TWO-STAR FIX WITHOUT USE OF ALTITUDE DIFFERENCE METHOD

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This paper deals with a direct method for computation of the coordinates of a ship's position from the observation of two selected stars without the need to use the altitude difference method known as the Marcq St. Hilaire method.

The St. Hilaire method is the one most generally used in the practice of navigation today. This method was worked out ninety-five years ago and during this relatively long period of time no modifications to it have been made except in the way of computing altitude and azimuth. Many short method tables have been published to date in order to simplify the computation of altitude and azimuth : one such was devised by the author in 1958 and under the title "Tables K 1" was published by the Yugoslavian Hydrographic Institute. But the St. Hilaire method is an indirect one, since once the altitudes and azimuths of two celestial bodies have been computed it is necessary to carry out an additional procedure (either graphical or mathematical) in order to obtain the coordinates of the observed position. Thus the availability of a direct method is of interest.

DESCRIPTION OF THE DIRECT METHOD

In the direct method, from simultaneous observations of two stars we know their sidereal hour angles declinations and observed altitudes. From the first spherical triangle PnJ_1J_2 (see figure 1) the angle A and the interstellar distance (90°-Vx) can be computed by means of the difference of sidereal hour angles (SHA_1-SHA_2) of the two stars observed and their declinations (D_1 and D_2) from the formulae :

$$\sin^2 \frac{90° - Vx}{2} = \sin^2 \frac{D_2 - D_1}{2} + \sin^2 \frac{SHA_1 - SHA_2}{2} \cos D_2 \cos D_1 \qquad (1)$$

$$\sin^2 \frac{A}{B} = \operatorname{cosec}\,(90^\circ - Vx)\,\sec D_2\,\cos R\,\sin\,(R - D_1) \tag{2}$$

$$R = \frac{D_1 + (90^\circ - Vx) + D_2}{2}$$

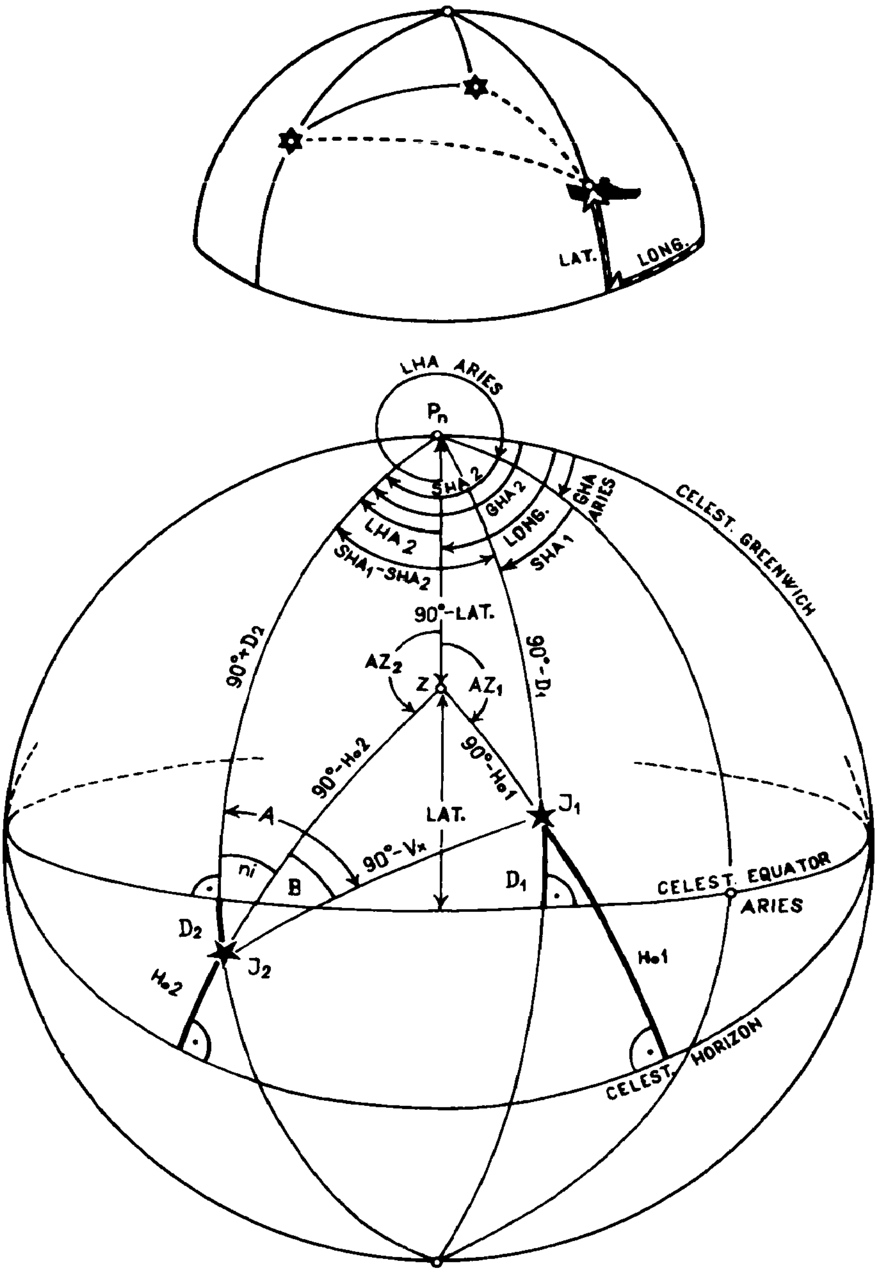


FIG. 1

From the second spherical triangle ZJ_1J_2 the angle B can be computed with the observed altitude Ho_1 and Ho_2 and the interstellar distance (90°-Vx) from the formula :

$$\sin^2 \frac{B}{2} = \text{cosec}\,(90^\circ - Vx)\ \sec Ho_2\ \cos R\ \sin (R - Ho_1) \qquad (3)$$

$$R = \frac{Ho_1 + (90^\circ - Vx) + Ho_2}{2}$$

This angle B, combined with angle A, gives the parallactic angle *ni* from one of the following relations, depending on the relative positions of the zenith and the two stars.

$$ni = A + B, \quad ni = A - B, \quad ni = B - A, \quad ni = 360^\circ - (A + B) \qquad (4)$$

Finally, from the third spherical triangle P_nZJ_2 (using the declination D_2, the observed altitude Ho_2 and the parallactic angle *ni*) the local hour angle LHA_2 of the second star and the LATITUDE of the observer can be computed from the formulae :

$$\sin^2 \frac{90^\circ - LAT}{2} = \sin^2 \frac{Ho_2 - D_2}{2} + \sin^2 \frac{ni}{2} \cos Ho_2 \cos D_2 \qquad (5)$$

$$\sin^2 \frac{LHA_2}{2} = \text{cosec}\,(90^\circ - D_2)\ \sec LAT\ \cos R\ \sin (R - Ho_2) \qquad (6)$$

$$R = \frac{Ho_2 + (90^\circ - D_2) + LAT}{2}$$

By subtracting the Greenwich hour angle GHA_2 for the second star from the local hour angle LHA_2 for the same star, the observed LONGITUDE and its sign (— for longitude W, and + for E) are determined. Attention must be paid to the fact that the second star must not be chosen in the vicinity of the observer's meridian.

Non-simultaneous sights on two stars may also be used for the direct computation of the observer's position. The principle is the same as that mentioned above for the simultaneous observations of two stars. The only difference is that the observed altitude of the first star has to be corrected for the distance the ship has run between the first and second sights as well as for the apparent movement of stars between sights. It is preferable that the second star sight be taken within four minutes of the first.

CONSTRUCTION OF THE TABLES

The procedure for the logarithmic computation of five unknown elements (90°-Vx, A, B, LAT. and LHA_2) in the three spherical triangles is long and is therefore unsuitable for navigational use because modern practice aboard ship demands short and simple methods for finding a ship's position at sea. Tables K 11 have therefore been devised in order to make the direct computation of a ship's observed position both shorter and simpler. In this method the direct solution for the observed position is found without the need to compute the auxiliary values 90°-Vx, A, B and *ni*. Both the observed latitude and the local hour angle of the second star are obtained directly from these Tables, and the observed longitude is determined by subtracting the Greenwich hour angle of the second star from its local hour angle.

The tabulation of these results in Tables K 11 was possible through the use of constant values for the two stars' declinations and difference of sidereal hour angles. For the differences of minutes of arc between the given and the tabulated altitudes, as well as for changes in minutes of arc for declinations, and for sidereal hour angles occurring between the date of their tabulation and that of their observation the author gives correction indices in the Main Tables which are used to obtain corrections to the tabulated latitude and to LHA Aries. For these corrections the Multiplication Table (Table V) is used.

Fifteen years have passed since the first version of Tables K 11 appeared in the publication "New Methods of Ship's Position Finding from Celestial Observations", also written by the present author and issued by the Yugoslavian Hydrographic Institute. An article on these Tables appeared in the *International Hydrographic Review* for May 1956. If we compare it with the latest Tables K 11 we see that several alterations have been made since that version. Some of these changes have considerably improved the method and made it more practical, in particular the transfer of the tabulated altitudes from the margin into the body of the Tables and the elimination of the separate auxiliary tables formerly used for star selection and for finding the page where the stars are tabulated. The improvement has achieved a reduction in the number of pages and provides the possibility of tabulating the results of position data for selected latitude zones in a few volumes. It also supplies a simple method of correcting the first star's observed altitude both for the ship's run and for the apparent movement of stars between sights by including Tables III and IV expressly constructed for this purpose. Computer techniques have facilitated the introduction of these improvements and have enabled the Tables to be issued much earlier than was envisaged fifteen years ago.

To facilitate the selection of the pair of stars for observation, the computed position data of which are given in the Tables, as well as to make it easier to find the required page, Tables K 11 have been constructed so that the navigator will only have to open them at the page for the approximate dead reckoning latitude and the local hour angle of Aries corresponding to the approximate time of the intended observation.

After the observations of the two selected stars have been made, the Tables are entered on this same page, but using the line showing figures nearest to the observed altitudes Ho_1 and Ho_2. On this line the LHA Aries is read from the left hand column and the LAT. and LHA correction indices, with their signs, from the same line at the right. The Multiplication Table (Table V) is then used with the Latitude and LHA correction indices as entering arguments in order to obtain corrections to the tabulated Latitude and LHA Aries for differences in minutes of arc between the given and the tabulated values of the altitudes, declinations and sidereal hour angles. Correction of the first star's altitude for movement of the ship and for apparent movement of the stars between sights is rendered easy on account of the Tables III and IV. The example given illustrates this computation.

The computation of a ship's observed position with Tables K 11 is thus much shortened, and so finding the observed latitude and local hour angle has now become fairly similar to the method of finding the computed altitudes and azimuths from a dead reckoning position with the American Tables H.O. 214.

Each volume of Tables K 11 covers 10° of latitude. The five volumes for latitudes 0°-50° N are now being printed by the Hydrographic Institute of the Yugoslavian Navy, Split. Thirty-seven stars of the first, second and third magnitudes in 155 different star pair combinations are involved in these Tables. In order to facilitate finding the tabulated stars in the sky the star's azimuth is given at the head of the Tables for both the upper and lower limits of the 20° interval for LHA Aries. This interval is the same as that used for the "New Star Finder", a work by the present author published by the Yugoslavian Hydrographic Institute in 1967. The asterisk after the star's name at the head of the Tables indicates that the star is of the first magnitude. The stars' coordinates (declinations and sidereal hour angles) used in the construction of these Tables are those for 1 January 1970. The tabulated altitudes and azimuths of the first and second star are computed with the following formulae :

$$\sin^2 \frac{90^\circ - Ho_1}{2} = \sin^2 \frac{LAT - D_1}{2} + \sin^2 \frac{LHA\,\gamma + SHA_1}{2} \cos LAT \cos D_1 \quad (7)$$

$$\sin^2 \frac{90^\circ - Ho_2}{2} = \sin^2 \frac{LAT - D_2}{2} + \sin^2 \frac{LHA\gamma + SHA_2}{2} \cos LAT \cos D_2 \quad (8)$$

$$\sin^2 \frac{AZ_1}{2} = \operatorname{cosec} (90^\circ - LAT) \sec Ho_1 \cos R \sin (R - D_1) \quad (9)$$

$$R = \frac{D_1 + (90^\circ - LAT) + Ho_1}{2}$$

$$\sin^2 \frac{AZ_2}{2} = \operatorname{cosec} (90^\circ - LAT) \sec Ho_2 \cos R \sin (R - D_2) \quad (10)$$

$$R = \frac{D_2 + (90^\circ - LAT) + Ho_2}{2}$$

The local hour angle of Aries is computed according to the formula :

$$\text{LHA Aries} = LHA_2 - SHA_2 \quad (11)$$

where LHA_2 is the local hour angle of the second star computed by formula (6), and SHA_2 is the sidereal hour angle of the same star given at the top of the Tables. If SHA_2 is greater than LHA_2 then the following formula is used :

$$\text{LHA Aries} = (LHA_2 + 360^\circ) - SHA_2 \quad (12)$$

Tabulation of the correction indices IV_1 in the two grouped columns headed "Index LAT. Corr." and "Index LHA Corr." (i.e. the indices showing a change in LAT. and in LHA Aries for changes of + 1′ in the altitude $Ho_1(V_1)$) of the first star is deduced from the formulae :

$$IV_1 \text{ in the column of Index LAT Corr.} = \frac{\text{diff LAT}}{\Delta\, Ho_1}\, 100 \qquad (13)$$

$$IV_1 \text{ in the column of Index LHA Corr.} = \frac{\text{diff. LHA}\gamma}{\Delta\, Ho_1}\, 100 \qquad (14)$$

where the difference of latitude (diff. LAT.) is obtained by subtracting the tabulated latitude from that computed from formulae (1) to (5) using the value $Ho_1 + \Delta Ho_1$ for Ho_1. ΔHo_1 is obtained from the Tables by subtracting the Ho_1 given in the line for which indices are to be computed from the Ho_1 shown in the line below. The value for diff. LHA γ in equation (14) is obtained by subtracting the tabulated LHA Aries (found in the line for which the correction indices are to be computed) from the LHA Aries computed from formulae (1) to (6) and (11) to (12). In the Main Table for easier tabulation the correction indices are multiplied by 100, whereas in the Multiplication Table (Table V) the tabulated results are divided by 100.

Computation of the other correction indices (i.e. IV_2, ID_1, ID_2 and ISU) in the columns " Index LAT. Corr. " and " Index LHA Corr. " is carried out in a similar way. These indices represent respectively changes in Latitude and in LHA Aries for changes of + 1′ in the tabulated values for $Ho_2(V_2)$, Dec. 1, Dec._2 and SHA_1-SHA_2(SU). The value ΔHo_2 will be obtained in the same way as ΔHo_1, but using the values from column Ho_2. ΔD_1 and ΔD_2 are obtained by increasing or decreasing the tabulated declinations by 30′ according to whether the stars' declinations are in the process of increasing or decreasing. The value of — 30′ is taken for ΔSU. Greater consistency in the LAT. and LHA Aries corrections can be achieved in this way, due to a reduction in the difference between the actual coordinates of the stars and the coordinates used for computing the correction indices.

For computation of the Auxiliary Tables III and IV the following formulae are used :

$$\text{Table III A} = \frac{\text{knots}}{3\,600} \cdot t^s \qquad (15)$$

where t^s is the time expressed in seconds. The result, tabulated in Table IIIA, is used as the entering argument for Table IIIB.

$$\text{Table IIIB} = \text{value from Table IIIA} \cdot \cos\,(\text{AZ-C}) \qquad (16)$$

where AZ-C is the relative bearing of the first star (i.e. the difference between its true azimuth and the true course of the ship). The result obtained with Table IIIB is the correction to the first star's altitude for the movement of the ship between the first and second sights.

$$\text{Table IV A} = 60 \cdot \cos \text{LAT} \cdot \sin \text{AZ} \qquad (17)$$

The result tabulated in Table IVA is used as the entering argument for Table IVB.

$$\text{Table IVB} = \frac{\text{value from Table IVA}}{240} \cdot t^s \qquad (18)$$

The result obtained with Table IVB is the correction to the first star's altitude for the time elapsed between the first and second sights.

A criticism of the first version of the Tables was that the page width for the Main Table might have been somewhat reduced by eliminating the three correction indices (ID_1, ID_2 and ISU) for Latitude and LHA Aries, and by introducing a separate short table giving the corrections to the fix for the precession and nutation effects (as in the American Tables H.O. 249 for tabulated selected stars). In the Tables K 11, however, this modification has not been made because the introduction of the precession and nutation corrections to the fix would necessitate additionally supplying the users with an annual correction table, wherever these users might be in the world. Thus the author and publisher would have a constant obligation for the future, and moreover the navigator buying the Tables would risk not being supplied in time (or ever) with the future correction tables that form an indispensable part of the Tables bought for everyday use. Tables K 11, with all correction indices tabulated, is a manual complete in itself and accordingly independent of annual supplements.

ABBREVIATIONS EMPLOYED

A	Angle J_2 in triangle PnJ_2Z (see figure 1).
Alt.	Altitude.
Approx.	Approximately.
AZ	Azimuth (true).
B	Angle J_2 in triangle ZJ_2J_1 (see figure 1).
C	Course (true).
CE	Chronometer error on GMT.
CORR., corr.	Correction; corrections.
cortd.	Corrected.
CT	Chronometer time.
D_1, $Dec._1$	Declination of the first star.
D_2, $Dec._2$	Declination of the second star.
dec., d	Declination of a celestial body.
d. GMT	Difference of GMT between the second and first star observations.
diff., diff	Difference.
diff. D_1	Difference of declination for first star (obtained by subtracting its declination as found in the Main Tables of K 11 from that taken from the Nautical Almanac).

diff. D_2	Difference of declination for second star (obtained by subtracting its declination as found in the Main Tables of K 11 from that taken from the Nautical Almanac).
diff. Ho_1	Difference of altitude for first star (obtained by subtracting the tabulated altitude of the first star from its observed altitude).
diff. Ho_2	Difference of altitude for second star (obtained by subtracting the tabulated altitude of the second star from its observed altitude).
diff. SHA	Difference of sidereal hour angle (obtained by subtracting the value for SHA_1-SHA_2 shown at the top of the page in the Main Tables K 11 from the value for SHA_1-SHA_2 taken from the Nautical Almanac).
DR	Dead reckoning position.
E	East.
GHA♈	Greenwich Hour Angle of Aries.
GHA_2	Greenwich Hour Angle for second star.
GMT	Greenwich Mean Time.
GMT_1	Greenwich Mean Time for first star.
GMT_2	Greenwich Mean Time for second star.
HA, t	Hour Angle; meridian angle.
Ho_1	Observed altitude of first star.
Ho_1 cortd.	Observed altitude of first star, corrected both for ship's run and apparent movement of the stars between sights.
Ho_2	Observed altitude of second star.
h	Hours.
hs_1	Sextant altitude of first star.
hs_2	Sextant altitude of second star.
IC	Index correction of a sextant.
ID	The entering argument (multipliers ID_1 and ID_2) in Table V for obtaining the correction to the tabulated Latitude and LHA Aries for the minutes of arc in the declination differences (diff. D_1 and diff. D_2).
ID_1	Index, in the Main Tables, represents the correction to the tabulated Latitude and LHA Aries for a change of $+ 1'$ in the first star's declination, computed for the tabulated entering arguments and multiplied by 100. This is the entering argument (the multiplier) in Table V for obtaining the tabulated Latitude and LHA Aries correction for minutes of arc in the first star's declination difference, diff. D_1.
ID_2	The same definition as for ID_1, but with the second star's declination.
INDEX LAT. CORR., IND. LAT.	Indices IV_1, IV_2, ID_1, ID_2 and ISU for finding the corrections to the tabulated Latitude. (Refer to the individual definitions of these five indices).

INDEX LHA CORR., IND. LHA	Indices IV_1, IV_2, ID_1, ID_2 and ISU for finding the corrections to the tabulated LHA Aries. (Refer to the individual definitions of these five indices).
IV	The entering argument (multipliers IV_1 and IV_2) in Table V for obtaining the correction to the tabulated Latitude and LHA Aries for the minutes of arc in the altitude differences (diff. V_1 and diff. V_2).
IV_1	Index, in the Main Tables, represents the correction to the tabulated Latitude and LHA Aries for a change of + 1′ in the first star's altitude, computed for the tabulated entering arguments and multiplied by 100. This is the entering argument (the multiplier) in Table V for obtaining the tabulated Latitude and LHA Aries correction for minutes of arc in the first star's altitude difference, diff. Ho_1.
IV_2	The same definition as for IV_1 above, but for the second star's altitude.
ISU	Index, in the Main Tables, represents the correction to the tabulated Latitude and LHA Aries for a change of + 1′ in the tabulated value of SHA_1-SHA_2, computed for the tabulated entering arguments and multiplied by 100. This is the entering argument (the multiplier) in Table V for obtaining the tabulated Latitude and LHA Aries correction for minutes of arc in the sidereal hour angle difference, diff. SHA.
J_1	First star.
J_2	Second star.
kn	Knot(s).
LAT., LAT, Lat., L	Latitude.
LHA ARIES, LHA♈	Local Hour Angle of the First Point of Aries.
LHA_2	Local Hour Angle of the second star.
LONG., Long.	Longitude.
m	Minutes of time.
N	North.
ni	Parallactic angle (sometimes called position angle) between the polar and the zenith distance of the second star.
Pn	Pole, North (celestial).
S	South.
s	Seconds of time.
SHA_1	Sidereal Hour Angle of first star.
SHA_2	Sidereal Hour Angle of second star.
t, HA	Meridian angle; Hour Angle.
TABL., Tab.	Table.

tabulated	Tabulated value in the Main Tables K 11.
tab. SHA_2	Sidereal Hour Angle of second star tabulated at the top of the page in the Main Tables K 11.
Vx	Complement of the interstellar distance.
W	West.
Z	Zenith.
ZD	Zone description.
ZT	Zone time.
*	Star of the first magnitude.
♈	First Point of Aries.
90°-Vx	Interstellar distance; Angular distance between second and first star.
Δ	Difference.

INSTRUCTIONS FOR USE

Preliminary work

1. Using the approximate Greenwich Mean Time (GMT) for the intended observation, take the Greenwich Hour Angle of Aries (GHA♈) from the Nautical Almanac. Compute the approximate Local Hour Angle of Aries (LHA♈) by adding the dead reckoning longitude with its sign (+ if East, — if West).

2. With the approximate dead reckoning latitude and LHA♈ found in Step 1 above, turn to the pages in Tables K 11 which include these data. Each volume is for 10° of latitude.

3. Choose one of the four pairs of stars given either on the left or the right page, and take a sight on the first and then on the second star of this pair (the name of the first star is given on the left). The asterisk after the star's name indicates that the star is of first magnitude. The star's azimuth (AZ) is given at the head of the Tables for both the upper and lower limits of the interval of the LHA♈, and this can be used to facilitate finding the star in the sky.

4. Observations of the two stars can be made with any time interval up to 4 minutes. The second sight can be taken within a short interval if the altitude of the second star is measured approximately in advance. The approximate altitude and position of the second star will thus be known in advance, and this makes the second sight quicker to take. If the 4-minute interval is exceeded, and the observations cannot be repeated, then the first star's altitude should first be corrected from Tables III and IV for 4 minutes and then for the remainder of the time. (See Step 11).

5. Take the compass azimuth for the first star and convert it into true azimuth (AZ). In addition take note of the true course (C) and the speed of the ship.

6. Solve the problem by inserting the values in their respective places on the work form that is shown in the solution of the example and also printed in a special booklet sold with the Tables. This will make the procedure shorter and will reduce the possibility of making errors.

7. The position is being solved for the time of the second sight. From the Nautical Almanac, using the Greenwich date and the GMT for the second sight find the GHA♈ and the coordinates for both stars (declinations and sidereal hour angles) D_1, D_2 SHA_1 and SHA_2.

8. Find the value SHA_1-SHA_2 by subtracting the smaller value. If the result exceeds 180° subtract it from 360°.

9. Find the Greenwich Hour Angle of the second star (GHA_2) from the Nautical Almanac.

10. Determine the difference of GMT between the two sights (d.GMT), as well as the relative bearing for the first star (difference between the true azimuth and the true course (AZ-C) by subtracting the smaller value.

11. Correct the sextant altitude of the first star (hs_1) by Table I (or by Table II if a bubble sextant was used) to obtain the observed altitude Ho_1. If the two sights were taken at different times — these should be within four minutes of each other, see Step 4 — the observed altitude of the first star should now be corrected by Table III (A, B) and Table IV (A, B). The signs are given in the Tables and no interpolations are needed. The observed altitude for the first star, corrected for both the ship's run and apparent movement of stars between sights (Ho_1 cortd.) is thus obtained.

12. Correct the sextant altitude of the second star (hs_2) by Table I (or by Table II if a bubble sextant was used) to obtain the observed altitude Ho_2.

Use of the Main Tables and the Multiplication Table

13. Enter the Main Tables on the same page and for the same pair of stars as in Steps 2 and 3 above, but in columns Ho_1 and Ho_2 using the line showing figures nearest to the observed altitude Ho_1 (or Ho_1 cortd.) found in Step 11 and the Ho_2 found in Step 12.

— From this line take out :

(a) The tabulated values Ho_1 and Ho_2;

(b) LHA Aries (from the column to the immediate left of Ho_1);

(c) The correction indices IV_1, IV_2, ID_1, ID_2 and ISU, with their signs, from the columns " Index LAT. Corr. " and " Index LHA Corr. " (printed on the right of Ho_2). All the values printed without a sign are positive.

— From the top of the Table take out the Latitude.

— Insert all the values, with their signs, in their respective places on the work form (see solution of the example).

14. Find the differences, together with their signs, between the given and the tabulated values of the altitudes, declinations and sidereal hour angles :

Ho_1 (cortd.) — Ho_1 tabulated	= diff. Ho_1
Ho_2 — Ho_2 tabulated	= diff. Ho_2
D_1 — D_1 tabulated	= diff. D_1
D_2 — D_2 tabulated	= diff. D_2
(SHA_1 — SHA_2) — (SHA_1 — SHA_2) tabulated	= diff. SHA

15. For easier computation the positive and negative corrections should be grouped separately. Therefore insert the signs of the LAT. and LHA corrections in the work form after determining them by means of the signs for the differences (diff. Ho_1, diff. Ho_2, diff. D_1, diff. D_2, diff. SHA) obtained in Step 14 and of the signs of the corresponding correction indices (" Index LAT. Corr. " and " Index LHA Corr. ") taken from the Main Table, Step 13 (c). When these differences are positive the signs for the corrections are the same as those for the correction indices in the Main Table. When the differences are negative the signs will be the opposite ones.

16. Enter Table V (Multiplication Table given at the end of the volume) with the correction index IV_1 on the left and with the diff. Ho_1 in whole minutes and tenths of a minute at the top to find the required correction. First of all the correction to the tabulated Latitude is obtained by using the IV_1 of the Index LAT. Corr. Then using the IV_1 of the Index LHA Corr. the correction to LHA Aries is obtained. Insert the corrections in the work form immediately after the signs inserted in accordance with Step 15.

Do the same for the IV_2 and diff. Ho_2, ID_1 and diff. D_1, ID_2 and diff. D_2, ISU and diff. SHA. No mental interpolation is required.

17. Add the positive corrections to the values of Latitude and LHA Aries, and subtract the sum of the negative corrections, in order to obtain the true value for LATITUDE and LHA♈.

18. To the LHA♈ add the tabulated SHA_2 (Sidereal Hour Angle of the second star) taken from the top of the Main Table to obtain the LHA_2 (Local Hour Angle of the second star). If the LHA_2 is greater than 360°, deduct 360°.

19. Subtract the GHA_2 (obtained in Step 9) from the LHA_2 to obtain the LONGITUDE with its sign (— for West and + for East). If the result is greater than 180° subtract this from 360°, changing the sign.

Example 1

On 7 July 1951 the GMT 0120 dead reckoning position of a ship is Lat. 12° 10.9′ N, Long. 96° 41.0′ W. The ship is on course 270°, speed 24 knots. The true position is required from observation of two stars at approx GMT 0122, using Tables K 11. With the approx. GMT and DR Longitude the approx. LHA♈ 208° is obtained from the Nautical Almanac. Then with this and the approx. Lat. 12° N, Tables K 11 are opened and the star pair ANTARES-VEGA is chosen for observation. Sights are taken, firstly on Antares (hs_1 36° 07.5′, GMT $1^h\,20^m\,17^s$), and then Vega (hs_2 22° 25.8′, GMT $1^h\,22^m\,21^s$). The compass azimuth for Antares converted into true azimuth is 136°. The index correction for the sextant, IC, is 0′, and the height of eye 10 metres.

Find a fix at the time of the second sight.

Note : The extracts from the Auxiliary Tables (Tables I, II, III and IV), the Main Table, and the Multiplication Table (Table V) required for this example are printed on the pages that follow.

Solution by Tables K 11

		ANTARES		VEGA	
Approx.GMT	1^h22^m	GMT $1^h20^m17^s$		GMT $1^h\ 22^m21^s$	
GHA♈	299.2°	hs1	36°07.5′		
corr.	5.5	Tab.I	- 6.9		
GHA♈	304.7	Ho1	36°00.6′		
+Long.	-96.7 W	Tab.III	- 0.6		
LHA♈	208.0°	Tab.IV	+20.4	hs2	22°25.8′
			+ 0.7	Tab.I	- 8.0
GMT2	$1^h22^m21^s$	Hol cortd.	36°21.1′	Ho2	22°17.8′
-GMT1	1 20 17	-tabulated	-36 29.0	-tabulated	22 39.0
d.GMT	$2^m\ 4^s$	diff.Hol	- 7.9′	diff.Ho2	-21.2′
C	270°	Dec.1	-26°19.8′	Dec.2	+38°44.2′
AZ	136	-tabulated	∓26 22.1	-tabulated	±38 45.1
AZ-C	134°	diff.D1	+ 2.3′	diff.D2	- 0.9′
		SHA1	113°23.2′	GHA♈	299°11.7′
		-SHA2	81 10.1	corr.	5 36.2
		SHA1-SHA2	32 13.1	+SHA2	81 10.1
		-tabulated	-32 05.2	GHA2	385°58.0′
		diff.SHA	+ 7.9′		

diff.		IND. LAT.	LAT. + corr.	LAT. -corr.	IND. LHA	LHA Aries + corr.	LHA Aries -corr.
			12°00.0′N			208°30.0′	
Hol(V1)-	7.9′	-80	+ 6.3		+62		- 4.9′
Ho2(V2)-	21.2	+69		-14.6′	+75		-16.0
D1 +	2.3	+53	+ 1.3		-41		- 0.9
D2 -	0.9	+ 3		- 0	+ 3		- 0
SHA(SU)+	7.9	+54	+ 4.3		-42		- 3.3
			12°11.9′	-14.6′		208°30.0′	-25.1′
		LAT.	11°57.3′N		LHAT	208°04.9′	
					+tab.SHA2	81 1.6	
					LHA2	289 06.5	
					-GHA2	-385 58.0	
					LONG. -	96°51.5′W	

In order to compare both the procedure and the result of a ship's position obtained by another method — one that is widely used in today's practice — this same example is now computed with the American Table H.O. 214.

Solution by Tables H.O. 214.

	ANTARES		VEGA
GMT	$1^h20^m17^s$		$1^h22^m21^s$
GHA Aries for 1^h GMT	229°11.7′		299°11.7′
for 20^m17^s	5 5.1	(22^m21^s)	5 36.2
SHA★	113 23.2		81 10.1
GHA★	417 40.0		385 58.0
Long.	-96 41.0 W		-96 41.0 W
LHA★	320 59.0 360		289 17.0 360
t, HA	39° 1.0′E diff. 1.0′		70°43.0′E diff.17.0′
dec.	26°19.8′S diff.10.2′		38°44.2′N diff.14.2′
Lat.	12°10.9′N diff.10.9′		12°10.9′N diff.10.9′

	ANTARES	VEGA
Alt. tabulated	35°58.9′Δd+65,Δt-68	22°15.0′Δd-04,Δt+78
Correction t,d,L ...	- 1.9	+19.2
Hc (Computed Alt.)..	35°57.0′	22°34.2′
Ho (Observed Alt.)..	36 00.6	22 17.8
a (Altitude diff.).	+ 3.6′	-16.4′
Zn (Azimuth)........	136.0°	053.0°

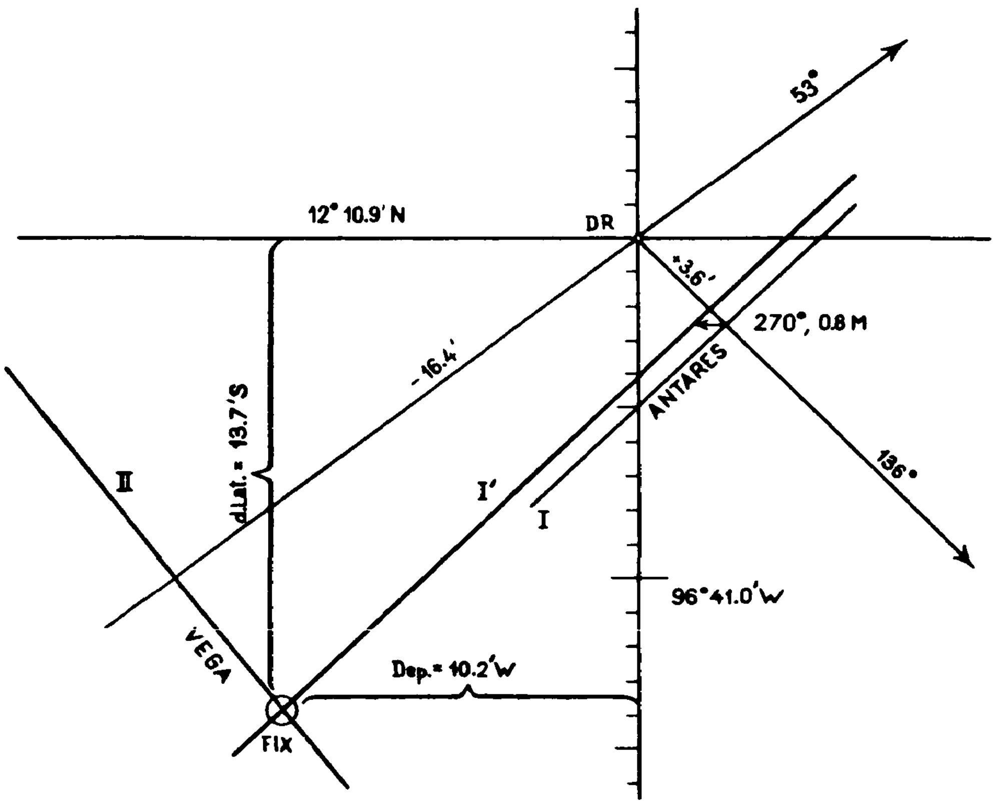
	ANTARES	VEGA
hs (Sextant Alt.)..	36°07.5′	22°25.8′
Total correction ..	- 6.9	- 8.0
Ho (Observed Alt.).	36°00.6′	22°17.8′

	+	-	+	-
t correction		0.7′	13.3′	
d correction	6.6′			0.6′
L correction		7.8	6.5	
Sum	6.6′	8.5′	19.8′	0.6′
Correction t,d,L ..		-1.9′	+19.2′	
Z (Azimuth angle)..	N 136.0°E		N 53.0°E	

GMT2	$1^h22^m20^s$	Speed ...	24 knots
-GMT1	1 20 17	Course ...	270°
d.GMT	$2^m\ 4^s$	Distance ..	0.8 Miles

For finding the coordinates of a ship's observed position from computed intercepts (altitude differences) and azimuths it is necessary to plot two position lines and to find the latitude and longitude of their intersection (see figure 2).

The Antares line of position is advanced 0.8 mile for a 2.1-minute run in the direction of the course, 270°, to obtain a fix at the time of the Vega sight.



DR Lat.	12°10.9'N	DR Long.	96°41.0'W	Dep	10.2'W
d. Lat.	13.7 S	d. Long.	10.4 W	d.Long.	= Dep.sec Lat
FIX: Lat.	11°57.2'N	Long.	96°51.4'W		= 10.2 . 1.02
					= 10.4'W

FIG. 2

The extracts from Tables K 11 (page 111) are given, not only so that the computation of the present example may be possible, but also to give the reader a clear picture of the appearance of the tables included in this celestial navigation manual. The extracts from Tables I, II, III, IV, the Main Tables, and Table V are here shown in reduced size.

UKUPNI POPRAVAK IZMJERENE VISINE ZVIJEZDA
(TOTAL CORRECTION OF SEXTANT ALTITUDE OF STARS)

TABLE I

ZA POMORSKI SEKSTANT
(MARINE SEXTANT)

App. Alt.	First corr.	Height of Eye	Second corr.
Visina izmje-rena	Prvi popr.	Visina oka	Drugi poprav.
° ′	′	met. (ft)	′
6 20	-8.1	0.5 (1.6)	-1.3
6 30	7.9	1 (3.3)	1.8
22 00	-2.4	10 (33)	-5.6
24 00	2.2	11 (36)	5.9
36 00	-1.3		
90 00	0.0	500 (1640)	-39.7

TABLE II

LIBELNI SEKSTANT
(BUBBLE SEXTANT)

App. Alt.	Total corr.
Visina izmje-rena	Ukupni popra-vak
° ′	′
6 20	-8.1
6 30	7.9
6 40	7.7
28 00	-1.8
30 00	1.7
90 00	0.0

TABLE III

POPRAVAK VISINE PRVE ZVIJEZDE ZA PREVALJENI PUT DO ČASA OSMATRANJA DRUGE ZVIJEZDE
(FIRST STAR ALTITUDE CORRECTION FOR MOVEMENT OF VESSEL UNTIL SECOND STAR SIGHT)

A

VRIJEME IZMEĐU DVA OSMATRANJA	BRZINA U ČVOROVIMA (SPEED IN KNOTS)																	INTERVAL BETWEEN SIGHTS
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	40	
0^m00^s	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.C	0.0	0^m00^s
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.	0.1	10
20	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.	0.2	20
30	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.	0.3	30
2 00	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1	1.3	2 00
10	0.1	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1	1.4	10
20	0.1	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.9	0.9	1.0	1.1	1.2	1	1.6	20
4 00	0.1	0.3	0.4	0.5	0.7	0.8	0.9	1.1	1.2	1.3	1.5	1.6	1.7	1.9	2.0	2.1	2.7	4 00

B

PRAMČANI KUT PRVE ZVIJEZDE AZ-K			VRIJEDNOST IZ TABL.III A (VALUE FROM TABL.III A)																					AZIMUTH RELATIVE TO COURSE AZ-C	
			0.1	0.2	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2	2.7			
			POPRAVAK U LUČNIM MINUTAMA (CORRECTION IN MINUTES OF ARC)																						
°	°																						°	°
000	360	+	0.1	0.2	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1		2.7	−	180	180
005	355	+	0.1	0.	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1		2.7	−	175	185
010	350	+	0.1	0.	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1		2.7	−	170	190
045	315	+	0.1	0.1	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.5		1.9	−	135	225
050	310	+	0.1	0.1	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.2	1.3	1.4		1.7	−	130	230
055	305	+	0.1	0.	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.2	1.		1.6	−	125	235
060	300	+	0.1	0.	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.		1.4	−	120	240
065	295	+	0.0	0.	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.		1.1	−	115	245
070	290	+	0.0	0.	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.		0.9	−	110	250
075	285	+	0.0	0.	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.		0.7	−	105	255
080	280	+	0.0	0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.		0.5	−	100	260
085	275	+	0.0	0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.		0.2	−	095	265
090	270	+	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.		0.0	−	090	270

TABLE IV

TABL.IV (A B) POPRAVAK VISINE PRVE ZVIJEZDE ZA PROTEKLO VRIJEME DO ČASA OSMATRANJA DRUGE ZVIJEZDE
(FIRST STAR ALTITUDE CORRECTION FOR THE TIME ELAPSED UNTIL SECOND STAR SIGHT)

A

AZIMUT / AZ / FI ŠIRINA	-324 -216 / +144 +036	'1 9 / 1 9	-320.5 -219.5 / +140.5 +039.5	-320 -220 / +140 +040	-319.5 -220.5 / +139.5 +040.5	-319 -221 / +139 +041	-318.5 -221.5 / +138.5 +041.5	-318 -222 / +138 +042	-317.5 -222.5 / +137.5 +042.5	-317 -223 / +137 +043	-316.5 -223.5 / +136.5 +043.5	-316 -224 / +136 +044	-315.5 -224.5 / +135.5 +044.5	-315 -225 / +135 +045	AZIMUTH / AZ / LAT LATITUDE
10° '	34.7	?	37.6	38.0	38.4	38.8	39.2	39.5	39.9	40.3	40.7	41.1	41.	41.8	10° '
10 30	34.7	1	37.5	37.9	38.3	38.7	39.1	39.5	39.9	40.2	40.6	41.0	41.	41.7	10 30
11	34.6	1	37.5	37.9	38.3	38.6	39.0	39.4	39.8	40.2	40.5	40.9	41	41.7	11
11 30	34.6	)	37.4	37.8	38.2	38.6	39.0	39.3	39.7	40.1	40.5	40.8	41	41.6	11 30
12	34.5		37.3	37.7	38.1	38.5	38.9	39.3	39.7	40.0	40.4	40.8	4?	41.5	12
12 30	34.4		37.3	37.7	38.0	38.4	38.8	39.2	39.6	40.0	40.3	40.7	4	41.4	12 30
13	34.4		37.2	37.6	38.0	38.4	38.7	39.1	39.5	39.9	40.2	40.6	4	41.3	13
19	33.4		36.1	36.5	36.8	37.2	37.6	38.0	38.3	38.7	39.1	39.4	39.8	40.1	19
19 30	33.2		36.0	36.4	36.7	37.1	37.5	37.8	38.2	38.6	38.9	39.3	39.6	40.0	19 30

B

VRIJEME IZMEĐU DVA OSMATRANJA	VRIJEDNOST I PREDZNAK IZ TABL.IV A (VALUE AND SIGN FROM TABL.IV A)										INTERVAL BETWEEN SIGHTS
	30		35	36	37	38	39	40	0.8	0.9	
			POPRAVAK U LUČNIM MINUTAMA (CORRECTION IN MINUTES OF ARC)								
m s											m s
0 00	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0 00
10	1.3		1.5	1.5	1.5	1.6	1.6	1.7	0.0	0.0	10
20	2.5		2.9	3.0	3.1	3.2	3.3	3.3	0.1	0.1	20
30	3.8		4.4	4.5	4.6	4.8	4.9	5.0	0.1	0.1	30
2 00	15.0		7.5	18.0	18.5	19.0	19.5	20.0	0.4	0.5	2 00
10	16.3		9.0	19.5	20.0	20.6	21.1	21.7	0.4	0.5	10
20	17.5		).4	21.0	21.6	22.2	22.8	23.3	0.5	0.5	20
30	18.8		.9	22.5	23.1	23.8	24.4	25.0	0.5	0.6	30
4 00	30.0		35.0	36.0	37.0	38.0	39.0	40.0	0.8	0.9	4 00

B

TABL.IV B NASTAVAK

TABL.IV B CONTINUED

POPRAVAK ZA 9S
(CORRECTION FOR 9S INTERVAL)

VRIJEME IZMEĐU DVA OSMATRANJA	IZ TABL.IV A (FROM TABL.IV A)					
	30	33	36	39	42	44
S	POPRAVAK (CORRECTION)					
1	0.1	0.1	0.2	0.2	0.2	0.2
2	0.3	0.3	0.3	0.3	0.4	0.4
4	0.5	0.6	0.6	0.7	0.7	0.7
9 INTERVAL BETWEEN SIGHTS	1.1	1.2	1.4	1.5	1.6	1.7

Extract from Tables K 11 ANTARES-VEGA

12° N FI (LAT.)	ANTARES *	VEGA *	SU1 - SU2 = 32 05.2 113 06.8 - 81 01.6 (SHA1-SHA2)									
ARIES	AZ 130-145 D1 -26 22.1	AZ 052-051 D2 +38 45.1	(INDEX LAT. CORR.) INDEKSI POPRAVAKA FI					(INDEX LHA CORR.) INDEKSI POPRAVAKA MS				
MS (LHA)	V1 (HO1)	V2 (HO2)	IV1	IV2	ID1	ID2	ISU	IV1	IV2	ID1	ID2	ISU
° ′	° ′	° ′										
200	30 26′3	16 1′5	-81	77	46	-4	61	63	68	-35	-3	-47
200 30	30 48′5	16 24′8	-81	77	46	-3	60	63	69	-36	-3	-47
201	31 10′6	16 48′2	-81	77	47	-3	60	63	69	-36	-3	-47
201 30	31 32′6	17 11′6	-81	76	47	-2	60	63	69	-36	-2	-46
202	31 54′6	17 35′0	-81	76	47	-2	59	63	70	-37	-2	-46
202 30	32 16′4	17 58′4	-81	75	48	-2	59	63	70	-37	-1	-46
203	32 38′1	18 21′8	-81	75	48	-1	59	63	70	-37	-1	-45
203 30	32 59′6	18 45′2	-81	74	49	-1	58	63	71	-38	-1	-45
204	33 21′1	19 8′5	-81	74	49	0	58	63	71	-38	0	-45
204 30	33 42′5	19 31′9	-81	73	49	0	58	63	71	-38	0	-45
205	34 3′7	19 55′3	-81	73	50	0	57	62	72	-39	0	-44
205 30	34 24′9	20 18′7	-81	72	50	1	57	62	72	-39	1	-44
206	34 45′9	20 42′1	-81	72	51	1	56	62	73	-39	1	-44
206 30	35 6′8	21 5′5	-80	71	51	2	56	62	73	-40	2	-43
207	35 27′5	21 28′9	-80	71	51	2	56	62	73	-40	2	-43
207 30	35 48′2	21 52′3	-80	70	52	2	55	62	74	-40	2	-43
208	36 8′7	22 15′7	-80	70	52	3	55	62	74	-41	3	-43
208 30	36 29′0	22 39′0	-80	69	53	3	54	62	75	-41	3	-42
209	36 49′3	23 2′4	-80	69	53	3	54	62	75	-41	4	-42
209 30	37 9′4	23 25′8	-80	68	53	4	54	62	75	-42	4	-42
210	37 29′3	23 49′1	-80	68	54	4	53	62	76	-42	5	-41
210 30	37 49′1	24 12′5	-80	67	54	5	53	62	76	-42	5	-41
211	38 8′8	24 35′8	-80	67	55	5	52	62	77	-43	6	-41
211 30	38 28′3	24 59′1	-80	66	55	5	52	62	77	-43	6	-41
212	38 47′7	25 22′5	-80	66	55	6	51	62	77	-43	6	-40
212 30	39 6′9	25 45′8	-79	65	56	6	51	62	78	-44	7	-40
213	39 26′0	26 9′0	-79	64	56	6	50	62	78	-44	7	-40
213 30	39 44′9	26 32′3	-79	64	57	6	50	62	79	-45	8	-39
214	40 3′6	26 55′6	-79	63	57	7	49	62	79	-45	8	-39
214 30	40 22′2	27 18′8	-79	63	58	7	49	62	80	-45	9	-39
215	40 40′6	27 42′1	-79	62	58	7	49	63	80	-46	9	-38
215 30	40 58′8	28 5′3	-79	62	58	8	48	63	81	-46	10	-38
216	41 16′9	28 28′5	-79	61	59	8	48	63	81	-47	10	-38
216 30	41 34′7	28 51′7	-79	60	59	8	47	63	82	-47	11	-37
217	41 52′4	29 14′8	-79	60	60	8	46	63	82	-48	12	-37
217 30	42 9′9	29 38′0	-79	59	60	9	46	63	83	-48	12	-37
218	42 27′2	30 1′1	-79	58	61	9	45	63	83	-49	13	-36
218 30	42 44′3	30 24′2	-79	58	61	9	45	63	84	-49	13	-36
219	43 1′3	30 47′3	-79	57	61	9	44	63	84	-50	14	-36
219 30	43 18′0	31 10′3	-79	56	62	10	44	64	85	-50	14	-35
220	43 34′5	31 33′4	-79	56	62	10	43	64	85	-51	15	-35

TABLE V

TABL.V POPRAVAK ŠIRINE (FI) I MJESNOG SATNOG KUTA (MS) ZA RAZLIKE VISINA, DEKLINACIJA I SUREKTASCENZIJA TABL.V
(LATITUDE AND LHA CORRECTIONS FOR DIFFERENCES IN ALTITUDES, DECLINATIONS AND SIDEREAL HOUR ANGLES)

IV ID ISU	dif. V1, V2, D1, D2, SU											(diff. Ho1, Ho2, D1, D2, SHA)												
	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'	20'	21'	30'	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.	0.4	0.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.	0.6	0.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.	0.8	0.8	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0	1.0	1.1	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
6	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.5	0.6	0	1.2	1.3	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
41	0.4	0.8	1.2	1.6	2.1	2.5	2.9	3.3	3.7	4.1	4.5	8.2	8.6	12.3	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4
42	0.4	0.8	1.3	1.7	2.1	2.5	2.9	3.4	3.8	4.2	4.6	8.4	8.8	12.6	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4
51	0.5	1.0	1.5	2.0	2.6	3.1	3.6	4.1	4.6	5.1	5.6	10.2	10.7	15.3	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5
52	0.5	1.0	1.6	2.1	2.6	3.1	3.6	4.2	4.7	5.2	5.	10.4	10.9	15.6	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5
53	0.5	1.1	1.6	2.1	2.7	3.2	3.7	4.2	4.8	5.3	5.	10.6	11.1	15.9	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5
54	0.5	1.1	1.6	2.2	2.7	3.2	3.8	4.3	4.9	5.4	5	10.8	11.3	16.2	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5
55	0.6	1.1	1.7	2.2	2.8	3.3	3.9	4.4	5.0	5.5	6	11.0	11.6	16.5	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5
61	0.6	1.2	1.8	2.4	3.1	3.7	4.3	4.9	5.5	6.1	6.7	12.2	12.8	18.3	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.6
62	0.6	1.2	1.9	2.5	3.1	3.7	4.3	5.0	5.6	6.2	6.8	12.4	13.0	18.6	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.6
63	0.6	1.3	1.9	2.5	3.2	3.8	4.4	5.0	5.7	6.3	6.9	12.6	13.2	18.9	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.6
69	0.7	1.4	2.1	2.8	3.5	4.1	4.8	5.5	6.2	6.9	7.6	13.8	14.5	20.7	0.1	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.6
70	0.7	1.4	2.1	2.8	3.5	4.2	4.9	5.6	6.3	7.0	7.7	14.0	14.7	21.0	0.1	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.6
75	0.8	1.5	2.3	3.0	3.8	4.5	5.3	6.0	6.8	7.5	8.3	15.0	15.8	22.5	0.1	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.7
76	0.8	1.5	2.3	3.0	3.8	4.5	5.3	6.1	6.8	7.6	8.4	15.2	16.0	22.8	0.1	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.7
77	0.8	1.5	2.3	3.1	3.9	4.6	5.4	6.2	6.9	7.7	8.5	15.4	16.2	23.1	0.1	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.7
78	0.8	1.6	2.3	3.1	3.9	4.7	5.5	6.2	7.0	7.8	8.6	15.6	16.4	23.4	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.6	0.7
79	0.8	1.6	2.4	3.2	4.0	4.7	5.5	6.3	7.1	7.9	8.7	15.8	16.6	23.7	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.6	0.7
80	0.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2	8.0	8.8	16.0	16.8	24.0	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.6	0.7
99	1.0	2.0	3.0	4.0	5.0	5.9	6.9	7.9	8.9	9.9	10.9	19.8	20.8	29.7	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
100	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	20.0	21.0	30.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9

Example 2. Work form for direct finding of a two-star fix with Tables K 11

Date May 4, 1969, zone time 22^h, zone description -4^h

Dead Reckoning Lat. $35^\circ 14'$N Long. $65^\circ 44'$W

Compass AZ of 1^{st} star ______, var. ____, dev. ____, True AZ 56.5°

Compass Course ______, True Course 206.5°, speed 8 kn, h.eye___, IC___

		1. VEGA		2. ARCTURUS	
Approx. LAT.	35° N		h m s		h m s
Greenwich date	May 5, 1969	CT		CT	
		CE		CE	
Approx. GMT	2^h05^m	GMT1	$2^h02^m00.0^s$	GMT2	$2^h05^m02.0^s$
Approx. GHA♈	252.8°	hs1	°		
corr.	1.3	IC			
		Tab.I or II			
Approx. GHA♈	254.1				
+Long.	- 65.7 W	Ho1	20°12.4′		
Approx. LHA♈	188.4°	Tab.III	- 0.4	hs2	
		Tab.IV	+30.5	IC	
			+ 0.3	Tab.I or II	
GMT2	$2^h05^m02.0^s$	Ho1 cortd.	20°42.8′	Ho2	62°29.5′
-GMT1	2 02 00.0	-tabulated	-20 43.0	-tabulated	-62 52.5
d.GMT	$3^m02.0^s$	diff.Ho1	- 0.2′	diff.Ho2	-23.0′
C	206.5°	Dec.1	+38°44.9′	Dec.2	+19°20.3′
AZ	56.5	-tabulated	±38 45.1	-tabulated	±19 20.0
AZ-C	150.0°	diff.D1	- 0.2′	diff.D2	+ 0.3′
		SHA1	81°01.3′	GHA♈	252°46.2′
		-SHA2	146 25.7	Corr.	1 15.7
		SHA1-SHA2	65°24.4′	+SHA2	146 25.7
		-tabulated	-65 24.1	GHA2	400°27.6′
		diff. SHA	+ 0.3′		

diff.	IND. LAT.	LAT. +corr.	LAT. -corr.	IND. LHA	LHA Aries +corr.	LHA Aries -corr.
		35°00.0′N			188°30.0′	
Ho1(V1) - 0.2′	+ 98		- 0.2′	+ 67		- 0.1′
Ho2(V2) - 23.0	- 94	+21.6		+ 76		-17.5
D1 - 0.2	- 43	+ 0.1		- 32	+ 0.1	
D2 + 0.3	+ 61	+ 0.2		- 49		- 0.1
SHA(SU) + 0.3	+ 68	+ 0.3		+ 45	+ 0.1	
		35°22.2′	- 0.2′		188°30.2′	-17.7′
	LAT.	35°22.0′N		LHA♈	188°12.5′	
				+tab. SHA2	146 25.7	
				LHA2	334 38.2	
				-GHA2	-400 27.6	
				LONG. -	65°49.4′W	

Note : In Example 1 the observation data have been taken from Tables H.O. 214, vol. II, 1952 Edition, and in Example 2 from E.M. WEYER's annual " Two-star position finding ", 1969 Edition.

An extract from the Main Tables K 11 required for the solution of Example 2 is given below.

Extract from Tables K-11

35° N FI (LAT.)	VEGA*	ARCTURUS*	SU1 - SU2 = 65 24.1 81 01.6 - 146 25.7 (SHA1-SHA2)									
ARIES	AZ 052-060 D1 +38 45.1	AZ 109-139 D2 +19 20.0	(INDEX LAT. CORR.) INDEKSI POPRAVAKA FI					(INDEX LHA CORR.) INDEKSI POPRAVAKA MS				
MS (LHA)	V1 (HO1)	V2 (HO2)	IV1	IV2	ID1	ID2	ISU	IV1	IV2	ID1	ID2	ISU
0 '	0 '	0 '										
180	15 2'0	56 30'2	113	-96	-62	55	75	49	89	-27	-51	31
180 30	15 21'6	56 53'4	113	-96	-62	55	75	50	88	-27	-50	32
181	15 41'3	57 16'5	112	-96	-61	56	75	51	87	-27	-50	32
181 30	16 1'1	57 39'6	111	-96	-60	56	74	52	86	-28	-50	33
188	20 22'5	62 30'9	99	-95	-49	61	69	66	77	-32	-49	44
188 30	20 43'0	62 52'5	98	-94	-48	61	68	67	76	-32	-49	45
189	21 3'5	63 14'0	97	-94	-47	62	68	68	75	-33	-49	46
189 30	21 24'1	63 35'4	96	-94	-46	62	67	69	75	-33	-49	47
200	28 45'9	70 15'9	66	-89	-27	73	49	95	61	-38	-50	67

CONCLUSION

To summarize, Tables K 11 give the coordinates of the observed position in a direct manner by tabulating precalculated values for three spherical triangles having the observer's zenith at the intersection of two circles of position.

A direct solution of the two-star fix by means of these Tables is obtained from this very complete book of computed position data without need for logarithmic operations, rules for signs, mental interpolation, and corrections to the fix when the plotted position lines do not coincide with the circle of position. Nor is there need to print supplements for the corrections to the fix for annual changes in the star coordinates. All such difficulties of computation inherent in methods using any of the other tables are avoided when Tables K 11 are used.

The text of Tables K 11 is bilingual — in the Servo-Croatian of Yugoslavia, and in English. Full explanations in English are also given in the body of the Tables themselves. (This is illustrated in the extracts printed in the present article). Thus any mariner with an understanding of English will find them easy to use.

A separate flying sheet is distributed with the Tables. This contains short instructions for use and shows the solution of an example; it is printed in colour to enable easier differentiation of the data taken from the Tables.

In addition blank copies of the work form can be purchased at the same time as the Tables and these enable the computations to be carried out more quickly and more easily.

Each volume of Tables K 11 has 400 pages. The format is 30 × 20 cm, and the price per volume 50.-N. dinars (4.-U.S. Dollars). d

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