

Contents

Part I Analytical Approach to Navigation

1 Terrestrial Navigation	3
1.1 On the Design of Conformal-Mercator and Non-conformal Charts and Plotting Sheets	3
1.2 Rhumb-Line or Loxodrome Navigation	7
1.3 Approximations of Loxodromes by Straight Lines on the Plotting Sheet	11
1.4 Applications and Numerical Examples	14
1.5 Gnomonic or Great-Circle Navigation	20
1.6 Numerical Examples and More Chart Projections	24
2 Astro-navigation	29
2.1 Lines of Position, Position Fix, Navigational Triangle and Fix by Computation	29
2.2 Celestial Sphere, Equatorial and Horizon System of Coordinates, Navigational Triangle and the Ecliptic Coordinate System	34
2.3 Conclusions and Numerical Examples	42
2.4 The Use of the Exact Equations for Finding the Position at Sea or Air by Employing Two or More Altitude Measurements Together with the Corresponding Measurements of Time	44
2.5 Conclusions and Numerical Examples	59
2.6 An Exact Method Based on Cartesian Coordinates and Vector Representations	63
2.7 Numerical Examples and Conclusions	73
2.8 On Approximate Solutions for Finding the Position at Sea or Air by Employing Two or More Altitude Observations	77
2.9 An Approximate Method Based on Matrices and the Least Square Approximation	91
2.10 Sumner's Line of Assumed Position Method as Scientific Method	94

2.11	Numerical Example and Logarithmic Algorithm.	97
2.12	How an Approximate Position at Sea or Air Can Be Found if an Approximate Value for the Azimuth or the Parallax Angle Is Known in Addition to One Altitude.	103
2.13	On the Effect of a Change in Time on the Altitude and Azimuth.	110
2.14	How to Determine Latitude at Sea or Air Without the Use of a Clock	112
2.15	On Calculating the Interval Between Meridian Passage and Maximum Altitude and Finding Approximate Longitude and Latitude of a Moving Vessel, and Longitude by Equal Altitudes	116
2.16	To Find Latitude by Observing Polaris When Exact UTC and Longitude or an Approximation Is Available.	125
2.17	The Most Probable Position When Only One LOP and DRP Are Known	128
2.18	How to Calculate the Time of Rising and Setting of Celestial Objects and How to Use the Measured Time of These Phenomena to Find Longitude	133
2.19	On the Identification of Stars and Planets.	139
2.20	How to Navigate Without a Sextant.	147
2.21	On Finding Time and Longitude at Sea, the Equation of Computed Time (ECT), and Being Completely Lost	149
3	Methods for Reducing Measured Altitude to Apparent Altitude . . .	173
3.1	Navigational Refraction that Includes Astronomical Refraction for Low Altitude Observations	173
3.2	The Dip of the Horizon as a Function of Temperature and Pressure	185
3.3	Planetary Parallax and Semi-diameter of the Sun and Moon . . .	191
3.4	Time and Timekeeping.	196
3.5	On the Minimization Procedure for the Random Errors in Determining Altitude and Time	200
4	Some of the Instruments and Mathematics Used by the Navigator	209
4.1	Some of the Formulae and Mathematics Used by the Navigator.	209
4.2	Some of the Instruments Used by the Navigator.	230
 Part II Formulae and Algorithms of Positional Astronomy		
5	Elements of Astronomy as Used in Navigation	241
5.1	Some Basic Concepts Describing the Motion of the Earth Around the Sun	241

5.2	An Approximation to the Time of Transit of Aries at Greenwich and the Greenwich Hour Angle GHA of Υ	244
5.3	The Right Ascension of RA of the Mean Sun, Mean Longitude, Mean Anomaly, Longitude of Perigee, Longitude of Epoch and Kepler's Equation	245
5.4	The Equation of the Center, Equation of Time and True Longitude of the Sun	248
5.5	Numerical Examples and Other Concepts of Time	250
5.6	An Approximate Method for Finding the Eccentricity, the Longitude of the Perigee and the Epoch	253
5.7	Some Improved Formulae for the Equation of Time and Center	257
6	Qualitative Description: The Relevant Astronomical Phenomena . . .	259
6.1	On the Change of the Elements of the Orbit with Time	259
6.2	The Concept of the Julian Date (JD) and Time Expressed by Julian Centuries (T)	260
6.3	The Elements of Our Orbit as a Function of the Time T Expressed by Polynomials	265
6.4	Qualitative Aspects of Precession and Nutation	266
6.5	The Concept of Proper Motion for Stars	268
6.6	Aberration	269
6.7	Annual Stellar Parallax, Definitions of Mean, True and Apparent Place of a Celestial Object	271
7	Quantitative Treatise of Those Phenomena	275
7.1	Effects of Precession on the RA and the Approximate Method of Declination	275
7.2	Rotational Transformations and Rigorous Formulae for Precession	277
7.3	Approximate Formulae for the RA Θ and Declination δ as the Result of Two Rotations Only	280
7.4	Effects of Nutation on the RA and Declination	282
7.5	Effects of Proper Motion on the RA and Declination δ	285
7.6	Effects of Aberration on the RA and Declination δ	287
7.7	Effects of Annual Parallax on the RA and Declination δ	290
7.8	Calculating the Apparent RA and Declination δ , and the Equation of the Equinox	291
8	Ephemerides	295
8.1	Low Accuracy Ephemeris for the Sun, a Numerical Example . . .	295
8.2	Intermediate Accuracy Ephemeris for the Sun	297
8.3	Low Accuracy Ephemeris for the Stars	300
8.4	Intermediate Accuracy Ephemeris for the Stars	303

8.5	Compressed Low Accuracy Ephemeris for the Sun and Stars for the Years 2014 \pm	306
8.6	The Earth Viewed as a Gyro	308
Appendix A: Condensed Catalogue for the 57 Navigational Stars and Polaris		315
Appendix B: Greek Alphabet.		317
Appendix C: Star Charts		319
References		321
Index		325

Astronavigation

A Method for Determining Exact Position by the Stars

Zischka, K.A.

2018, XIX, 328 p. 101 illus., 8 illus. in color., Softcover

ISBN: 978-3-319-47993-4