# ON A WIRELESS DIRECTION FINDING CHART.

(SKAGERRAK - KATTEGAT)

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ECONOMICAL utilisation of merchant-vessels nowadays puts ever increasing demands on the skill of masters to navigate their ships with speed and safety. The wireless direction-finding method has already given navigators very valuable help, and this system will certainly make rapid advances in respect to the instruments as well as in their general utilisation.

At present two direction-finding stations, Vinga and Hallö are available for passing Skagen (the Skaw) and making the inlets to Gothenburg. A third station is under construction at Morup and will be opened to traffic this year. The value of this third station will be evident from a glance at the annexed chart. Its radius of action extends far to the West of Skagen, and it will give valuable aid in the rounding of this point which is well known to be somewhat difficult. It will be useful to navigation in the Kattegat and to the southward of Anholt Island also.

In order to facilitate the use of the bearings received from the three stations mentioned, the Hydrographic Office of Sweden has essayed a new form of chart for this purpose. This chart is a Mercator's chart and is, mainly, a photographic combination of existing Swedish charts; the combination of an ordinary chart with a direction-finding chart is calculated to facilitate its use by Mariners. Some of the other advantages gained by this method appear to be : —

Navigators generally find it difficult to lay off a very long bearing through a certain point, no such difficulty will arise when using this chart, for the true bearings from the stations in question are drawn at every five degrees and every degree is marked at certain radii. The radial distances between the circles graduated in single degrees are such that the arc of a great circle between two corresponding points on adjacent graduations may be taken practically to be a straight line. This method of plotting will without doubt be found to be both simple and reliable. Moreover the azimuth correction applied when plotting wireless bearings on ordinary Mercator's charts will not be necessary, for the lines of bearing shown are calculated and laid off as arcs of great circles and will give the ship's true bearing independently of the distance from the station. Thus the use of this chart combines greater accuracy with greater rapidity in plotting the bearings.

It may be pointed out that, when using this chart for plotting bearings taken with the ship's own direction-finder, it will be necessary first to apply *twice* the ordinary correction to Mercator bearings, i. e. the total amount of meridian convergence. This, as is well known, is the case with the gnomonic chart also.

The rapid expansion of wireless direction-finding methods is, without doubt, still causing charts of varying type to be produced. It is hoped that the type advocated here may be regarded as a step in the right direction.

## THE CALCULATION OF THE ORTHODROMIC CURVES.

The problem of obtaining the orthodromic curves on the Mercator's chart is, in the present case, a moderately simple one, but it is believed however that a short description of the procedure might be of some interest.

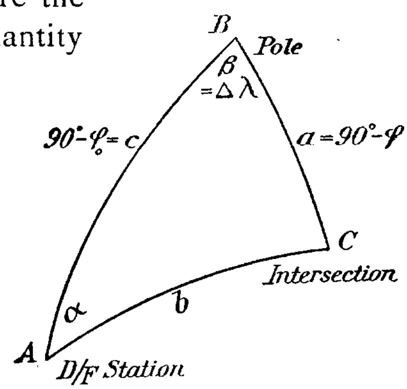
The great circles required lie mainly in an approximately east and west direction, and the great circles lying nearer to the direction of the meridians will be very nearly straight lines; thus it was deemed more convenient to calculate the intersections of the orthodromic curves with certain meridians on the chart. It was not found practicable to calculate these curves from the special properties of the Mercator's projection, neither could great circle sailing tables be utilised as the degree of accuracy thereof is insufficient. The curves therefore were deduced directly from angular relations on the sphere. The spherical triangle considered is that of which the angles are the Pole, the Direction Finding Station and the point of intersection sought. This triangle is represented by the figure; thus BA is the meridian of the D/F station, BC that of the intersection sought, and AC is a part of the orthodromic curve to be determined.

$\varphi_0$ is the latitude of the D/F station and $\varphi$ the required latitude of the intersection. $\triangle \lambda$ is the difference of longitude, and $\alpha$ is the bearing or azimuth at A of the orthodromic curve in question.

The known quantities in this triangle are the side c and the angles $\alpha$ and $\beta$. The only quantity to be determined is a. In Hammer's Handbook of Trigonometry two solutions of this problem are given. However, a simpler solution is given by the well-known formula

$$\sin \beta \cot \alpha = \cot a \sin c - \cos c \cos \beta$$

Substituting the sides and angles of the triangle under consideration this gives, after some transformation :




$$\tan \varphi = \tan \varphi_0 \cos \triangle \lambda + \frac{\sin \triangle \lambda}{\cos \varphi_0} \cot \alpha$$

This formula is preferable because it gives $\varphi$ directly from the known quantities and also because $\alpha$ and $\triangle \lambda$ appear as separate arguments to the functions. This will permit essential simplification of the calculations, for these must be made for a number of values of $\alpha$ and $\triangle \lambda$, separated by intervals small enough to permit graphical interpolation between the points calculated.

Thus for every station a series of curves for values of $\alpha$ varying by 10° was calculated and on each curve values for every 20′ of longitude were deduced. Tests showed that the intervals between the points were sufficiently small to permit graphical interpolation both radially and transversally with an error smaller than that which might be expected on account of the method of reproduction.

It may be noted that the bearings have been calculated above as great circles on the sphere, whereas the strictly theoretical bearing would be the spheroidal geodetic line. On one of the curves laid down on the chart a check was made by aid of Bessel's formulae for calculating the geodetic line*, and it was found that the approximate method will cause a maximum error, within the limits of this chart, of about 3/4 of a millimeter. As the difference is thus of no practical importance and the calculation of the exact values is very lengthy and difficult the spherical formula has been used without corrections.

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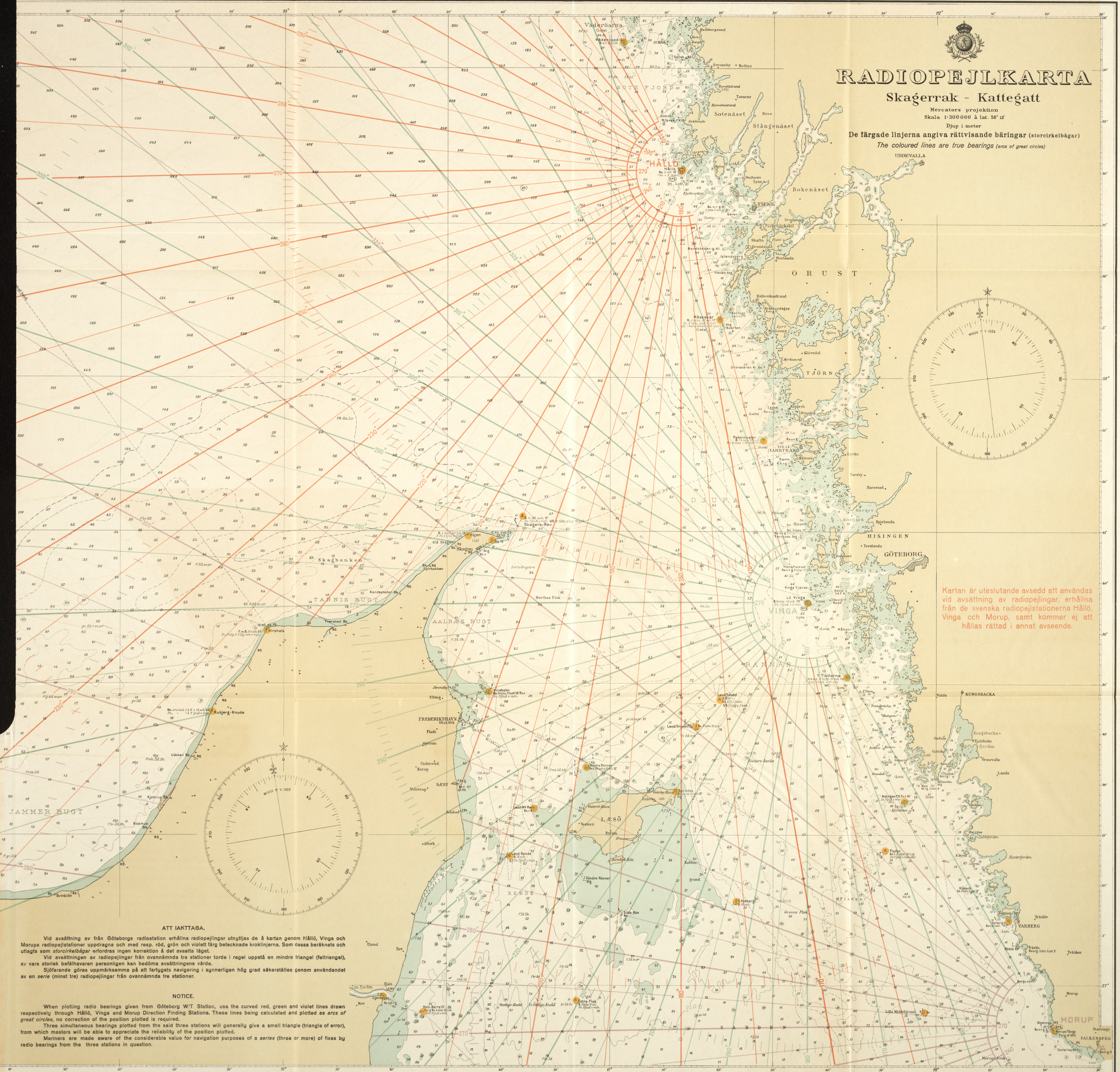
* Astronomische Nachrichten No 86, 1826.




## ATT IAKTTAGA.

Vid avsättning av från Göteborgs radiostation erhållna radiopejlingar utnyttjas de å kartan genom Hållö, Vinga och Morups radiopejlstationer uppdragna och med resp. röd, grön och violett färg betecknade kroklinjerna. Som dessa beräknats och utlagts som *storcirkelbågar* erfordras ingen korrektion å det avsatta läget.

Vid avsättningen av radiopejlingar från ovannämnda tre stationer torde i regel uppstå en mindre triangel (feltriangel), av vars storlek befälhavaren personligen kan bedöma avsättningens värde.

Sjöfarande göras uppmärksamma på att fartygets navigering i synnerligen hög grad säkerställes genom användandet av en *serie* (minst tre) radiopejlingar från ovannämnda tre stationer.

## NOTICE.

When plotting radio bearings given from Göteborg W/T Station, use the curved red, green and violet lines drawn respectively through Hållö, Vinga and Morup Direction Finding Stations. These lines being calculated and plotted as *arcs of great circles*, no correction of the position plotted is required.

Three simultaneous bearings plotted from the said three stations will generally give a small triangle (triangle of error), from which masters will be able to appreciate the reliability of the position plotted.

Mariners are made aware of the considerable value for navigation purposes of a *series* (three or more) of fixes by radio bearings from the three stations in question.

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FOTOLITOGRAFI UTFÖRD VID STATENS REPRODUKTIONSANSTALT