ON ISOGONIC CHARTS

by

GUSTAF S. LJUNGDAHL

Kungl. Sjökarteverket, Stockholm.

The Swedish Hydrographic Service (Kungl. Sjökarteverket) is preparing a new edition of "Svensk Lots", III ("Bothnian-Gulf-Pilot") which will contain an isogonic chart of a type which differs from that in general use. Directions for the use of this chart, which will appear only as a *trial*, will be given in the Swedish language as well as a short account of the motives for trying a new type. It may, perhaps, be of some interest to present these reasons in another language also and to add some further remarks.

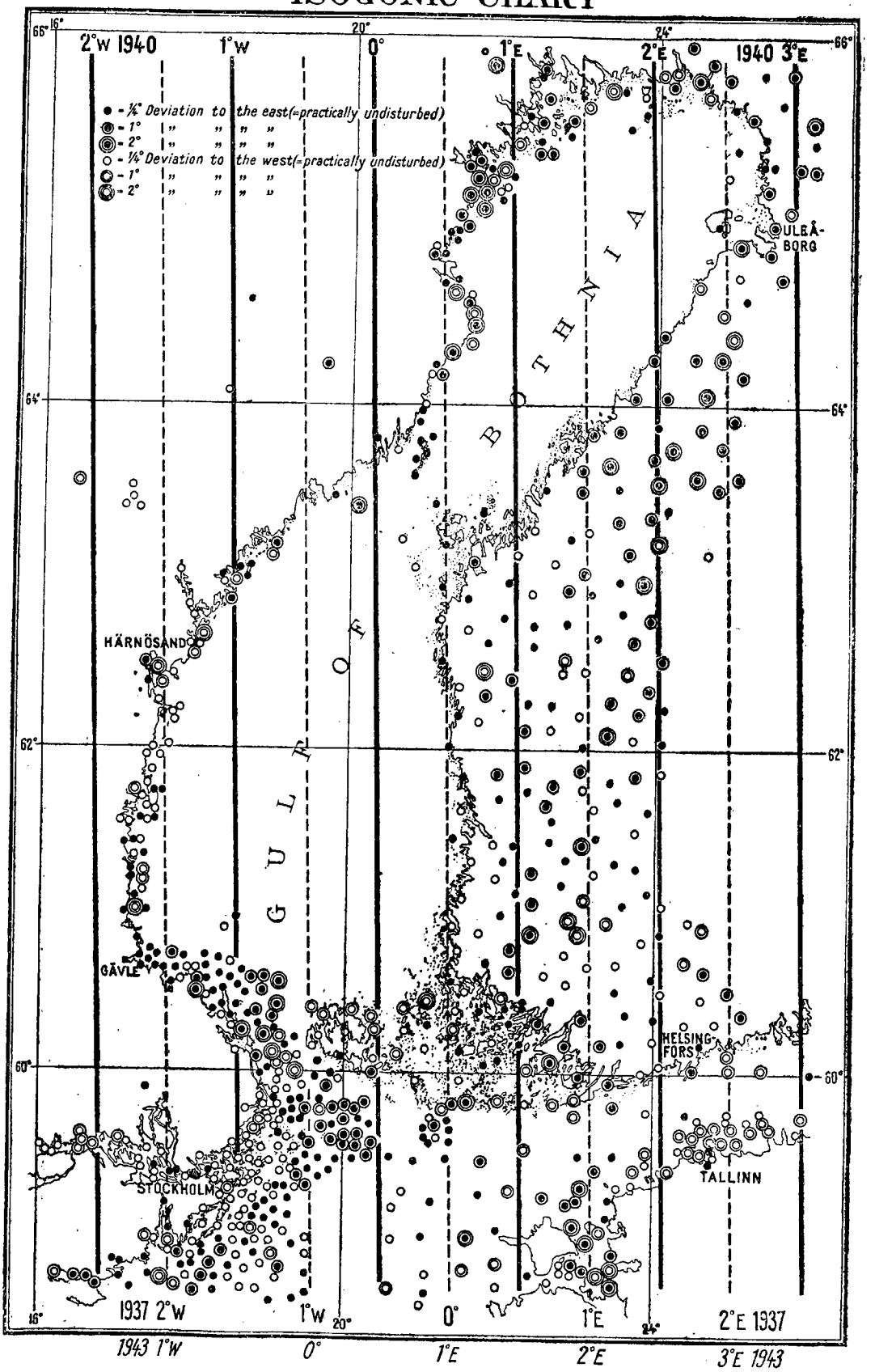
Magnetic charts on larger scales than are used for magnetic world-charts should give detailed information on local irregularities. On a magnetic chart of the conventional type, showing the isogonic lines (or lines of equal magnetic variation) over an area of which certain parts only are satisfactorily surveyed, these lines are often drawn deviating considerably from the average or "normal" values even in parts where observations are lacking. Besides, the lines over unsurveyed areas very often show curves and details the physical bases of which are not sufficiently stated, as they refer only to interpolation between distant points of observation. Without local observations, it is very difficult to decide how far the magnetic conditions are connected with values at observation stations some distance away, or to what degree a certain parallelism may exist between isomagnetic lines. In such cases, the most correct procedure seems to be to trace the isogonic lines in as close agreement as possible with the most probable average or normal lines, and to give detailed information about the declination at such places only where it is really known.

The chart should, if possible, clearly bring out to what extent the values given were ascertained from trustworthy observations, or merely obtained by interpolation.

While the magnetic elements and the isomagnetic lines are subject to great and unceasing changes in accordance with the secular variation, the magnetic anomalies — being associated with the structure of the earth's crust mostly remain constant, at least for considerable periods of time. It seems self-evident that magnetic charts for almost every purpose should distinguish — as far as possible — between the part which remains relatively constant and that which varies with time.

In magnetically disturbed regions — for instance in Baltic waters — the mariner should know the approximate amplitude of the magnetic disturbances and especially where the magnetic conditions may be regarded as being practically undisturbed. (When checking the ship's deviation or when taking bearings with the compass, the isogonic chart should be more accurate

ISOGONIC CHART



than is necessary for steering the vessel in the open sea. Within areas which are so disturbed that the declination varies during the period of observation, according to the change in the position of the vessel, compass observations will of course be less reliable). (*)

In the Baltic the regularity of the isogonic lines is greatly deranged by frequent anomalies. It is only exceptionally that *quite* undisturbed regions are found. The amplitude and extension of the disturbances vary. Within "local" anomalies the departures from the normal declination values sometimes reach several tens of degrees, even at sea. Within "regional" anomalies the departures do not, as a rule, exceed one or two degrees, but such regions may sometimes extend over very great distances. Charts which try to give, as correctly as possible, the "real" or "true" isogonic lines in disturbed regions, often present rather confusing curves, and those with more or less smoothed lines often do not sufficiently indicate the known details.

There are certain advantages in representing the magnetic declination as a departure from the "normal" declination, the latter being indicated by very smoothed lines. Figures as well as "symbols" can then be used to indicate the deviation at the places of observation. This matter has been the subject of some discussion during the last few years (1), and it will be appreciated, indeed, if the advantages and disadvantages of the new type of isogonic charts be taken into consideration by mariners also during practical use.

On the annexed chart, all observation spots are indicated by symbols. *Black, solid circles* indicate departures to the east, *open circles* to the west. The small circles correspond to deviations from the interpolated values of 1/4° (= practically undisturbed), the next in size, 1°, and the largest, 2°. All values between 0° and 1/2° are given as 1/4°, between 1/2° and 1 1/2° as 1°, and between 1 1/2° and 2 1/2° as 2°. The greatest error possible of a value represented by a small circle will be ± 1/4°, and of the other value ± 1/2°. The accuracy is, thus, greatest at places with small deviations. (A few deviations, greater than 2 1/2°, have not been given any special symbol, but are represented by the same symbol as 2°. Some very strong

---

(*) As an example thereof — certainly an extreme case — the following may be quoted :

"Während der magnetischen Störung waren die Kompasse sehr unruhig. Der nach Peilungen festgestellte Schiffsort lag etwa 3 bis 4 Sm. westlicher als der durch Winkelmessung mit Sextanten bestimmte Schiffsort." — Bericht des Kapt. HÜCKEL vom Dampfer "Fritz Hugo Stinnes 5", *Deutsche Seewarte,* Dampferhandbuch für die Ostsee, Hamburg 1931, p. 303.

"During the magnetic disturbance the compasses were very unsteady. The position of the ship obtained by bearings was some 3 to 4 sea-miles to the westward of that obtained by sextant angles".

(1) WEINBERG, On the principles of Magnetic Cartography, *Terr. Magn.*, 1935, pp. 325-331. LJUNGDAHL, An attempt to simplify Magnetic Charts, *Terr. Magn.*, 1936, pp. 101-104. KERANEN, LJUNGDAHL, ROSE, Resolution of the Subcommission for uniformity of Magnetic Charts, *Assoc. Internat. de Magnétisme et Electricité Terrestres, Assemblée d'Edimbourg,* 1936 (not yet printed).

local disturbances are totally excluded, because the sole purpose of the chart is to demonstrate the type). (2)

Directions for use of the chart :

In order to get the true magnetic declination at a certain place, the "normal" declination is first determined by interpolation between the isogonic lines. The value thus obtained is corrected for the local deviation to the east or to the west, according to the symbols.

Illustration : At *Gävle* (the places are indicated on the chart) the normal declination is 1° 8 W. The deviation is 1/4° to the east. The true declination (= variation) is, thus, about 1 1/2° W.

At *Härnösand* the normal declination is 1° 3 W. The deviation is 1/4° to the west. The true declination is, thus, about 1 1/2° W.

At *Uleaborg* the normal declination is 2° 9 E. The deviation is 1° to the east. The true declination is, thus, about 3° 9 E.

At *Nargö,* near *Tallinn,* the normal declination is 2° 2 E. The deviation is 1° to the west. The true declination is, thus, about 1° 2 E.

This chart differs from the above mentioned official chart in so far that the latter will be printed in two colours (red indicating deviations to the west, and black to the east) and that the symbols will not be exactly the same; all "practically undisturbed" stations will be shown by small, black or red open circles; and stations with deviations of 1°, 2°, as well as 3° or more, will be shown by symbols of greater size. Thus, the optical impression of the symbols on the eye will be, to a certain degree, proportional to the magnitude of the disturbances. In principle, however, both charts are identical.

As regards the advantages of symbols over figures (the latter have often previously been used in a similar way), it should be remembered that figures are a kind of symbols. A figure indicates not a definite value, but a certain interval between values. When 1° is selected as the unit, the interval would be too great to indicate slight but important irregularities, and if 0.1 of a degree be used as the unit, the interval would be too small, and one or more figures at each station would fill the chart without giving the clearness desirable. (On the annexed chart, values from some 700 stations are included.) The difference between figures and the proposed symbols is mainly, that the symbols can be chosen with a more suitable gradation than

(2) The following material has been used in the construction of the chart :
GERNET, Die Endgültigen Ergebnisse der magnetischen Messungen in See der Jahre 1925 und 1926, Topo-Hüdrograafia Aastaraamat 1929/29, pp. 33-35, Tallinn, 1930.
KERANEN, Declination values in the western parts of Finland, 1933, (manuscript, kindly placed at disposal).
LJUNGDAHL, Earth magnetic researches along the Coasts of Sweden, Part I — Magnetic declination, *Kungl. Sjökarteverket, Jordmagn. Publ.,* Nr 10, Stockholm, 1936.

is possible with a continuous series of figures, and that they can be made smaller and yet much more distinct. The size of the symbols should be to a certain extent proportional to the magnitude of the deviation.

In the Baltic nowadays, the isogonic lines are continually moving from east to west, in accordance with the secular variation. In the western parts of the chart, the annual change is about 10', and in the south-eastern parts 8', corresponding to a change during three years of 30' in the western parts and of 24' in the south-eastern parts. By simply changing the figures of the 1/2° isogonic lines, the chart can easily be made to refer to each of the three years 1937, 1940, and 1943. (The process mentioned is illustrated by less heavy figures at the bottom of the lines on the chart). In the western part of the chart, no appreciable errors will result by doing this, but within the south-eastern parts, an error of about 0° 1 will appear and of half a tenth of a degree in the north-eastern parts. These errors are too small to cause any error of influence in practical work.

It should be emphasized, perhaps, that errors in the system of smoothed isomagnetic lines do not influence the accuracy of the scaled values, since they are as great as the corresponding defects in the differences shown by the symbols.

The chart will immediately indicate, in every part of the area shown, how far the scaled values have been determined from observations. The distribution of the symbols of different kinds readily gives appraisal of the features of the magnetic anomalies. Furthermore, it is possible to add values from new stations (after reduction to the epoch of the chart) without altering the earlier data which appear on the chart.

I am fully aware of the inconvenience of using both interpolation and correction to obtain a desired value, but I think that in many cases such inconvenience will be fully compensated by the advantages over magnetic charts of the conventional type with " true " and often very confused isomagnetic lines.

When constructing a chart of this type, the greatest difficulty arises from the lack of a general definition of the " normal " values. If some international agreement on this matter could be adopted, so that the same principles were used in adjacent countries when computing the " normal " values, it would be possible to obtain charts of larger areas by simple juxtaposition of the charts of such countries. The choice of the symbols and of their gradation would, of course, always be left to personal judgement, but in all other respects such a chart could be made in a quite objective and uniform manner. Nevertheless, comparisons between charts constructed according to the method outlined would be much facilitated even without such agreement.

The main practical advantages of this type of chart may be summarized as follows :

Within surveyed areas, disturbed and undisturbed regions are clearly distinguished, and the average amplitudes of the irregularities may easily be estimated.

Areas which are sufficiently undisturbed for checking the ship's deviation and for taking bearings with the compass with satisfactory accuracy, are distinguished.

The chart clearly shows to what extent the values given are ascertained by observation, each observation being indicated by a dot. Where no dots are shown, observations are lacking (as on a mariner's chart in parts without soundings).

Within unsurveyed areas, the most probable value is given.

Even on small scale charts, most of the details of practical importance may be indicated.

It is possible to add values from new station and to change the epoch of the chart (within certain limits) without altering the details already given.

Symbols have the advantage over figures in that they immediately show the magnitude of the disturbances if their size is so chosen as to give the impression of proportionality to the eye.

The chart can be made in a comparatively objective manner, and charts constructed on similar principles can be compared by simple juxtaposition.

Objections have been raised against the new type of isogonic chart on the ground that it would be too difficult to understand for the ordinary sailor. I cannot share this opinion. The average magnetic conditions can be determined in exactly the same way on the new chart as on the conventional ones, and the details seem to be more clearly and completely indicated on it. In reality the necessary instructions are quite simple to understand, especially if the meaning of the explanations be exemplified, as above.

The mariner's compass is of the greatest value only when used in conjunction with as complete and clear as possible magnetic charts, and the trial in practice of the type of chart described, promised by the Swedish Hydrographic Service, will, perhaps, prove to be a step in the right direction.