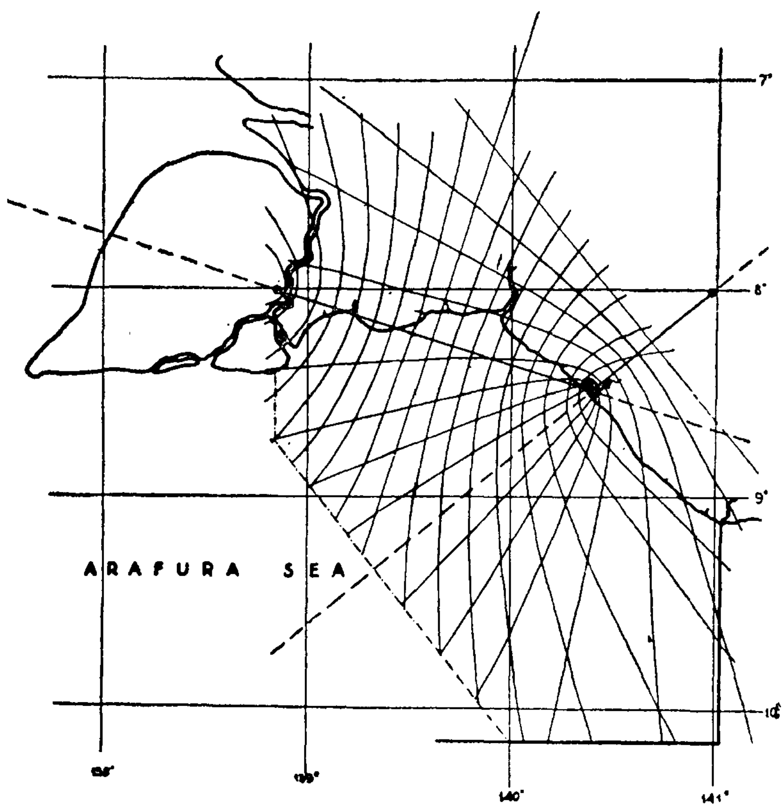

Fig. 2.

The picture shows that the mathematical properties of the Decca lattice are better on land than at sea, a slight disadvantage that had to be accepted because of the absence of any alternative sites for the transmitters. However, the lattice on land is not completely lost to the hydrographic survey, as many rivers and estuaries cut deeply into the coast and will also be charted. Moreover, the angles of intersection of the Red and Green hyperbolae at sea are rather good for most of the intended coverage. Only near the Red baseline extension did some difficulties have to be overcome. Near the extension the Red pattern is too unstable to give an unambiguous fix. The surveying vessel can cross the Red baseline extension, staying on the predetermined Green hyperbola between the last reliable fix before crossing the extension and the first fix after crossing it. The mean length of such a cross-over is about 30 nautical miles, increasing from 10 miles near the coast, to 40 miles near the fringe of the coverage. The differences in depth along these cross-overs fortunately appeared to be very small, i.e. of the magnitude of 2 to 5 metres. This method of solving the problem near the baseline extension therefore seems completely justified.

At Merauke and Kimaan astronomical observations were made to determine a provisional length and azimuth of the Green baseline. Counting the number of Green lanes thereafter gave a provisional value for the speed of propagation of the radio waves of that particular frequency. By application of the Norton-Bremmer theory, the propagation speed was found for the waves with frequencies used at the Red Slave and after lane-counting round the Red baseline (Merauke-Erambo), the Red baseline length could be provisionally determined. This procedure guaranteed an accuracy relation, between the lengths of both baselines, of the same order of magnitude as the intrinsic accuracy of the Norton Bremmer theory, i.e. of the order 1/10,000.

The length of the Red baseline thus having been determined, its azimuth remained to be found. In order to find a value of this azimuth consistent with all other values used in the computation so far, an astronomical position at Erambo certainly could *not* be used, because of the unknown influence of the plumbline deflections. To overcome these difficulties, Mr. Verstelle, of the Netherlands Hydrographic Office, developed a method of observing the Red pattern at the Green Slave. The Red lane number and its fraction observed at Kimaan gave a value for the distance between both Slaves, Kimaan and Erambo. The same procedure was repeated at Erambo, where the Green pattern was observed and again a value for the distance between both Slaves was found. This distance was of the order of 235 kms and the difference in distance as determined at the Red and at the Green Slave was about 25 metres i.e. 1/10,000, consequently in accordance with the accuracy of the Norton Bremmer theory employed. The observations at both Slaves covered two days' readings at each Slave.

By computation of the triangle Kimaan - Erambo - Merauke on the International Ellipsoid, the provisional value of the angle between both baselines was found. The final check on all these provisional data was acquired as follows : at a distance of about 40 kms west of the Master a series of Decca observations was obtained, enabling determination of the distance and azimuth to the Master in the provisional system of coordinates. Moreover the site of these observations was also connected to the Master by a first-order traverse. The closing error in distance appeared to be of the order 1/40,000 and in azimuth 32 seconds of arc with a standard deviation of 15". It was therefore quite unnecessary to change the provisional coordinates at all, which consequently were considered as final.

This method of computation of all necessary parameters has the advantage of giving a geometrically and electronically closed system. The fact that no appreciable discrepancies were found between provisional and final values of these parameters only means that the difference in plumbline deflection at Kimaan and Merauke is negligible ; a conclusion that is acceptable from a geological and geophysical point of view.

It is of interest to mention that afterwards an astronomical position was determined at Erambo, which position showed a marked difference with the electronically determined position. This difference in position must be seen as caused mainly by the difference in plumbline deflection at Kimaan and Merauke on one side and at Erambo on the other. The astro position at Erambo was determined by the observation of some 80 stars. The differences found were 1.7" of arc in latitude and 12.6" of arc in longitude with a standard deviation of 1.6". The direction of this difference was compatible with geological and geophysical data.

The questions arising in connection with the computation of the Decca lattice, given the position and orientation of the chain, are numerous. Several methods of tackling the problem are possible, all of them having a number of advantages and disadvantages. One thing, however, is clear : the computation of the lattice must be done with one set of propagation speeds for the whole coverage. Corrections for differences in propagation speed over land and over sea must be determined afterwards and these corrections cannot be incorporated into the lattice itself, but must be applied to the Decometer readings.

All Decometer readings refer directly to the pattern actually radiated, but these readings are used to determine one's position on a chart by means of a representation of this pattern. Because of anomalies in radio propagation these Decometer readings are subject to corrections before being applicable to the pattern appearing on the chart. It therefore seems reasonable to use a simplified method of calculating the pattern, and to determined corrections that must be applied also to the Decometer readings in order to be able to consider the pattern on the chart as a good representation of the pattern actually radiated.

There are several methods of calculation used to determine the spheroidal hyperbolae, but they all have one thing in common ; a rather tedious amount of arithmetic. Plane hyperbolae are much easier to calculate though they do not exactly represent the radiated pattern. In New Guinea, Mr. Verstelle chose to eliminate the difference between the calculated plane hyperbolae and the spheroidal hyperbolae, by computing the intersections of meridians and parallels in terms of fractions of the plane hyperbola numbers. This means that all discrepancies between plane and spheroidal hyperbolae disappear into the system of meridians and parallels. The question as to whether or not this is acceptable depends on scale errors that are caused by this procedure. In this case these did not exceed 1 $^{\circ}/_{00}$ i.e. the errors introduced do not exceed the errors implicit in the drawing of a chart.

These calculations were carried out on board the surveying vessel, and the procedure seemed to meet the required standards of accuracy and speed. But it should be mentioned that new methods have been developed since that promise even greater speed without loss of accuracy. One of the methods I refer to is the Sadler-Atherton table for 400 standard hyperbolae giving coordinates for points of these hyperbolae at (mutual) distances that enable linear interpolation. After lane-counting, the actually radiated number of hyperbolae is known, after which these curves can be constructed by applying suitable factors to the Sadler-Atherton coordinates.

Mr. Verstelle (Netherlands Hydrographic Office), however, goes still further and proposes to represent these 400 standard hyperbolae after photographic reduction on the scale of the baseline considered in the construction sheet. This implies the use of a variable multiplication factor to be built into the Decometers enabling these Decometers to reduce the pattern actually radiated to the standard 400-pattern. This method is of ultimate simplicity, and the building of such multiplication factors into the Decometers does not seem to be impossible. The necessary preliminary work at the Hydrographic Office is increased thereby, but the time available for actual survey work increases also and this latter is of paramount importance.

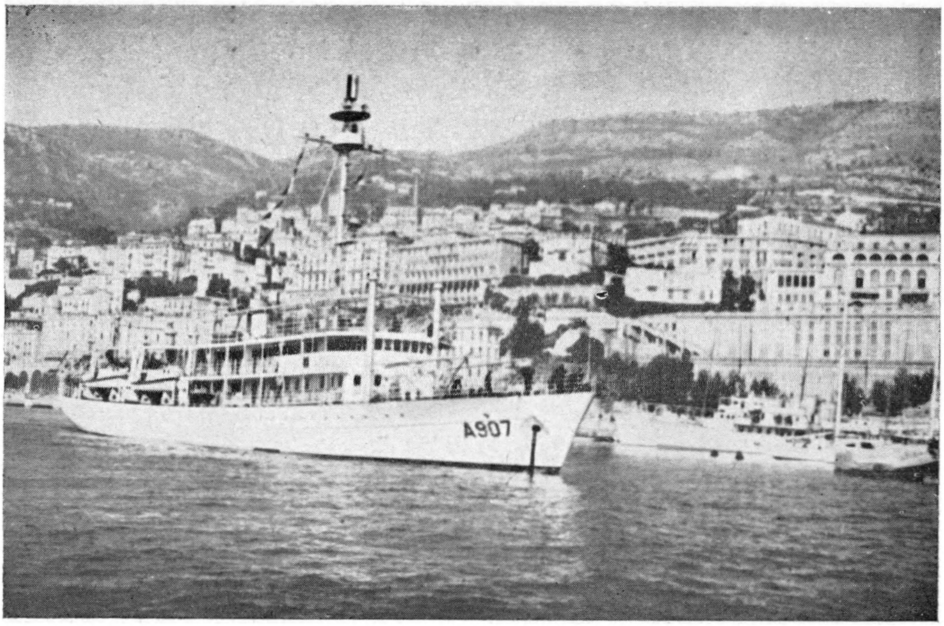

Fig. 3.

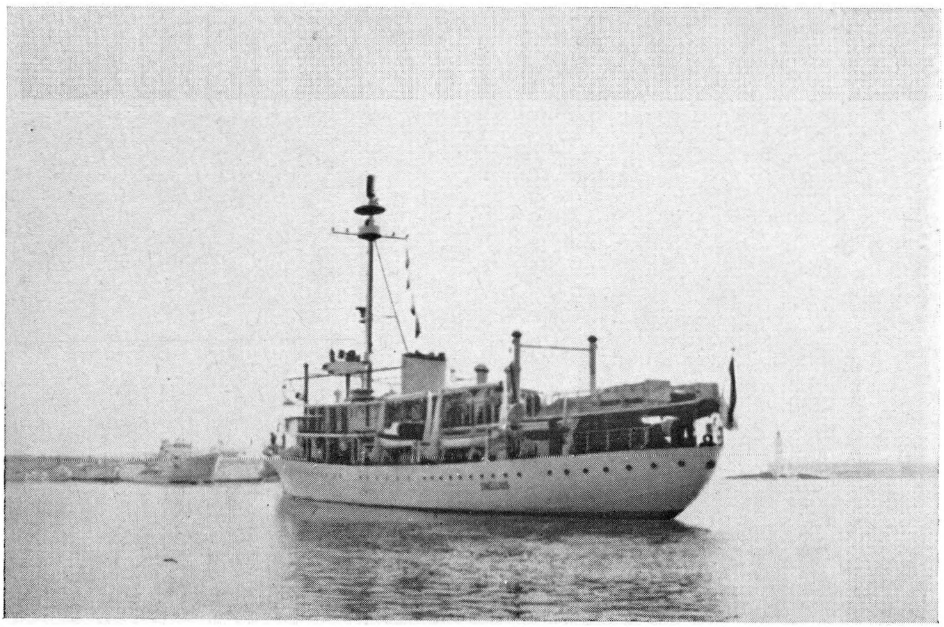

***Fig.* 4.**

H.N.M.S. *Snellius.*