tends to suggest a reduction by some three-tenths of a minute (to 34!5) on the second day; it may be noted that his curve for this day passes above both the points which represent the two observations closest to the horizon. Such a change would alter the second residual from −1!5 to −1!8, but the average residual for the three days would be altered only from −1!1 to −1!2, and the general nature of the result would be unchanged.

Such deviations at the horizon are only to be expected, and are quite insufficient to warrant a deduction that there is anything wrong with the standard values.

Why not Graphical Sight Reduction?

from Robert W. Byerly

MR. J. B. PARKER, in his review of *Sight Reduction Tables for Air Navigation*, published on pages 98–103 of Vol. VII of this *Journal*, states that the time required by him to resolve a three-star fix by means of A.P. 3270 is 10 minutes (p. 100). He comments on the 'errors due to the plotted fix being a hundred or more miles behind the aircraft's position' (p. 101). Later he says: 'An accuracy of sight reduction of anything better than certainly 5 minutes of arc, and more logically 10 minutes of arc, will therefore be wasted on a navigator flying with present-day instruments in a fast modern aircraft in high latitudes' (p. 102).

If Mr. Parker has correctly summarized the needs of an aircraft navigator, which I have no reason to doubt, it would seem that graphical methods of sight reduction should be considered more seriously than they have been in the past. A considerable number of such methods have been devised, all with the object of reducing the time required for sight reduction at the expense of some loss in accuracy. Many of them give an accuracy well within Mr. Parker's limit of 10 minutes of arc and a time of sight reduction well below the 10 minutes required by A.P. 3270.

The simplest and most direct graphical method of sight reduction of which I am aware is one which I devised during the war and brought to the attention of the U.S. Coast & Geodetic Survey. The Survey provided the charts needed in my method. They are known as Equatorial Gnomonic Projection, C. & G. S. Chart No. 3062, and Polar Equatorial Gnomonic Projection, C. & G. S. Chart No. 3063. All that is required, in addition to the gnomonic charts themselves, is an overlay of transparent markable material pivoted at the centre of each chart.

To obtain a line of position from sight and Nautical Almanac data by means of these charts, it is necessary only to plot three points and sketch one short line. With a little practice the time required may be reduced to less than a minute. An example will make this plain:

Figs. 1–3 show part of a 10°-equatorial gnomonic network with a transparent overlay pivoted at its centre, and illustrate resolving a sight from the following data: Observed and corrected altitude, 20°; D.R. position, N. 31° W. 19°; Sun's G.H.A. 85°, Dec. S. 6°.

The first step is to plot the Sun and the dead reckoning position on the transparent overlay, as shown in Fig. 1.

In the second step, shown in Fig. 2, the overlay is turned on its pivot to bring the two plotted points on the same meridian of the network. The observed zenith distance (70°) is laid off along this meridian from the Sun point. At the end of this distance, a point is plotted, and a short line is drawn through the point parallel to the nearest parallel of latitude on the network.

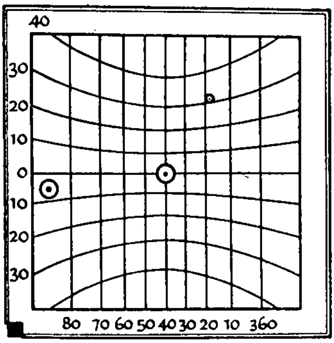

Fig. 1.

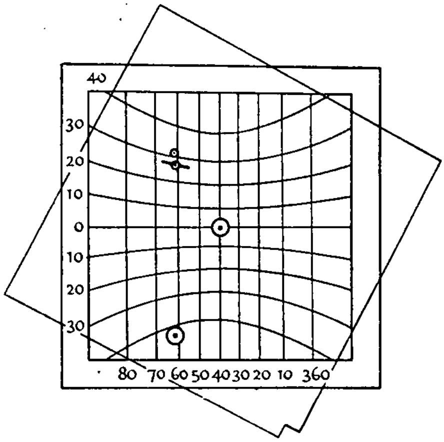

Fig. 2.

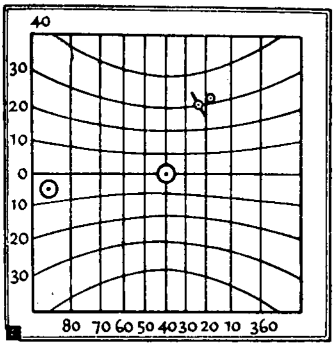

Fig. 3.

The third step, shown in Fig. 3, consists in returning the overlay to its original position. The short line drawn in the second step is the line of position, and can easily be transferred to the navigating chart by observing its points of intersection with meridians or parallels close to the dead reckoning point.

The C. & G. S. charts have 1° networks measuring about 18 in. by 18 in. With them, there is no difficulty in plotting and reading to 10 minutes of arc. Any navigator who is interested in testing this can easily do so by obtaining C. & G. S. Chart No. 3062 (price 10 cents), covering it with a piece of tracing paper, and putting a pin or tack at the centre for a pivot. It is well to reinforce the centre of the paper with a small piece of Scotch tape.

During the war, the Survey put out a small quantity of so-called 'Byerly Navigation Devices' which consisted merely of C. & G. S. Charts Nos. 3062 and 3063 mounted on opposite sides of a piece of sheet aluminium with an acetate sheet overlying each chart and pivoted at the centre of the aluminium sheet. They were tried by a number of aviators during the war and proved

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satisfactory, but their accuracy, which was about 10 nautical miles, was then considered too low to justify their general adoption.

If, as Mr. Parker writes, an accuracy of 10 miles is all that is required in celestial navigation in modern aircraft, this navigation device would seem to fill the present needs by giving that degree of accuracy and at the same time radically simplifying sight reduction.

Mr. Sadler comments:

I am glad that Mr. Byerly has called the attention of readers of the *Journal* to his method of sight reduction using C. & G. S. Charts Nos. 3062 and 3063. This ingenious method possesses the great merit of simplicity of principle; it uses directly the fact that the position line is part of the small circle of position centred at the sub-stellar point and radius equal to the (corrected) zenith distance. The direct measurement on the chart of distances of up to, say, 80° naturally involves large size and small scale; if these are acceptable, then the method offers an exceedingly fast means of sight reduction marred only by the necessity of transferring the position lines, or fix, to the navigating chart.

Mr. W. A. Scott points out that this method can be used on any axial projection on to a tangent plane to the Earth's surface, including both the orthographic and the stereographic. The meridians will of course no longer be straight lines, but this is no great disadvantage compared to the possible advantages of a conformal projection.

Mr. Byerly writes:

Like Mr. Scott, I thought that it might be better to use a conformal projection in which the line of position could be drawn perpendicular to the azimuth. After using a gnomonic projection for some time, I secured a stereographic projection from the C. & G. S. and tried it. My personal experience was that the facility and accuracy with which two points can be set on a straight line in the gnomonic chart considerably outweighed the advantage of conformality. Furthermore, the wide variation in the gnomonic scale to some extent meets Mr. Sadler's criticism of the smallness of the scale, for it is usually possible to number the meridians so as to place the plotted points in the outer part of the chart where the scale is quite large.

Plotting Sights with the Douglas Protractor

from F. K. Humphreys

THE 10-in. Douglas protractor can be modified to reduce the time taken to plot astronomical sights in the following manner. Two narrow slots are cut parallel to the central E.–W. line, and ¾ in. each side of it, from the central N.–S. line to the western margin of the graticule.

To plot the sight, the intercept is marked on the centre line, measuring from the centre to the west, by comparison with the scale of the chart. The centre of the protractor is placed on the assumed position and the required azimuth (read on the inner reciprocal scale) aligned with the parallel of latitude—to the eastern side for intercepts towards and to the western side for away. Marks are then made on the chart through each of the slots, opposite the pencilled intercept distance, and joined to give the position line.