18. METHODS

BOWDITCH, in the first edition of *The American Practical Navigator,* printed in 1802, provided for the work of the navigator at sea by the then known methods including ***lunars*** and ***time sights*** for longitude and ***noon*** or ***meridian altitude sights*** for latitude. Since the time of Bowditch there has been a gradual, but increasingly rapid, development of the science of navigation. Some thirty methods for finding the solution of the astronomical triangle have been published, and the required computations have been greatly simplified.

Experienced navigators may, and do, differ as to the method they prefer to use, but one should remember that *with any method:*

(1) A single observation gives only a line of position at right angles to the bearing of the body. There are as yet no practical methods for obtaining a fix from a single sight.

(2) To determine a line of position, the navigator must first observe, time, and correct the altitude; must determine from the Almanac the declination and the Greenwich hour angle of the observed body; and thereafter must find its local hour angle. There is no "short" method which can eliminate this part of the work, wherein many errors and blunders occur.

290. Old and new. The methods for computing the results of celestial observations taught in this Primer are the simplest and best at present available and are sufficient under all circumstances. Mention of other methods is for the information of the student when in contact with older navigators or when reading other books.

291. Special sights for latitude are less important than in the past but are often convenient.

Noon sight for latitude by the meridian altitude of the sun is so simple and accurate that it continues to be used by all navigators. It does not require an exact knowledge of time and may be worked without tables other than those in the Almanac.

Latitude by Polaris is almost as simple to compute as by a noon sight of the sun. With one correction the true altitude of Polaris is the latitude of the observer.

Meridian altitudes of bodies other than the sun give latitude with equal exactness. Except for the problem of finding when the body will be on the meridian they are worked as is a noon sight. Navigators working with modern tables seldom use such sights because of the ease with which a line of position may be worked at any time without bothering with the time of transit.

Ex-meridians are sights for latitude taken when a body is near the meridian. Should the noon sight be lost owing to clouds or for other reasons, an ex-meridian altitude of the sun may be corrected and worked for latitude as is any noon sight. This ***reduction to the meridian*** was an important element of the old navigation but is practically obsolete for the same reason as are meridian altitudes of bodies other than the sun.

292. General methods. It is in this field that progress has been most rapid. Any one of the newer short methods serves to compute a line of position from any sight of a navigational body taken at any time.

Time sight (1763). This is the standard computation method of the old navigation and is widely used in the Merchant Marine. Latitude is assumed as that of the D.R. The difference between the local time, as computed from the observation, and the Greenwich time, as determined from the chronometer, gives the longitude, hence the name "time sight." Without any plotting the D.R. latitude and the computed longitude define a point of position. Such a point is correct only if the assumed latitude is correct. If two different latitudes are assumed and two points be computed, a line through the points is a line of position as accurate as that found by any method. Time sights, with supporting details which make the method practical, are fully discussed in Bowditch, where all necessary tables are given.

The time sight method is fairly long, must not be used within an hour or more of the meridian, and requires the use of apparent or sidereal time. It is not used in modern navy practice and, although it may be used for laying down a line of position, should be avoided by the student.

H. O. No. 203 (1923) and *H. O. No.* 204 (1925). These two bulky books tabulate almost 500,000 solutions of the astronomical triangle for hour angle (time sight) and azimuth. As with time sights, apparent or sidereal time is used and the tables should not be used within an hour of the meridian. Although popular when first published, this method may be considered as obsolete.

Marcq Saint-Hilaire or cosine-haversine. Strictly speaking, all the methods of the new navigation which plot a line of position by any process of altitude differences with the corresponding azimuth are Marcq Saint-Hilaire methods.

In the more common use of the term, a navigator saying he uses Marcq Saint-Hilaire means that he computes the calculated altitude by the *cosine-haversine* formula of Saint-Hilaire. This gives the intercept but the azimuth must be taken from azimuth tables or found by an additional computation.

This method came into general use in the Navy about 1910, was taught during the World War, and today remains in common use by navigators so trained. Although the method has been popular for many years, plots from the D.R. position, and requires few rules or precepts, it is somewhat long and is being supplanted by new methods which give both altitude and azimuth with less work.

The four methods next outlined are all based on the process of altitude differences proposed by Saint-Hilaire, but determine the computed altitude and the azimuth in different ways.

Line of Position Book, Weems (1927), is a small book of Japanese tables by Ogura which provide a short method for computing the altitude from an especially assumed trial position. It has had considerable publicity for aviation work and was used by Colonel Lindbergh, but seldom is used by surface navigators either because the line of position cannot be laid down from the D.R. or because the azimuth is taken from a diagram whereon it is easy to blunder.

H. O. No. 208, *Dreisonstok* (1928), is a book of about 90 pages. The tables provide for calculating altitude and azimuth from an especially assumed position with a minimum of figures and without interpolation. The assumed position must be of a whole degree of latitude and of a longitude to give a whole degree of hour angle. These *Navigation Tables for Mariners and Aviators,* with their accompanying instructions and examples, remain popular in the Navy and the Merchant Marine and with other navigators who adopted this method when first published.

H. O. No. 211, *Ageton* (1932), contains about 55 pages. This general method for computing the altitude and the azimuth of any body at any time is very popular (1940) and is that taught in Chapter 20. Ageton's *Dead Reckoning Altitude and Azimuth Tables* will be found in the Appendix. In many ways these tables are suitable for a beginner.

(1) Sights may be worked from the D.R. as an assumed position and the line of position may be plotted from that point.

(2) No interpolation is required.

(3) Azimuth is easily obtained.
(4) Solution is short, simple, and uniform under all conditions.
(5) The tables are convenient, universal, and inexpensive.

The Weems (Ogura), Dreisonstok, and Ageton methods illustrate the rapid development of small tables for conveniently computing the altitude and determining the azimuth from an assumed trial position.

H. O. No. 214, *Tables of Computed Altitude and Azimuth* (1936-1940). These tables consist essentially of tabulated solutions of the astronomical triangle, so arranged as to give the computed altitude and azimuth by inspection. The scheme of precomputing such values is not new; it is in scope, arrangement, and convenience of interpolation that these tables are unique. As planned, they are applicable to all sights of the navigational bodies. Vols. I, II, III, and IV, each for 10° of latitude from 0° to 39° (N or S) were available in May, 1940, and it is expected that all necessary volumes will be completed during that year. Each volume ($3.00) has about 280 large pages and the complete work will tabulate about three million solutions of the astronomical triangle.

168 **DECLINATION SAME NAME AS LATITUDE**

Lat. 36°

H.A.	20° 00′ Alt.	Δd Δt	Az.	20° 30′ Alt.	Δd Δt	Az.	21° 00′ Alt.	Δd Δt	Az.	21° 30′ Alt.	Δd Δt	Az.
°	° ′	Δd Δt	°	° ′	Δd Δt	°	° ′	Δd Δt	°	° ′	Δd Δt	°
00	74 00.0	1.0 03	180.0	74 30.0	1.0 02	180.0	75 00.0	1.0 03	180.0	75 30.0	1.0 03	180.0
1	73 58.4	1.0 07	176.6	74 28.5	1.0 07	176.5	74 58.4	1.0 08	176.4	75 28.4	1.0 08	176.3
2	73 54.0	99 12	173.2	74 24.1	99 12	173.0	74 53.8	99 13	172.8	75 23.7	99 13	172.6
3	73 46.9	99 16	169.9	74 16.8	99 17	169.6	74 46.2	99 17	169.3	75 16.0	98 18	169.0
4	73 37.0	98 21	166.6	74 06.6	98 22	166.2	74 35.8	98 22	165.8	75 05.2	97 23	165.4
05	73 24.5	97 25	163.3	73 53.6	97 26	162.8	74 22.5	97 27	162.4	74 51.5	96 27	161.9
6	73 09.3	96 30	160.2	73 38.0	95 30	159.5	74 06.4	95 31	159.1	74 35.1	94 32	158.2
7	72 51.5	95 33	157.1	73 19.9	94 34	156.5	73 47.8	94 35	155.9	74 16.0	93 36	155.2
8	72 31.5	93 37	154.2	72 59.4	92 38	153.5	73 26.7	92 38	152.9	73 54.5	91 40	152.1
9	72 09.3	91 41	151.3	72 36.7	90 41	150.6	73 03.6	90 42	149.9	73 30.7	89 43	149.1
10	71 44.9	89 43	148.6	72 11.9	88 45	147.8	72 38.1	88 46	147.1	73 04.8	87 46	146.2
1	71 18.8	88 47	145.9	71 45.1	87 48	145.2	72 10.9	87 48	144.4	72 36.9	86 49	143.5
2	70 50.8	86 50	143.5	71 16.5	85 50	142.7	71 41.8	85 51	141.8	72 07.2	84 52	140.9
3	70 21.0	84 52	141.0	70 46.3	83 53	140.2	71 10.9	83 54	139.4	71 35.8	82 55	138.5
4	69 49.9	83 55	138.7	70 14.5	81 55	137.9	70 38.7	81 56	137.0	71 02.9	80 57	136.1

Fig. 292. Excerpt from H. O. No. 214.

The appearance of these tables is indicated in Fig. 292, which shows an upper left corner of a large page. The tables are entered with nearest whole degree of latitude, nearest whole or half degree of declination, and nearest whole degree of hour angle. They are most convenient when the assumed position is of a whole degree of latitude and of a longitude to give a whole degree of hour angle as when using H. O. 208. In such a case, the tabulated altitude requires only the one correction for the exact declination, which is the general method for line of position now taught at Annapolis. The azimuth as obtained from the tables may be used for plotting lines of position without correction. H. O. 214 has other uses than finding the computed altitude and azimuth. It is a most complete azimuth table and its star identification tables are superior for use with modern methods. The description of the tables, and the instructions printed in each volume are unusually clear and will not be repeated except as they are reflected by an appropriate work form and the several examples in Chapter 23.

At present (1940), time has not permitted H. O. 214 to come into general use among other than navy navigators. It is evidently an important step in advance which will facilitate the work of many mariners. Only two openings of the tables are required, arithmetic for finding the computed altitude has been almost eliminated, and the azimuth is found by inspection. Thus it is not only the shortest method but the possibility of blunders is reduced. Officers familiar with the development of H. O. 214 in the U. S. Navy consider all of the older methods, including H. O. 208 and H. O. 211, to be obsolete. The extent to which its necessarily high price will limit the use of these wonderful tables remains to be determined.

* * *

The methods above discussed are a few of many which have been developed for obtaining the desired elements of the astronomical triangle. All are sufficiently accurate and all result in identical Sumner lines; not one can fix the position of the ship from a single observation. The newer tables facilitate and shorten a part of the work but in no case do they eliminate the necessity of understanding basic principles.