

THE AIR ALMANAC 2015

Issued by
The Nautical Almanac Office
United States Naval Observatory
under the authority of the
Secretary of the Navy



Washington: 2014

AIM AND PRINCIPLE

1. *Object.* The object of *The Air Almanac* is to provide in a convenient form the astronomical data required for air navigation.

2. *Principle.* The position in the sky of an astronomical body can be determined from a knowledge of its Local Hour Angle (LHA) and its Declination (Dec.). The LHA is obtained by applying the longitude of the observer to the Greenwich Hour Angle (GHA). In this Almanac the GHA and Dec. of the Sun, Moon and planets are tabulated directly with Universal Time (UT) as argument. For celestial navigation, UT is equivalent to Greenwich Mean Time (GMT). For the stars the Dec. is given directly, but the GHA has to be formed by adding the tabulated Sidereal Hour Angle (SHA) to GHA Aries. The SHA and Dec. of the stars vary slowly and may be considered constant to a precision of 1'.5 for SHA, and 0'.9 for Dec. However, GHA Aries is tabulated for each 10^m. The *Sight Reduction Tables for Air Navigation* (Pub. No. 249, A.P. 3270) and other tables and instruments take advantage of the approximate fixity of the stars and use LHA Aries (or its equivalent) as argument.

3. *Layout.* This volume contains ephemeral data for the year, together with auxiliary tables and graphs, and a brief Explanation of the use of the volume. The daily pages contain data for the Sun, Aries, planets and Moon. The data for the 57 stars in the standard list are given on both the inside front cover and on the flap for convenience in use with the daily pages. The remaining tables, diagrams and explanatory material are arranged, as far as possible, in order of importance *backwards* from the end of the volume. The list of contents is given on the inside back cover.

DESCRIPTION AND USE OF DAILY PAGES

4. *Sun, Planets and Moon.* The data for each day are presented on a single sheet. The two sides of the sheet are identical in arrangement and give, for every 10^m of UT, the GHA and Dec. of the Sun, the GHA of Aries, and of the three planets most suitable for observation at that time, and the GHA and Dec. of the Moon. The Dec. of Aries is, by definition, zero and is not tabulated; further, the Dec. of the planets change so slowly that it is unnecessary to repeat the values more often than every hour.

The times of moonrise are given on the A.M. page, and of moonset on the P.M. page. Corrections for the Moon's parallax-in-altitude are given for the half day appropriate to each page.

The semidiameters of the Sun and Moon (required to correct observations made with a marine sextant), and the percent of the Moon's disk illuminated with waxing (+) and waning (−), are given on each page. The horizontal parallax of the Moon is the value occurring at the head of the P. in A. table. For the planets, the magnitudes are given immediately following their names in the column headings.

To facilitate computer input the hourly rates of change of the GHA and Dec. of the Sun, Moon and planets are given at the foot of the page. When a value for the hourly rate of the Moon's Dec. is marked with an asterisk, the value of the Dec. derived using this rate will be in error by at least 2' at the end of a six-hour interval.

With the exceptions that the Dec. of the Sun and Moon are given for every 10^m and a separate interpolation table is used for the Moon, the GHA and Dec. of the Sun, planets and Moon are taken out in an identical manner.

Beginning with the 2008 edition, tabular values of the GHA of the Moon are no longer adjusted; they are accurate to the precision printed. No adjustments have ever been made to the Sun and planets. The tabular values of Dec. (except for the Sun) are given to correspond to the mid-point of the following interval of time (10^m for the Moon, 1^h for the planets), making interpolation unnecessary. It is thus important always to take out the GHA and Dec. for the tabular UT immediately *before* the time of observation. For use with astro-trackers (see page A4), the GHA and Dec. of the Sun are given to 0'.1; *for general use, as in the Examples, it suffices to ignore this decimal instead of rounding off in the normal way.*

Examples. On 2004 January 1 at 07^h47^m16^s UT, the GHA and Dec. of the Sun, Venus and the Moon are found as:

	h m s	Sun		Venus		Moon	
		GHA ° /	Dec. ° /	GHA ° /	Dec. ° /	GHA ° /	Dec. ° /
A.M. page for 2004 Jan 1, (page A5), UT =	07 40	294 11	S.23 02	258 41	S.18 29	185 36	N.10 27
F3 (flap), increment for	<u>7 16</u>	<u>1 49</u>		<u>1 49</u>		<u>1 45</u>	
Sum = GHA	07 47 16	296 00		260 30		187 21	

The main entry is made for the line immediately before that of the UT required; the Dec. is taken, without interpolation, from either that line or (in the case of the planets) the top line of the block of six. The increment to GHA is always to be added.

The interpolation tables for the GHA (on the inside front cover and on the flap) are based on mean values for the increase in GHA during a time interval of 10^m; separate values on the right are used for the Moon. The tables are arranged as critical tables, and the increment, in ordinary type, is to be found opposite the interval in bold type (in the left-hand column for the Sun, Aries and planets, and in the right-hand column for the Moon) in which the difference of UT occurs; if the difference is an exact tabular value (e.g., 06^m31^s for the Moon), the upper of the two possible increments should be taken (i.e., 1°34'). This rule applies generally to all critical tables. *When GHA Sun (or Aries) is taken out to a precision of 0'.1, the interpolation tables on pages A164 and A165 must be used.*

5. *Stars.* The first step in finding the GHA of a star is to find GHA Aries; this is done in precisely the same way as for the Sun and planets, as in the paragraph above. For use with astro-trackers (see page A4) GHA Aries is given to 0'.1; *for general use, as in the Examples, it suffices to ignore this decimal instead of rounding off in the normal way.*

For normal use, the SHA and Dec. of the stars are taken directly from the list of stars on the inside front cover (repeated on the flap - F3), and the GHA is found from:

$$\text{GHA star} = \text{GHA Aries} + \text{SHA star}$$

The star list gives the number, name, magnitude, SHA and Dec. of the 57 stars selected for astronomical navigation, arranged in alphabetical order of proper name. An asterisk following the number in the first column indicates that the star is one of the 41 used in the *Sight Reduction Tables for Air Navigation* (Pub. No. 249, A.P. 3270) Vol. 1. A dagger (†) after the name indicates that the star may be used with the declination tables of Pub. No. 249 (A.P. 3270) Vols. 2 and 3. The stars are listed in numerical order on page F4 of the flap. A separate list of 173 stars is given to a precision of 0'.1 on pages A158–A163 for use with astro-trackers (see page A4).

Examples. On 2004 January 1 the GHA and Dec. of *Arcturus* (**37**) at 03^h56^m37^s UT and of *Sirius* (**18**) at 10^h58^m44^s UT are found as:

	<i>Arcturus</i>			<i>Sirius</i>		
A.M. page for 2004 Jan 1,	h	m s		h	m s	
(page A5) GHA Aries:	UT = 03	50	157 39	UT = 10	50	262 56
F3 (flap), GHA increment for	6	37	1 39	8	44	2 11
F3 (flap), SHA & Dec. of star*			146 02			258 40
Sum	03	56 37	305 20	10	58 44	523 47

N.19° 10' S.16° 43'

Multiples of 360° may be subtracted from the GHA though it is generally preferable to form LHA first (i.e., 523°47' = 163°47').

6. *Local Hour Angle.* LHA is found by applying longitude (east +, west –) to GHA

$$\text{LHA} = \text{GHA} + \text{east} (- \text{west}) \text{ longitude}$$

The LHA thus found may be more than 360°, or even 720°, or may be negative; multiples of 360° must be subtracted or added to bring the LHA between 0° and 360°. It is usual to plot sights from an “assumed” position, chosen so that the longitude will make the resulting LHA an integral degree. The following examples illustrate the various cases.

Examples. On 2004 January 1, the LHA of the Sun and Moon at 16^h33^m17^s UT in D.R. longitude W.59°03'; of Aries, *Aldebaran* (**10**) and *Pollux* (**21**) at 11^h02^m00^s UT in D.R. longitude E.165°58' are found as:

	UT	Sun	Moon	UT	Aries	<i>Aldebaran</i>	<i>Pollux</i>
	h m s	° '	° '	h m s	° '	° '	° '
Pages for 2004 Jan 1,							
(page A6, A5) GHA for	16 30	66 39	314 23	11 00	265 26	265 26	265 26
F3 (flap), increment for	3 17	0 49	0 48	2 00	0 30	0 30	0 30
F3 (flap), SHA stars*						290 57	243 36
Sum = GHA	16 33 17	67 28	315 11	11 02 00	265 56	556 53	509 32
Longitude (D.R., W.59°03')		-59 28	-59 11	(E.165°58')	+166 04	+166 07	+166 28
Sum = LHA		8	256		432	723	676
Multiples of 360°					-360	-720	-360
LHA		8	256		72	3	316

7. *Moon's P. in A.* The Moon's parallax-in-altitude correction, given in a critical table with altitude as argument, is to be added to the sextant altitude of the Moon. It should be applied at the same time as the other altitude corrections given on the back cover and facing page.

SPECIAL USE WITH ASTRO-TRACKERS

8. *General.* When an accuracy of better than one minute of arc (1') is required, as for example when using some form of astro-tracker, the values tabulated in *The Air Almanac* enable the GHA and Dec. of the Sun and stars to be taken out with a nominal accuracy of 0'.1.

The values of the GHA and Dec. of the Sun and GHA Aries are taken from the daily pages, in the usual way, for the 10^m immediately prior to the time of observation. No interpolation is required for the Sun's Dec., but increments must be added to the GHA of the Sun and Aries for the excess of the time of observation over the tabular 10^m. These increments must be taken from the interpolation tables on the inside front cover and the flap. These interpolation tables are based on mean values of the increments of GHA Sun (2°30'.0) and GHA Aries (2°30'.4) in 10^m.

Separate tabulations of the SHA and Dec., to a precision of 0'.1, of 173 stars are given on pages A158–A163. The values are tabulated for the middle of each month and no interpolation is necessary. GHA is found, as usual, by adding the SHA to GHA Aries.

*These figures are taken from the front cover of flap (F3) of *The Air Almanac* 2004, and as seen on page A7.

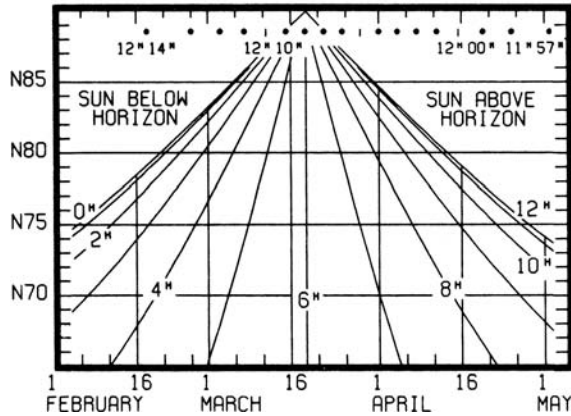
EXPLANATION

Extracts from the *Air Almanac* 2004, for use with the examples in the Explanation.

2 (DAY 001) GREENWICH P. M. 2004 JANUARY 1 (THURSDAY)												
UT	SUN		ARIES		VENUS-4.0		JUPITER-2.2		SATURN-0.5		MOON	
	GHA	Dec.	GHA	Dec.	GHA	Dec.	GHA	Dec.	GHA	Dec.	GHA	Dec.
16 00	59 09.3	S23 01.2	340 39.2		23 36	S18 21	170 23	N 5 31	240 09	N22 25	307 06	N12 11
10	61 39.2	01.1	343 09.6		26 06		172 53		242 40		309 32	13
20	64 09.2	01.1	345 40.0		28 36		175 24		245 10		311 57	15
30	66 39.1	01.1	348 10.4		31 06		177 54		247 41		314 23	17
40	69 09.1	01.0	350 40.8		33 35		180 25		250 11		316 49	19
50	71 39.0	01.0	353 11.2		36 05		182 55		252 42		319 15	21
17 00	74 09.0	S23 01.0	355 41.6		38 35	S18 20	185 26	N 5 31	255 12	N22 25	321 41	N12 24
10	76 39.0	00.9	358 12.0		41 05		187 56		257 42		324 06	26
20	79 08.9	00.9	0 42.4		43 35		190 26		260 13		326 32	28
30	81 38.9	00.9	3 12.9		46 05		192 57		262 43		328 58	30
40	84 08.8	00.8	5 43.3		48 35		195 27		265 14		331 24	32
50	86 38.8	00.8	8 13.7		51 05		197 58		267 44		333 49	34
18 00	89 08.7	S23 00.8	10 44.1		53 35	S18 19	200 28	N 5 31	270 15	N22 25	336 15	N12 36
10	91 38.7	00.7	13 14.5		56 04		202 58		272 45		338 41	38
20	94 08.6	00.7	15 44.9		58 34		205 29		275 16		341 07	40
30	96 38.6	00.7	18 15.3		61 04		207 59		277 46		343 33	42
40	99 08.5	00.6	20 45.7		63 34		210 30		280 16		345 58	44
50	101 38.5	00.6	23 16.1		66 04		213 00		282 47		348 24	46

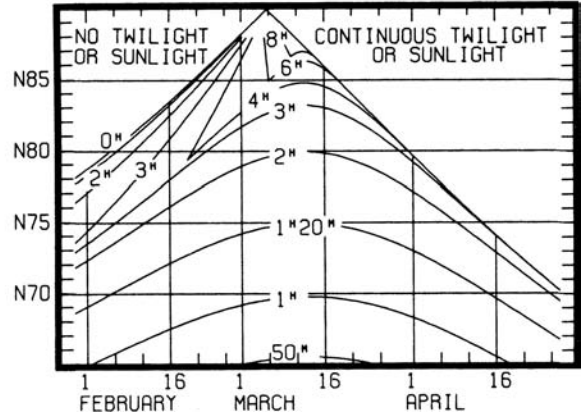
From page A153

SEMIDURATION OF SUNLIGHT



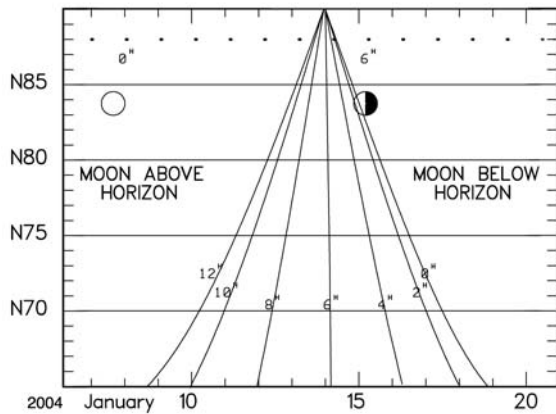
From page A154

DURATION OF TWILIGHT



From pages A130, A131 for 2004

SEMIDURATION OF MOONLIGHT



Sunrise				Morning Civil Twilight					
Lat.	Dec. 30		January 5		Lat.	Dec. 30		January 5	
	h	m	h	m		h	m	h	m
N40	07 21	07 22	07 22	07 22	N40	06 51	06 52	06 52	06 52
35	07 07	07 08	07 09	07 09	35	39	40	41	41
30	06 55	06 56	06 57	06 57	30	29	30	30	30
N20	06 34	06 35	06 36	06 36	N20	06 10	06 11	06 12	06 12

Sunset				Evening Civil Twilight					
Lat.	Dec. 30		January 5		Lat.	Dec. 30		January 5	
	h	m	h	m		h	m	h	m
N40	16 43	16 46	16 48	16 48	N40	17 14	17 16	17 19	17 19
35	16 57	17 00	17 02	17 02	35	25	28	30	30
30	17 10	17 12	17 14	17 14	30	36	38	40	40
N20	17 31	17 32	17 34	17 34	N20	17 55	17 56	17 58	17 58

The positions of the stars, planets, and Sun are shown for the fifteenth of the month.

☉ Sun

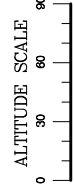
☾ MOON

- ① Position, 1st of month
- ② Position, 2nd of month
- etc.

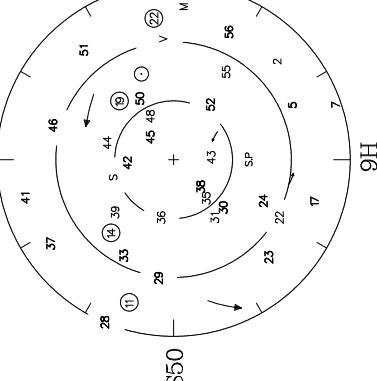
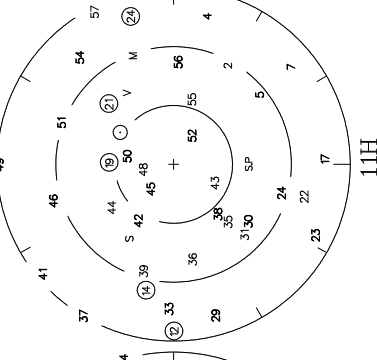
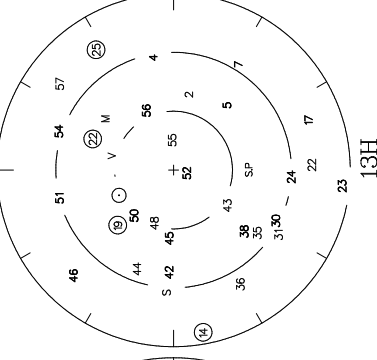
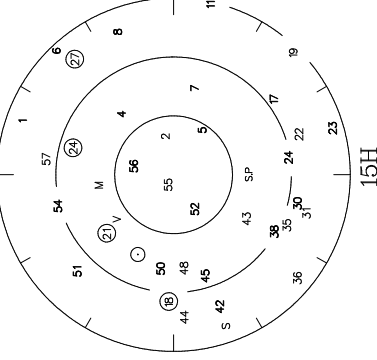
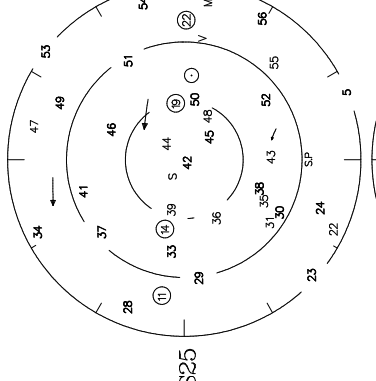
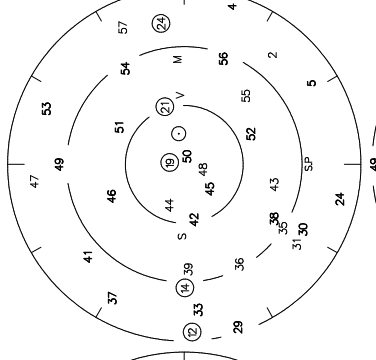
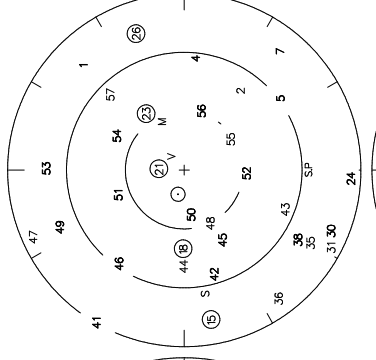
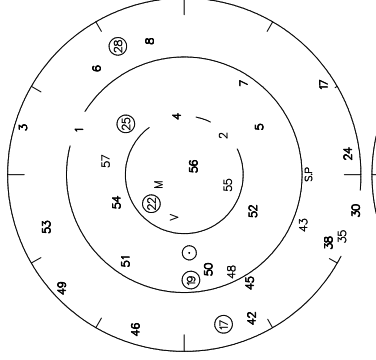
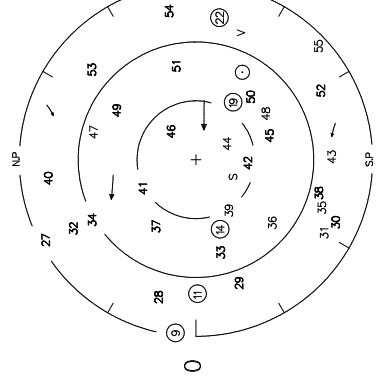
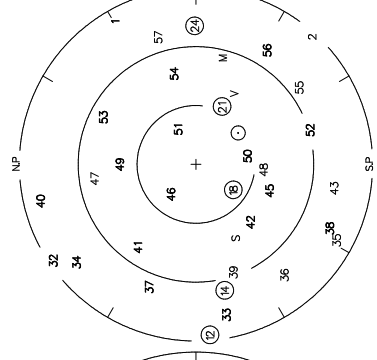
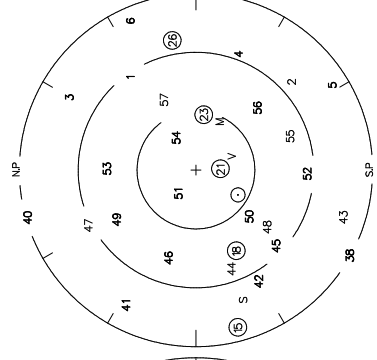
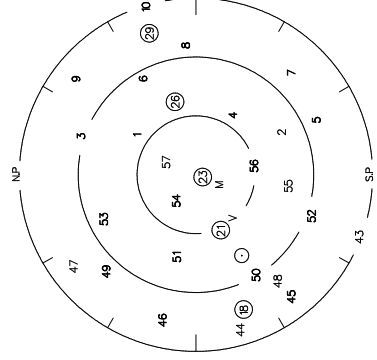
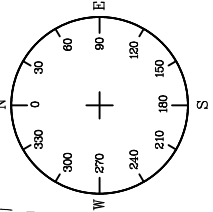
PLANETS Vis. Mag.

- V Venus -3.9
- M Mars 1.1
- J Jupiter -2.5
- S Saturn 0.6

POLES
N•P North S•P South



AZIMUTH



CORRECTIONS TO BE APPLIED TO SEXTANT ALTITUDE A167

REFRACTION

To be subtracted from sextant altitude (referred to as observed altitude in A.P. 3270)

R_0	Height above sea level in units of 1 000 ft.												R_0	$R = R_0 \times f$			
	Sextant Altitude													f			
	Sextant Altitude													R			
	0	5	10	15	20	25	30	35	40	45	50	55		0.9	1.0	1.1	1.2
0	90	90	90	90	90	90	90	90	90	90	90	90	0	0	0	0	0
1	63	59	55	51	46	41	36	31	26	20	17	13	1	1	1	1	1
2	33	29	26	22	19	16	14	11	9	7	6	4	2	2	2	2	2
3	21	19	16	14	12	10	8	7	5	4	2 40	1 40	3	3	3	3	4
4	16	14	12	10	8	7	6	5	3 10	2 20	1 30	0 40	4	4	4	4	5
5	12	11	9	8	7	5	4 00	3 10	2 10	1 30	0 39	+0 05	5	5	5	5	6
6	10	9	7	5 50	4 50	3 50	3 10	2 20	1 30	0 49	+0 11	-0 19	6	5	6	7	7
7	8 10	6 50	5 50	4 50	4 00	3 00	2 20	1 50	1 10	0 24	-0 11	-0 38	7	6	7	8	8
8	6 50	5 50	5 00	4 00	3 10	2 30	1 50	1 20	0 38	+0 04	-0 28	-0 54	8	7	8	9	10
9	6 00	5 10	4 10	3 20	2 40	2 00	1 30	1 00	0 19	-0 13	-0 42	-1 08	9	8	9	10	11
10	5 20	4 30	3 40	2 50	2 10	1 40	1 10	0 35	+0 03	-0 27	-0 53	-1 18	10	9	10	11	12
12	4 30	3 40	2 50	2 20	1 40	1 10	0 37	+0 11	-0 16	-0 43	-1 08	-1 31	12	11	12	13	14
14	3 30	2 50	2 10	1 40	1 10	0 34	+0 09	-0 14	-0 37	-1 00	-1 23	-1 44	14	13	14	15	17
16	2 50	2 10	1 40	1 10	0 37	+0 10	-0 13	-0 34	-0 53	-1 14	-1 35	-1 56	16	14	16	18	19
18	2 20	1 40	1 20	0 43	+0 15	-0 08	-0 31	-0 52	-1 08	-1 27	-1 46	-2 05	18	16	18	20	22
20	1 50	1 20	0 49	+0 23	-0 02	-0 26	-0 46	-1 06	-1 22	-1 39	-1 57	-2 14	20	18	20	22	24
25	1 12	0 44	+0 19	-0 06	-0 28	-0 48	-1 09	-1 27	-1 42	-1 58	-2 14	-2 30	25	22	25	28	30
30	0 34	+0 10	-0 13	-0 36	-0 55	-1 14	-1 32	-1 51	-2 06	-2 21	-2 34	-2 49	30	27	30	33	36
35	+0 06	-0 16	-0 37	-0 59	-1 17	-1 33	-1 51	-2 07	-2 23	-2 37	-2 51	-3 04	35	31	35	38	42
40	-0 18	-0 37	-0 58	-1 16	-1 34	-1 49	-2 06	-2 22	-2 35	-2 49	-3 03	-3 16	40	36	40	44	48
45		-0 53	-1 14	-1 31	-1 47	-2 03	-2 18	-2 33	-2 47	-2 59	-3 13	-3 25	45	40	45	50	54
50		-1 10	-1 28	-1 44	-1 59	-2 15	-2 28	-2 43	-2 56	-3 08	-3 22	-3 33	50	45	50	55	60
55			-1 40	-1 53	-2 09	-2 24	-2 38	-2 52	-3 04	-3 17	-3 29	-3 41	55	49	55	60	66
60				-2 03	-2 18	-2 33	-2 46	-3 01	-3 12	-3 25	-3 37	-3 48	60	54	60	66	72
							-2 53	-3 07	-3 19	-3 31	-3 42	-3 53					

f	Temperature in °C.												f	f			
	Temperature in °C.													f			
0.9	+47	+36	+27	+18	+10	+3	-5	-13					0.9	0.9	1.0	1.1	1.2
1.0	+26	+16	+6	-4	-13	-22	-31	-40					1.0	1.0	1.0	1.1	1.2
1.1	+5	-5	-15	-25	-36	-46	-57	-68					1.1	1.1	1.1	1.2	1.2
1.2	-16	-25	-36	-46	-58	-71	-83	-95					1.2	1.2	1.2	1.2	1.2
	-37	-45	-56	-67	-81	-95											

Choose the column appropriate to height, in units of 1 000 ft., and find the range of altitude in which the sextant altitude lies; the corresponding value of R_0 is the refraction, to be subtracted from sextant altitude, unless conditions are extreme. In that case find f from the lower table, with critical argument temperature. Use the table on the right to form the refraction, $R = R_0 \times f$.

CORIOLIS (Z) CORRECTION

To be applied by moving the position line a distance Z to starboard (right) of the track in northern latitudes and to port (left) in southern latitudes.

G/S KNOTS	Latitude					G/S KNOTS	Latitude				
	0° 10°	20° 30°	40° 50°	60° 70°	80° 90°		0° 10°	20° 30°	40° 50°	60° 70°	80° 90°
150	0 1	1 2	3 3	3 4	4 4	550	0 3	5 7	9 11	12 14	14 14
200	0 1	2 3	3 4	5 5	5 5	600	0 3	5 8	10 12	14 15	16 16
250	0 1	2 3	4 5	6 6	6 7	650	0 3	6 9	11 13	15 16	17 17
300	0 1	3 4	5 6	7 7	8 8	700	0 3	6 9	12 14	16 17	18 18
350	0 2	3 5	6 7	8 9	9 9	750	0 3	7 10	13 15	17 18	19 20
400	0 2	4 5	7 8	9 10	10 10	800	0 4	7 10	13 16	18 20	21 21
450	0 2	4 6	8 9	10 11	12 12	850	0 4	8 11	14 17	19 21	22 22
500	0 2	4 7	8 10	11 12	13 13	900	0 4	8 12	15 18	20 22	23 24