FORUM

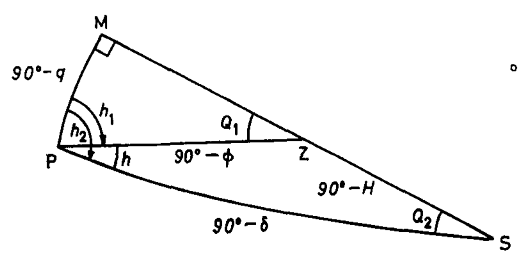
A Note on Short-method Tables

D. H. Sadler

In my article (this *Journal*, **1**, 290, 1948) on *The Provision for Astronomical Navigation at Sea* I called attention (p. 302) to the possible advantages of dividing the standard PZS triangle of astronomical navigation into two right-angled (or quadrantal) triangles by a perpendicular (or quadrantal arc) from the pole P to ZS, or ZS produced. In particular I wrote 'the method is one which might be further explored, . . .'; it is only recently that I have had occasion to do so. As far as I have been able to discover from the material available to me (including, by courtesy of Captain Charles H. Cotter, a copy of the typescript of his *A History of Nautical Astronomical Tables*), the only published method or tables using this principle is 'Tables for the Abbreviated Computation of Zenith Distance and Azimuth of Celestial Bodies', by Frane Flego (Split, 1957). Unfortunately, as pointed out by W. A. Scott and myself in a review article (this *Journal*, **11**, 207, 1958), Captain Flego failed to overcome some of the technical difficulties of the method.

There are two main difficulties: the first is that the two components into which the local hour angle is divided are not initially known; and the second is that the resulting formulae and tables have singularities. However, I am now able to state with reasonable probability that these difficulties can be overcome and that a practical method, comparing favourably with other 'short' methods, could readily be developed. In order to make such an assertion it has been necessary to make an error-analysis of the procedure, to prepare an outline design of the tables and to consider the 'rules' for combining the quantities in the various cases that can arise. The error-analysis is complicated, and I give no details here; but I think the error limits are correct, except possibly very close to the zenith.

I describe the method in relation to the combination of signs illustrated in the



PM $= 90° - q$ MS $= 90° - H_2$

ZS $= 90° - H$ H $= 90° + H_2 - H_1$

MZ $= 90° - H_1$ $h = h_2 - h_1$

FIG. 1

https://doi.org/10.1017/S0373463300039175 Published online by Cambridge University Press

diagram, with latitude (ϕ) and declination (δ) of the same name; the local hour angle $(h) = h_2 - h_1$, and the altitude $(H) = 90° + H_2 - H_1$. Suffixes 1, 2 refer respectively to the latitude triangle PMZ and to the declination triangle PMS. The first step is to obtain approximate values of h_1, h_2 or q to facilitate entering the tables; it is suggested that this can be done by sliding a Favé-style diagram (for declination) over an identical diagram (for latitude) through a distance corresponding to h. The point of intersection of the curves corresponding to the given values of δ and ϕ gives the corresponding values of h_2 and h_1, as ordinates, and of q as the common abscissa. A scale of one degree = 1 mm would seem to be adequate. By duplicating the diagrams (for example, to cover declinations of opposite name and hour angles greater than 90°), the positions of the diagrams can be used to indicate precisely how h_1 and h_2, H_1 and H_2 are to be combined and how the azimuth angle (Q_1) may be converted to true azimuth.

For each integral degree of ϕ (and of δ) a table gives, to 0'.1, the four quantities

$$h_1, q_1; H_1, Q_1$$

By obvious symmetry the entries can be read in reverse order to give

$$Q_1, H_1; q_1, h_1$$

This reversal enables the singularities at the pole and the zenith to be avoided by using a non-uniform interval of tabulation in h_1; this is possible because no interpolation is required in the table itself. Considerable economy of tabulation is also possible since the table need be continued, in its direct form, only as far as $h_1 = \sin^{-1} (1 + \sin \phi)^{-1/2}$; but some extension would probably be desirable in practice. The main interval in h_1 could well be 30′, but there is no reason why this should not be varied to meet requirements of presentation.

The table for ϕ is entered with the approximate value of h_1, and that for δ with the approximate value of h_2; the combination of the tabular arguments h_1 and h_2 that makes q_1 and q_2 most nearly equal is chosen, provided (as will be almost always so) that $h_2 - h_1$ is within about half-a-degree of h. Then the tables give:

for latitude ϕ: h_1, q_1;	H_1, Q_1 = azimuth angle
for declination δ: h_2, q_2;	H_2, Q_2 = parallactic angle
and for LHA $h = h_2 - h_1$:	altitude $H = 90° + H_2 - H_1$

Interpolation is required to the exact declination $\delta + \Delta\delta$ and, if plotting from the DR position, to the DR latitude $\phi + \Delta\phi$ and DR longitude corresponding to LHA $h + \Delta h$; the corrections, which are identical in form (this being one of the main advantages of the method), are simply:

for declination	$\Delta\delta \cos Q_2$
for latitude	$\Delta\phi \cos Q_1$
for longitude	$\Delta h \cos q_1$ (or $\cos q_2$)

It must be noted that q_1 and q_2 need not be equal, since the first-order corrections to H_1 and H_2 arising from the correction θ to h_1 and h_2, necessary to make them equal, cancel. θ should not exceed half the larger of the two tabular intervals in h_1 and h_2, and, with a maximum of 15′, the error in H will rarely exceed 0'.1; the corresponding errors in Q_1 and Q_2 will rarely, if ever, exceed 0°.2 corresponding to errors in H of not more than 0'.1.

Although Captain Flego took full advantage of this latter point, he did not utilize the fact that the pairs h, q and H, Q can be reversed. I am not aware of any method or table in which this is *used*, but Aquino specifically calls attention to the possibility of interchange and gives appropriate table headings in his *Sea and Air Navigation Tables*, 1938. Full advantage of the reversal cannot be taken when the PZS triangle is divided by perpendiculars from Z or S; but some benefit appears possible.

I give no numerical examples since these cannot be fully illustrated. However the maximum discrepancy in altitude, before interpolation for declination, in the examples I have done using Aquino's 1938 tables (at an interval of 1° in h_1 and h_2) is $0'.2$.

Before writing such a note as this, an author has a duty to examine published material and to refer to relevant work; in this case it is a formidable task and I cannot believe that such references do not exist. I await with interest their revelation; in anticipation I quote one of the many manuscript annotations made by Admiral Radler de Aquino in my valued copy of his 1938 tables: he writes (in connection with a minor acknowledgment) 'This is the first time I mention this: *Errare humanum est.*'

Automatic Radar Plotters: the Importance of the Future Position Control

Captain F. J. Wylie, O.B.E., R.N.(ret.)

ANYONE who has read articles by the present writer about automatic radar plotters but has not handled at sea one of those systems in which the vector lengths are time-correlated and have a fine (minute-by-minute) adjustment, might think that they tend to exaggerate its importance as an aid to realistic and rapid appraisal. I hope that the pictorial presentation which follows may serve to reverse such opinions even though, with still pictures, it is difficult to create the sense of a continuous and rapid series of brief manual movements and mental assessments.

Far from needing elimination, as suggested by Riggs (*Journal*, **28**, 143), the rapidly extensible vectors lend apparent acceleration to the radar picture, which always changes so slowly on the PPI, and thus convey with verisimilitude a sense of the predicted movement of the entire complement of echoes in their proper mutual relationship. Further, in situations demanding particular care or perhaps a change of course or speed, they can be used to give a rapid forecast of the probable duration of the emergency.

In the seven figures which follow, the situation represented is one in which own ship (O) has two ships (A and B) crossing from starboard and one (D) crossing from port; a fourth ship (C) is overtaking from the starboard quarter. The caption on each figure is important. Figures 1, 2 and 4 (true plot) and 3 (relative plot) represent the appraisal, although the pause after Fig. 1 is hardly necessary; evasive action is planned on 2, taken on 5 (true plot) and course resumed on 6 (true plot), with a final check on 7 (relative).

Of course the verbiage makes this sound complicated but it has to be remembered that changes of plot method are instantaneous while changes of vector length take only a second or two. The vector lengths chosen here are quite