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TWO-STAR FIX

A LETTER TO THE EDITOR

from Rear Admiral Robert W. KNOX, USC&GS (Ret)
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Sir,

Dr Stjepo KOTLARIĆ, Assistant Director of the Hydrographic Institute of the Yugoslav Navy, has computed and published a series of tables — K_{11} — for the direct computation of a ship's position by the observation of two stars; articles explaining the method have appeared in the *I.H. Review* [1], [2], [3]. The method is a model of simplicity and with the use of available work forms and a familiarity with the computation a fix may be computed within a very few minutes. More than a dozen fixes by this method were checked against the rigid formulas appearing in the Introduction of the volumes and used in the computation of the tables — some actual, others simulated, including a few with differences between assumed and actual positions as much as a degree. The average difference between the two methods was less than a half-minute of arc, thus verifying the accuracy of the tables.

However, these tables limit the navigator in his choice of stars to one of four pairs, and the use of an unlisted pair might be desirable or necessary; by computation, a pair could be selected from the 40 or so navigation stars whose hour angles and declinations are listed in the Nautical Almanac. DOZIER's method [4] for a two-star fix involves the successive solution of seven formulas, two of which are merely additions or subtractions. These sine-cosine formulas are preferred over those of the haversine used in Tables K_{11} because considerably fewer operations are involved. Such a solution by logarithms would be tedious, but with a pocket calculator the time element probably would be no longer than that required for the computation of two lines of position by the classic Marcq St. Hilaire method.

If the observations are not simultaneous, corrections for the apparent motion of the first star and the speed and course of the vessel between sights may be calculated by the simple formulas found in any standard text book on navigation. Furthermore, a fix by the two-star method is computed on the sphere, which inherently is more accurate than one plotted on a chart by the intersection of lines of position.

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(Signed) R.W. KNOX
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Dr. KOTLARIĆ writes :

"I am grateful to Admiral Knox for his remarks on the limited number of star pairs in K_{11}, as he has stimulated me to advance plans for their modification. This limitation was in fact observed before the first Volume was despatched (1971), but the manuscript was already computed and typed on IBM-1130 for all five Volumes. The modification is planned for the next edition, or in a possible republication by some foreign issuing agency, and will show for each opening of the Tables (left and right page) 8 different star pairs without increasing the number of pages. Every page will give 4 star pairs within the same range of 20° LHA Aries, but divided separately for each 10° range. The smaller range of LHA Aries allows the listing of a larger number of stars. 8 different star pairs for every assumed position should be quite sufficient for navigation practice, and indeed sometimes it is difficult to find more star pairs forming well-shaped triangles and avoiding high altitudes and small differences in azimuth and SHA.

Regarding the use of a pocket calculator for direct solution of the two-star fix, I am just preparing a paper for submission to the *I.H. Review*, analysing the solution of that problem by the non-programmed Texas Instruments SR-50 and the programmed Hewlett Packard HP-65. For computation of Hc, Zn and Altitude Difference alone, the SR-50 needs 36 steps and 156 button pressings (this includes conversion of entering arguments to decimal degrees), while the HP-65 with its magnetic card Nav-Pac 1-19A needs only 9 steps and 38 button pressings. However, for direct computation of the complete two-star fix from simultaneous observations, the HP-65 needs 39 steps and 190 pressings, even when the program card Math.Pac. 1-23A is used. It is also necessary to make a sketch of the star situation and to apply rules to determine parallactic angle and LHA. Besides, the navigator must be skilful in his selection of stars to avoid a small change in the observed altitude making a large change in the coordinates of the fix.

Therefore, until the capacity of these pocket gadgets further approaches that of their bigger electronic brothers, their application for the two-star fix seems limited. However, a pocket calculator *could* be useful once a selection of star pairs and the first half of their resultant relations are published in the Nautical Almanacs (see *I.H. Review*, July 1975, p. 166). The Almanacs could give all usable star pairs for direct computation of the two-star fix.

The above assessment applies to *simultaneous* observations of two stars; in practice, non-simultaneous observations (i.e. by one observer) predominate, and in that case, although the classic formula for correction of the first star's altitude for time elapsed between observation ($dHo = -dt \cdot \cos Lat \cdot \sin Z$) is simple to solve on a pocket calculator, there is the special difficulty of taking the compass azimuth of the first star. For high altitude stars this almost impossible. Tables K_{11}, on the other hand, allow for non-simultaneous observations, the correction for elapsed time being inserted directly into the coordinates of the observer's zenith."

REFERENCES

[1] KOTLARIĆ, S. : New methods of ship position finding from celestial observations. *Int. Hydr. Review,* XXXIII(1), May 1956, pp. 97-119.

[2] KOTLARIĆ, S. : Two-star fix without use of altitude difference method. *Int. Hydr. Review,* XLVIII(2), July 1971, pp. 93-115.

[3] KOTLARIĆ, S. : Simplification in observation and computation of a two-star fix. *Int. Hydr. Review,* LII(2), July 1975, pp. 157-167.

[4] *American Practical Navigator* (H.O. Pub. 9). N. BOWDITCH, 1958 edition, pp. 548-549.