PUB. NO. 249
VOL. 1

SIGHT REDUCTION TABLES

FOR

AIR NAVIGATION

(SELECTED STARS)

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TABLE 1. — ALTITUDE CORRECTION FOR CHANGE IN POSITION OF OBSERVER

Correction for 4 Minutes of Time

Rel. Zn	Ground Speed in Knots																		Rel. Zn
	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	
°	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	°
000	+ 3	+ 7	+ 10	+ 13	+ 17	+ 20	+ 23	+ 27	+ 30	+ 33	+ 37	+ 40	+ 43	+ 47	+ 50	+ 53	+ 57	+ 60	**000**
005	3	7	10	13	17	20	23	27	30	33	37	40	43	46	50	53	56	60	**355**
010	3	7	10	13	16	20	23	26	30	33	36	39	43	46	49	53	56	59	**350**
015	3	6	10	13	16	19	23	26	29	32	35	39	42	45	48	52	55	58	**345**
020	3	6	9	13	16	19	22	25	28	31	34	38	41	44	47	50	53	56	**340**
025	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	**335**
030	+ 3	+ 6	+ 9	+ 12	+ 14	+ 17	+ 20	+ 23	+ 26	+ 29	+ 32	+ 35	+ 38	+ 40	+ 43	+ 46	+ 49	+ 52	**330**
035	3	5	8	11	14	16	19	22	25	27	30	33	35	38	41	44	46	49	**325**
040	3	5	8	10	13	15	18	20	23	26	28	31	33	36	38	41	43	46	**320**
045	2	5	7	9	12	14	16	19	21	24	26	28	31	33	35	38	40	42	**315**
050	2	4	6	9	11	13	15	17	19	21	24	26	28	30	32	34	36	39	**310**
055	2	4	6	8	10	11	13	15	17	19	21	23	25	27	29	31	33	34	**305**
060	+ 2	+ 3	+ 5	+ 7	+ 8	+ 10	+ 12	+ 13	+ 15	+ 17	+ 18	+ 20	+ 22	+ 23	+ 25	+ 27	+ 28	+ 30	**300**
065	1	3	4	6	7	8	10	11	13	14	15	17	18	20	21	23	24	25	**295**
070	1	2	3	5	6	7	8	9	10	11	13	14	15	16	17	18	19	21	**290**
075	1	2	3	3	4	5	6	7	8	9	9	10	11	12	13	14	15	16	**285**
080	1	1	2	2	3	3	4	5	5	6	6	7	8	8	9	9	10	10	**280**
085	+ 0	+ 1	+ 1	+ 1	+ 1	+ 2	+ 2	+ 2	+ 3	+ 3	+ 3	+ 3	+ 4	+ 4	+ 4	+ 5	+ 5	+ 5	**275**
090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**270**
095	− 0	− 1	− 1	− 1	− 1	− 2	− 2	− 2	− 3	− 3	− 3	− 3	− 4	− 4	− 4	− 5	− 5	− 5	**265**
100	1	1	2	2	3	3	4	5	5	6	6	7	8	8	9	9	10	10	**260**
105	1	2	3	3	4	5	6	7	8	9	9	10	11	12	13	14	15	16	**255**
110	1	2	3	5	6	7	8	9	10	11	13	14	15	16	17	18	19	21	**250**
115	1	3	4	6	7	8	10	11	13	14	15	17	18	20	21	23	24	25	**245**
120	2	3	5	7	8	10	12	13	15	17	18	20	22	23	25	27	28	30	**240**
125	− 2	− 4	− 6	− 8	− 10	− 11	− 13	− 15	− 17	− 19	− 21	− 23	− 25	− 27	− 29	− 31	− 33	− 34	**235**
130	2	4	6	9	11	13	15	17	19	21	24	26	28	30	32	34	36	39	**230**
135	2	5	7	9	12	14	16	19	21	24	26	28	31	33	35	38	40	42	**225**
140	3	5	8	10	13	15	18	20	23	26	28	31	33	36	38	41	43	46	**220**
145	3	5	8	11	14	16	19	22	25	27	30	33	35	38	41	44	46	49	**215**
150	3	6	9	12	14	17	20	23	26	29	32	35	38	40	43	46	49	52	**210**
155	− 3	− 6	− 9	− 12	− 15	− 18	− 21	− 24	− 27	− 30	− 33	− 36	− 39	− 42	− 45	− 48	− 51	− 54	**205**
160	3	6	9	13	16	19	22	25	28	31	34	38	41	44	47	50	53	56	**200**
165	3	6	10	13	16	19	23	26	29	32	35	39	42	45	48	52	55	58	**195**
170	3	7	10	13	16	20	23	26	30	33	36	39	43	46	49	53	56	59	**190**
175	3	7	10	13	17	20	23	27	30	33	37	40	43	46	50	53	56	60	**185**
180	− 3	− 7	− 10	− 13	− 17	− 20	− 23	− 27	− 30	− 33	− 37	− 40	− 43	− 47	− 50	− 53	− 57	− 60	**180**

Interpolation for Altitude Correction for Less Than 4 Minutes of Time

Interval of Time	Value from Tables 1 and 2 (For values greater than 60′ see opposite page)																				Interval of Time
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	
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	0	**0 00**
10	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	**10**
20	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	**20**
30	0	1	1	2	2	2	3	3	3	4	4	5	5	5	6	6	6	7	7	8	**30**
40	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	**40**
0 50	1	1	2	3	3	4	4	5	6	6	7	8	8	9	9	10	11	11	12	13	**0 50**
1 00	1	2	2	3	4	5	5	6	7	8	8	9	10	11	11	12	13	14	14	15	**1 00**
10	1	2	3	4	4	5	6	7	8	9	10	11	11	12	13	14	15	16	17	18	**10**
20	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	**20**
30	1	2	3	5	6	7	8	9	10	11	12	14	15	16	17	18	19	20	21	23	**30**
40	1	3	4	5	6	8	9	10	11	13	14	15	16	18	19	20	21	23	24	25	**40**
1 50	1	3	4	6	7	8	10	11	12	14	15	17	18	19	21	22	23	25	26	28	**1 50**
2 00	2	3	5	6	8	9	11	12	14	15	17	18	20	21	23	24	26	27	29	30	**2 00**
10	2	3	5	7	8	10	11	13	15	16	18	20	21	23	24	26	28	29	31	33	**10**
20	2	4	5	7	9	11	12	14	16	18	19	21	23	25	26	28	30	32	33	35	**20**
30	2	4	6	8	9	11	13	15	17	19	21	23	24	26	28	30	32	34	36	38	**30**
40	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	**40**
2 50	2	4	6	9	11	13	15	17	19	21	23	26	28	30	32	34	36	38	40	43	**2 50**
3 00	2	5	7	9	11	14	16	18	20	23	25	27	29	32	34	36	38	41	43	45	**3 00**
10	2	5	7	10	12	14	17	19	21	24	26	29	31	33	36	38	40	43	45	48	**10**
20	3	5	8	10	13	15	18	20	23	25	28	30	33	35	38	40	43	45	48	50	**20**
30	3	5	8	11	13	16	18	21	24	26	29	32	34	37	39	42	45	47	50	53	**30**
40	3	6	8	11	14	17	19	22	25	28	30	33	36	39	41	44	47	50	52	55	**40**
3 50	3	6	9	12	14	17	20	23	26	29	32	35	37	40	43	46	49	52	55	58	**3 50**
4 00	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	**4 00**

Time of fix (tab 1) or computation (tab 2)	Sign from 4-min. Table	To observed altitude	To tabulated altitude	To intercept
Later than observation	+	Add	Subtract	Toward
	−	Subtract	Add	Away
Earlier than observation	+	Subtract	Add	Away
	−	Add	Subtract	Toward

TABLE 2. — ALTITUDE CORRECTION FOR CHANGE IN POSITION OF BODY

Correction for 4 Minutes of Time

True Zn	Latitude in Degrees																		True Zn
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	
°	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	°
090	+ 60	+ 60	+ 59	+ 58	+ 56	+ 54	+ 52	+ 49	+ 46	+ 42	+ 39	+ 34	+ 30	+ 25	+ 21	+ 16	+ 10	+ 5	**090**
095	60	60	59	58	56	54	52	49	46	42	38	34	30	25	20	15	10	5	**085**
100	59	59	58	57	56	54	51	48	45	42	38	34	30	25	20	15	10	5	**080**
105	58	58	57	56	54	53	50	47	44	41	37	33	29	24	20	15	10	5	**075**
110	56	56	56	54	53	51	49	46	43	40	36	32	28	24	19	15	10	5	**070**
115	54	54	54	53	51	49	47	45	42	38	35	31	27	23	19	14	9	5	**065**
120	+ 52	+ 52	+ 51	+ 50	+ 49	+ 47	+ 45	+ 43	+ 40	+ 37	+ 33	+ 30	+ 26	+ 22	+ 18	+ 13	+ 9	+ 5	**060**
125	49	49	48	47	46	45	43	40	38	35	32	28	25	21	17	13	9	4	**055**
130	46	46	45	44	43	42	40	38	35	33	30	26	23	19	16	12	8	4	**050**
135	42	42	42	41	40	38	37	35	33	30	27	24	21	18	15	11	7	4	**045**
140	39	38	38	37	36	35	33	32	30	27	25	22	19	16	13	10	7	3	**040**
145	34	34	34	33	32	31	30	28	26	24	22	20	17	15	12	9	6	3	**035**
150	+ 30	+ 30	+ 30	+ 29	+ 28	+ 27	+ 26	+ 25	+ 23	+ 21	+ 19	+ 17	+ 15	+ 13	+ 10	+ 8	+ 5	+ 3	**030**
155	25	25	25	24	24	23	22	21	19	18	16	15	13	11	9	7	4	2	**025**
160	21	20	20	20	19	19	18	17	16	15	13	12	10	9	7	5	4	2	**020**
165	16	15	15	15	15	14	13	13	12	11	10	9	8	7	5	4	3	1	**015**
170	10	10	10	10	10	9	9	9	8	7	7	6	5	4	4	3	2	1	**010**
175	+ 5	+ 5	+ 5	+ 5	+ 5	+ 5	+ 5	+ 4	+ 4	+ 4	+ 3	+ 3	+ 3	+ 2	+ 2	+ 1	+ 1	+ 0	**005**
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**000**
185	− 5	− 5	− 5	− 5	− 5	− 5	− 5	− 4	− 4	− 4	− 3	− 3	− 3	− 2	− 2	− 1	− 1	− 0	**355**
190	10	10	10	10	10	9	9	9	8	7	7	6	5	4	4	3	2	1	**350**
195	16	15	15	15	15	14	13	13	12	11	10	9	8	7	5	4	3	1	**345**
200	21	20	20	20	19	19	18	17	16	15	13	12	10	9	7	5	4	2	**340**
205	25	25	25	24	24	23	22	21	19	18	16	15	13	11	9	7	4	2	**335**
210	30	30	30	29	28	27	26	25	23	21	19	17	15	13	10	8	5	3	**330**
215	− 34	− 34	− 34	− 33	− 32	− 31	− 30	− 28	− 26	− 24	− 22	− 20	− 17	− 15	− 12	− 9	− 6	− 3	**325**
220	39	38	38	37	36	35	33	32	30	27	25	22	19	16	13	10	7	3	**320**
225	42	42	42	41	40	38	37	35	33	30	27	24	21	18	15	11	7	4	**315**
230	46	46	45	44	43	42	40	38	35	33	30	26	23	19	16	12	8	4	**310**
235	49	49	48	47	46	45	43	40	38	35	32	28	25	21	17	13	9	4	**305**
240	52	52	51	50	49	47	45	43	40	37	33	30	26	22	18	13	9	5	**300**
245	− 54	− 54	− 54	− 53	− 51	− 49	− 47	− 45	− 42	− 38	− 35	− 31	− 27	− 23	− 19	− 14	− 9	− 5	**295**
250	56	56	56	54	53	51	49	46	43	40	36	32	28	24	19	15	10	5	**290**
255	58	58	57	56	54	53	50	47	44	41	37	33	29	24	20	15	10	5	**285**
260	59	59	58	57	56	54	51	48	45	42	38	34	30	25	20	15	10	5	**280**
265	60	60	59	58	56	54	52	49	46	42	38	34	30	25	20	15	10	5	**275**
270	− 60	− 60	− 59	− 58	− 56	− 54	− 52	− 49	− 46	− 42	− 39	− 34	− 30	− 25	− 21	− 16	− 10	− 5	**270**

Interpolation for Altitude Correction for Less Than 4 Minutes of Time

Interval of Time	Value from Tables 1 and 2 (For values less than 60′ see opposite page)																				Interval of Time
	63	66	69	72	75	78	81	84	87	90	93	96	99	102	105	108	111	114	117	120	
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	0	**0 00**
10	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	5	5	5	5	5	**10**
20	5	6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10	10	10	**20**
30	8	8	9	9	9	10	10	11	11	11	12	12	12	13	13	14	14	14	15	15	**30**
40	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	**40**
0 50	13	14	14	15	16	16	17	18	18	19	19	20	21	21	22	23	23	24	24	25	**0 50**
1 00	16	17	17	18	19	20	20	21	22	23	23	24	25	26	26	27	28	29	29	30	**1 00**
10	18	19	20	21	22	23	24	25	25	26	27	28	29	30	31	32	32	33	34	35	**10**
20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	**20**
30	24	25	26	27	28	29	30	32	33	34	35	36	37	38	39	41	42	43	44	45	**30**
40	26	28	29	30	31	33	34	35	36	38	39	40	41	43	44	45	46	48	49	50	**40**
1 50	29	30	32	33	34	36	37	39	40	41	43	44	45	47	48	50	51	52	54	55	**1 50**
2 00	32	33	35	36	38	39	41	42	44	45	47	48	50	51	53	54	56	57	59	60	**2 00**
10	34	36	37	39	41	42	44	46	47	49	50	52	54	55	57	59	60	62	63	65	**10**
20	37	39	40	42	44	46	47	49	51	53	54	56	58	60	61	63	65	67	68	70	**20**
30	39	41	43	45	47	49	51	53	54	56	58	60	62	64	66	68	69	71	73	75	**30**
40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	**40**
2 50	45	47	49	51	53	55	57	60	62	64	66	68	70	72	74	77	79	81	83	85	**2 50**
3 00	47	50	52	54	56	59	61	63	65	68	70	72	74	77	79	81	83	86	88	90	**3 00**
10	50	52	55	57	59	62	64	67	69	71	74	76	78	81	83	86	88	90	93	95	**10**
20	53	55	58	60	63	65	68	70	73	75	78	80	83	85	88	90	93	95	98	100	**20**
30	55	58	60	63	66	68	71	74	76	79	81	84	87	89	92	95	97	100	102	105	**30**
40	58	61	63	66	69	72	74	77	80	83	85	88	91	94	96	99	102	105	107	110	**40**
3 50	60	63	66	69	72	75	78	81	83	86	89	92	95	98	101	104	106	109	112	115	**3 50**
4 00	63	66	69	72	75	78	81	84	87	90	93	96	99	102	105	108	111	114	117	120	**4 00**

Time of fix (tab 1) or computation (tab 2)	Sign from 4-min. Table	To observed altitude	To tabulated altitude	To intercept
Later than observation	+	Add	Subtract	Toward
	−	Subtract	Add	Away
Earlier than observation	+	Subtract	Add	Away
	−	Add	Subtract	Toward

TABLE 3. — CONVERSION OF ARC TO TIME

°	h m	°	h m	°	h m	°	h m	°	h m	°	h m
0	0 00	**60**	4 00	**120**	8 00	**180**	12 00	**240**	16 00	**300**	20 00
1	0 04	**61**	4 04	**121**	8 04	**181**	12 04	**241**	16 04	**301**	20 04
2	0 08	**62**	4 08	**122**	8 08	**182**	12 08	**242**	16 08	**302**	20 08
3	0 12	**63**	4 12	**123**	8 12	**183**	12 12	**243**	16 12	**303**	20 12
4	0 16	**64**	4 16	**124**	8 16	**184**	12 16	**244**	16 16	**304**	20 16
5	0 20	**65**	4 20	**125**	8 20	**185**	12 20	**245**	16 20	**305**	20 20
6	0 24	**66**	4 24	**126**	8 24	**186**	12 24	**246**	16 24	**306**	20 24
7	0 28	**67**	4 28	**127**	8 28	**187**	12 28	**247**	16 28	**307**	20 28
8	0 32	**68**	4 32	**128**	8 32	**188**	12 32	**248**	16 32	**308**	20 32
9	0 36	**69**	4 36	**129**	8 36	**189**	12 36	**249**	16 36	**309**	20 36
10	0 40	**70**	4 40	**130**	8 40	**190**	12 40	**250**	16 40	**310**	20 40
11	0 44	**71**	4 44	**131**	8 44	**191**	12 44	**251**	16 44	**311**	20 44
12	0 48	**72**	4 48	**132**	8 48	**192**	12 48	**252**	16 48	**312**	20 48
13	0 52	**73**	4 52	**133**	8 52	**193**	12 52	**253**	16 52	**313**	20 52
14	0 56	**74**	4 56	**134**	8 56	**194**	12 56	**254**	16 56	**314**	20 56
15	1 00	**75**	5 00	**135**	9 00	**195**	13 00	**255**	17 00	**315**	21 00
16	1 04	**76**	5 04	**136**	9 04	**196**	13 04	**256**	17 04	**316**	21 04
17	1 08	**77**	5 08	**137**	9 08	**197**	13 08	**257**	17 08	**317**	21 08
18	1 12	**78**	5 12	**138**	9 12	**198**	13 12	**258**	17 12	**318**	21 12
19	1 16	**79**	5 16	**139**	9 16	**199**	13 16	**259**	17 16	**319**	21 16
20	1 20	**80**	5 20	**140**	9 20	**200**	13 20	**260**	17 20	**320**	21 20
21	1 24	**81**	5 24	**141**	9 24	**201**	13 24	**261**	17 24	**321**	21 24
22	1 28	**82**	5 28	**142**	9 28	**202**	13 28	**262**	17 28	**322**	21 28
23	1 32	**83**	5 32	**143**	9 32	**203**	13 32	**263**	17 32	**323**	21 32
24	1 36	**84**	5 36	**144**	9 36	**204**	13 36	**264**	17 36	**324**	21 36
25	1 40	**85**	5 40	**145**	9 40	**205**	13 40	**265**	17 40	**325**	21 40
26	1 44	**86**	5 44	**146**	9 44	**206**	13 44	**266**	17 44	**326**	21 44
27	1 48	**87**	5 48	**147**	9 48	**207**	13 48	**267**	17 48	**327**	21 48
28	1 52	**88**	5 52	**148**	9 52	**208**	13 52	**268**	17 52	**328**	21 52
29	1 56	**89**	5 56	**149**	9 56	**209**	13 56	**269**	17 56	**329**	21 56
30	2 00	**90**	6 00	**150**	10 00	**210**	14 00	**270**	18 00	**330**	22 00
31	2 04	**91**	6 04	**151**	10 04	**211**	14 04	**271**	18 04	**331**	22 04
32	2 08	**92**	6 08	**152**	10 08	**212**	14 08	**272**	18 08	**332**	22 08
33	2 12	**93**	6 12	**153**	10 12	**213**	14 12	**273**	18 12	**333**	22 12
34	2 16	**94**	6 16	**154**	10 16	**214**	14 16	**274**	18 16	**334**	22 16
35	2 20	**95**	6 20	**155**	10 20	**215**	14 20	**275**	18 20	**335**	22 20
36	2 24	**96**	6 24	**156**	10 24	**216**	14 24	**276**	18 24	**336**	22 24
37	2 28	**97**	6 28	**157**	10 28	**217**	14 28	**277**	18 28	**337**	22 28
38	2 32	**98**	6 32	**158**	10 32	**218**	14 32	**278**	18 32	**338**	22 32
39	2 36	**99**	6 36	**159**	10 36	**219**	14 36	**279**	18 36	**339**	22 36
40	2 40	**100**	6 40	**160**	10 40	**220**	14 40	**280**	18 40	**340**	22 40
41	2 44	**101**	6 44	**161**	10 44	**221**	14 44	**281**	18 44	**341**	22 44
42	2 48	**102**	6 48	**162**	10 48	**222**	14 48	**282**	18 48	**342**	22 48
43	2 52	**103**	6 52	**163**	10 52	**223**	14 52	**283**	18 52	**343**	22 52
44	2 56	**104**	6 56	**164**	10 56	**224**	14 56	**284**	18 56	**344**	22 56
45	3 00	**105**	7 00	**165**	11 00	**225**	15 00	**285**	19 00	**345**	23 00
46	3 04	**106**	7 04	**166**	11 04	**226**	15 04	**286**	19 04	**346**	23 04
47	3 08	**107**	7 08	**167**	11 08	**227**	15 08	**287**	19 08	**347**	23 08
48	3 12	**108**	7 12	**168**	11 12	**228**	15 12	**288**	19 12	**348**	23 12
49	3 16	**109**	7 16	**169**	11 16	**229**	15 16	**289**	19 16	**349**	23 16
50	3 20	**110**	7 20	**170**	11 20	**230**	15 20	**290**	19 20	**350**	23 20
51	3 24	**111**	7 24	**171**	11 24	**231**	15 24	**291**	19 24	**351**	23 24
52	3 28	**112**	7 28	**172**	11 28	**232**	15 28	**292**	19 28	**352**	23 28
53	3 32	**113**	7 32	**173**	11 32	**233**	15 32	**293**	19 32	**353**	23 32
54	3 36	**114**	7 36	**174**	11 36	**234**	15 36	**294**	19 36	**354**	23 36
55	3 40	**115**	7 40	**175**	11 40	**235**	15 40	**295**	19 40	**355**	23 40
56	3 44	**116**	7 44	**176**	11 44	**236**	15 44	**296**	19 44	**356**	23 44
57	3 48	**117**	7 48	**177**	11 48	**237**	15 48	**297**	19 48	**357**	23 48
58	3 52	**118**	7 52	**178**	11 52	**238**	15 52	**298**	19 52	**358**	23 52
59	3 56	**119**	7 56	**179**	11 56	**239**	15 56	**299**	19 56	**359**	23 56
60	4 00	**120**	8 00	**180**	12 00	**240**	16 00	**300**	20 00	**360**	24 00

′	m s
0	0 00
1	0 04
2	0 08
3	0 12
4	0 16
5	0 20
6	0 24
7	0 28
8	0 32
9	0 36
10	0 40
11	0 44
12	0 48
13	0 52
14	0 56
15	1 00
16	1 04
17	1 08
18	1 12
19	1 16
20	1 20
21	1 24
22	1 28
23	1 32
24	1 36
25	1 40
26	1 44
27	1 48
28	1 52
29	1 56
30	2 00
31	2 04
32	2 08
33	2 12
34	2 16
35	2 20
36	2 24
37	2 28
38	2 32
39	2 36
40	2 40
41	2 44
42	2 48
43	2 52
44	2 56
45	3 00
46	3 04
47	3 08
48	3 12
49	3 16
50	3 20
51	3 24
52	3 28
53	3 32
54	3 36
55	3 40
56	3 44
57	3 48
58	3 52
59	3 56
60	4 00

″	s
0	0.00
1	0.07
2	0.13
3	0.20
4	0.27
5	0.33
6	0.40
7	0.47
8	0.53
9	0.60
10	0.67
11	0.73
12	0.80
13	0.87
14	0.93
15	1.00
16	1.07
17	1.13
18	1.20
19	1.27
20	1.33
21	1.40
22	1.47
23	1.53
24	1.60
25	1.67
26	1.73
27	1.80
28	1.87
29	1.93
30	2.00
31	2.07
32	2.13
33	2.20
34	2.27
35	2.33
36	2.40
37	2.47
38	2.53
39	2.60
40	2.67
41	2.73
42	2.80
43	2.87
44	2.93
45	3.00
46	3.07
47	3.13
48	3.20
49	3.27
50	3.33
51	3.40
52	3.47
53	3.53
54	3.60
55	3.67
56	3.73
57	3.80
58	3.87
59	3.93
60	4.00

TABLE 6 — CORRECTION *(Q)* FOR *POLARIS*

LHA ♈	Q	LHA ♈	Q	LHA ♈	Q	LHA ♈	Q	LHA ♈	Q	LHA ♈	Q	LHA ♈	Q
° ′	′	° ′	′	° ′	′	° ′	′	° ′	′	° ′	′	° ′	′
359 01	− 31	**87 17**	− 28	**123 10**	− 5	**155 56**	+ 18	**209 49**	+ 41	**284 52**	+ 18	**317 47**	− 5	**353 11**	− 28
1 06	− 32	**89 10**	− 27	**124 34**	− 4	**157 29**	+ 19	**232 32**	+ 40	**286 25**	+ 17	**319 11**	− 6	**355 04**	− 29
3 18	− 33	**90 59**	− 26	**125 58**	− 3	**159 03**	+ 20	**238 15**	+ 39	**287 56**	+ 16	**320 35**	− 7	**357 00**	− 30
5 35	− 34	**92 46**	− 25	**127 21**	− 2	**160 39**	+ 21	**242 31**	+ 38	**289 27**	+ 15	**321 59**	− 8	**359 01**	− 31
8 01	− 35	**94 30**	− 24	**128 44**	− 1	**162 16**	+ 22	**246 05**	+ 37	**290 56**	+ 14	**323 24**	− 9	**1 06**	− 32
10 38	− 36	**96 12**	− 23	**130 08**	0	**163 54**	+ 23	**249 14**	+ 36	**292 25**	+ 13	**324 49**	− 10	**3 18**	− 33
13 27	− 37	**97 52**	− 22	**131 32**	+ 1	**165 35**	+ 24	**252 05**	+ 35	**293 53**	+ 12	**326 15**	− 11	**5 35**	− 34
16 33	− 38	**99 30**	− 21	**132 55**	+ 2	**167 17**	+ 25	**254 42**	+ 34	**295 20**	+ 11	**327 41**	− 12	**8 01**	− 35
20 05	− 39	**101 07**	− 20	**134 19**	+ 3	**169 02**	+ 26	**257 10**	+ 33	**296 46**	+ 10	**329 08**	− 13	**10 38**	− 36
24 18	− 40	**102 41**	− 19	**135 42**	+ 4	**170 50**	+ 27	**259 29**	+ 32	**298 12**	+ 9	**330 35**	− 14	**13 27**	− 37
29 57	− 41	**104 15**	− 18	**137 06**	+ 5	**172 40**	+ 28	**261 41**	+ 31	**299 38**	+ 8	**332 04**	− 15	**16 33**	− 38
52 24	− 40	**105 47**	− 17	**138 30**	+ 6	**174 34**	+ 29	**263 48**	+ 30	**301 03**	+ 7	**333 33**	− 16	**20 05**	− 39
58 03	− 39	**107 18**	− 16	**139 54**	+ 7	**176 32**	+ 30	**265 49**	+ 29	**302 27**	+ 6	**335 03**	− 17	**24 18**	− 40
62 16	− 38	**108 48**	− 15	**141 18**	+ 8	**178 33**	+ 31	**267 47**	+ 28	**303 51**	+ 5	**336 34**	− 18	**29 57**	− 41
65 48	− 37	**110 17**	− 14	**142 43**	+ 9	**180 40**	+ 32	**269 41**	+ 27	**305 15**	+ 4	**338 06**	− 19	**52 24**	− 40
68 54	− 36	**111 46**	− 13	**144 09**	+ 10	**182 52**	+ 33	**271 31**	+ 26	**306 39**	+ 3	**339 40**	− 20	**58 03**	− 39
71 43	− 35	**113 13**	− 12	**145 35**	+ 11	**185 11**	+ 34	**273 19**	+ 25	**308 02**	+ 2	**341 14**	− 21	**62 16**	− 38
74 20	− 34	**114 40**	− 11	**147 01**	+ 12	**187 39**	+ 35	**275 04**	+ 24	**309 26**	+ 1	**342 51**	− 22	**65 48**	− 37
76 46	− 33	**116 06**	− 10	**148 28**	+ 13	**190 16**	+ 36	**276 46**	+ 23	**310 49**	0	**344 29**	− 23	**68 54**	− 36
79 03	− 32	**117 32**	− 9	**149 56**	+ 14	**193 07**	+ 37	**278 27**	+ 22	**312 13**	− 1	**346 09**	− 24	**71 43**	− 35
81 15	− 31	**118 57**	− 8	**151 25**	+ 15	**196 16**	+ 38	**280 05**	+ 21	**313 37**	− 2	**347 51**	− 25	**74 20**	− 34
83 20	− 30	**120 22**	− 7	**152 54**	+ 16	**199 50**	+ 39	**281 42**	+ 20	**315 00**	− 3	**349 35**	− 26	**76 46**	− 33
85 21	− 29	**121 46**	− 6	**154 25**	+ 17	**204 06**	+ 40	**283 18**	+ 19	**316 23**	− 4	**351 22**	− 27	**79 03**	− 32
87 17		**123 10**		**155 56**		**209 49**		**284 52**		**317 47**		**353 11**		**81 15**	

The above table, which does *not* include refraction, gives the quantity *Q* to be applied to the corrected sextant altitude of *Polaris* to give the latitude of the observer. In critical cases ascend.

Polaris: Mag. 2.1, SHA 318° 49′, Dec N 89° 18.7′

TABLE 7 — AZIMUTH OF *POLARIS*

LHA ♈	Latitude							LHA ♈	Latitude						
	0°	**30°**	**50°**	**55°**	**60°**	**65°**	**70°**		**0°**	**30°**	**50°**	**55°**	**60°**	**65°**	**70°**
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
0	0.5	0.5	0.7	0.8	0.9	1.1	1.4	**180**	359.5	359.5	359.3	359.2	359.1	358.9	358.7
10	0.4	0.4	0.6	0.6	0.7	0.9	1.1	**190**	359.6	359.6	359.5	359.4	359.3	359.2	359.0
20	0.2	0.3	0.4	0.4	0.5	0.6	0.7	**200**	359.8	359.7	359.6	359.6	359.5	359.4	359.3
30	0.1	0.2	0.2	0.2	0.3	0.3	0.4	**210**	359.9	359.8	359.8	359.8	359.7	359.7	359.6
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**220**	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	359.9	359.9	359.8	359.8	359.8	359.7	359.7	**230**	0.1	0.1	0.2	0.2	0.2	0.2	0.3
60	359.8	359.7	359.6	359.6	359.5	359.5	359.3	**240**	0.2	0.3	0.3	0.4	0.4	0.5	0.6
70	359.7	359.6	359.5	359.4	359.3	359.2	359.0	**250**	0.3	0.4	0.5	0.6	0.7	0.8	0.9
80	359.6	359.5	359.3	359.2	359.1	359.0	358.7	**260**	0.4	0.5	0.7	0.7	0.8	1.0	1.2
90	359.5	359.4	359.2	359.1	358.9	358.8	358.5	**270**	0.5	0.6	0.8	0.9	1.0	1.2	1.5
100	359.4	359.3	359.1	359.0	358.8	358.6	358.2	**280**	0.6	0.7	0.9	1.0	1.2	1.4	1.7
110	359.4	359.3	359.0	358.9	358.7	358.5	358.1	**290**	0.6	0.7	1.0	1.1	1.3	1.5	1.9
120	359.3	359.2	358.9	358.8	358.6	358.4	358.0	**300**	0.7	0.8	1.0	1.2	1.3	1.6	2.0
130	359.3	359.2	358.9	358.8	358.6	358.4	358.0	**310**	0.7	0.8	1.1	1.2	1.4	1.6	2.0
140	359.3	359.2	358.9	358.8	358.6	358.4	358.0	**320**	0.7	0.8	1.1	1.2	1.4	1.6	2.0
150	359.3	359.2	359.0	358.9	358.7	358.5	358.1	**330**	0.7	0.8	1.0	1.1	1.3	1.6	1.9
160	359.4	359.3	359.1	359.0	358.8	358.6	358.3	**340**	0.6	0.7	0.9	1.1	1.2	1.4	1.8
170	359.5	359.4	359.2	359.1	358.9	358.8	358.5	**350**	0.5	0.6	0.8	0.9	1.1	1.3	1.6
180	359.5	359.5	359.3	359.2	359.1	358.9	358.7	**360**	0.5	0.5	0.7	0.8	0.9	1.1	1.4

When Cassiopeia is left (right), *Polaris* is west (east).

TABLE 8 — REFRACTION

To be subtracted from sextant altitude

R_0	Height above sea level in thousands of feet												R_0	$R = R_0 \times f$			
	0	5	10	15	20	25	30	35	40	45	50	55		f			
	Sextant Altitude													0.9	1.0	1.1	1.2
′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	′	R			
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					
	Height above sea level in thousands of feet													0.9	1.0	1.1	1.2
	0	5	10	15	20	25	30	35	40	45	50	55		f			
f	Temperature in degrees Celsius (centigrade)												f				
0.9	+ 47	+ 36	+ 27	+ 18	+ 10	+ 3	− 5	− 13	For these heights no temperature correction is necessary: use $R = R_0$				0.9	Refraction $R = R_0 \times f$			
1.0	+ 26	+ 16	+ 6	− 4	− 13	− 22	− 31	− 40					1.0				
1.1	+ 5	− 5	− 15	− 25	− 36	− 46	− 57	− 68					1.1				
1.2	− 16	− 25	− 36	− 46	− 58	− 71	− 83	− 95					1.2				
	− 37	− 45	− 56	− 67	− 81	− 95								When R_0 is less than 10′ or the height is more than 35, 000 ft.: use $R = R_0$			

Choose the column appropriate to height, in units of 1,000 feet, and find the range of altitude in which the sextant altitude lies; thus find R_0. This is the refraction corresponding to the sextant altitude unless conditions are extreme. In that case find f from the lower table corresponding to the range of temperature for the appropriate height, and use the table on the right to find R. Example: at a height of 30,000 feet and temperature (-) 60° C, a celestial body is observed at altitude (-) 2° 36′. R_0 is 50′, f is 1.1 and R is 55′. Subtracting this from sextant altitude gives (–) 3° 31′.

TABLE 9 — CORIOLIS (*Z*) CORRECTION

Ground speed knots	Latitude										Ground speed knots
	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	
	′	′	′	′	′	′	′	′	′	′	
50	0	0	0	1	1	1	1	1	1	1	50
100	0	0	1	1	2	2	2	2	3	3	100
150	0	1	1	2	3	3	3	4	4	4	150
200	0	1	2	3	3	4	5	5	5	5	200
250	0	1	2	3	4	5	6	6	6	7	250
300	0	1	3	4	5	6	7	7	8	8	300
350	0	2	3	5	6	7	8	9	9	9	350
400	0	2	4	5	7	8	9	10	10	10	400
450	0	2	4	6	8	9	10	11	12	12	450
500	0	2	4	7	8	10	11	12	13	13	500
550	0	3	5	7	9	11	12	14	14	14	550
600	0	3	5	8	10	12	14	15	16	16	600
650	0	3	6	9	11	13	15	16	17	17	650
700	0	3	6	9	12	14	16	17	18	18	700
750	0	3	7	10	13	15	17	18	19	20	750
800	0	4	7	10	13	16	18	20	21	21	800
850	0	4	8	11	14	17	19	21	22	22	850
900	0	4	8	12	15	18	20	22	23	24	900

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.

STANDARD DOME REFRACTION

To be *subtracted* from observed altitude when using sextant suspension in a perspex dome.

Alt. °×	Refn. ′	Alt. °	Refn. ′
10	8	50	4
20	7	60	4
30	6	70	3
40	5	80	3

This table must not be used if a calibration table is fitted to the dome, or if a flat glass plate is provided, or for non-standard domes.

BUBBLE SEXTANT ERROR

Sextant No.

Alt. °	Corr. ′

To facilitate use of Pub. No. 249, Volume 1, 2, and 3.

Correction for 1 Minute of Time

Rel. Zn	Ground Speed in Knots																		Rel. Zn
	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	
°	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	°
000	+ 0.8	+ 1.7	+ 2.5	+ 3.3	+ 4.2	+ 5.0	+ 5.8	+ 6.7	+ 7.5	+ 8.3	+ 9.2	+ 10.0	+ 10.8	+ 11.7	+ 12.5	+ 13.3	+ 14.2	+ 15.0	**000**
002	0.8	1.7	2.5	3.3	4.2	5.0	5.8	6.7	7.5	8.3	9.2	10.0	10.8	11.7	12.5	13.3	14.2	15.0	**358**
004	0.8	1.7	2.5	3.3	4.2	5.0	5.8	6.7	7.5	8.3	9.1	10.0	10.8	11.6	12.5	13.3	14.1	15.0	**356**
006	0.8	1.7	2.5	3.3	4.1	5.0	5.8	6.6	7.5	8.3	9.1	9.9	10.8	11.6	12.4	13.3	14.1	14.9	**354**
008	0.8	1.7	2.5	3.3	4.1	5.0	5.8	6.6	7.4	8.3	9.1	9.9	10.7	11.6	12.4	13.2	14.0	14.9	**352**
010	+ 0.8	+ 1.6	+ 2.5	+ 3.3	+ 4.1	+ 4.9	+ 5.7	+ 6.6	+ 7.4	+ 8.2	+ 9.0	+ 9.8	+ 10.7	+ 11.5	+ 12.3	+ 13.1	+ 14.0	+ 14.8	**350**
012	0.8	1.6	2.4	3.3	4.1	4.9	5.7	6.5	7.3	8.2	9.0	9.8	10.6	11.4	12.2	13.0	13.9	14.7	**348**
014	0.8	1.6	2.4	3.2	4.0	4.9	5.7	6.5	7.3	8.1	8.9	9.7	10.5	11.3	12.1	12.9	13.7	14.6	**346**
016	0.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2	8.0	8.8	9.6	10.4	11.2	12.0	12.8	13.6	14.4	**344**
018	0.8	1.6	2.4	3.2	4.0	4.8	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.1	11.9	12.7	13.5	14.3	**342**
020	+ 0.8	+ 1.6	+ 2.3	+ 3.1	+ 3.9	+ 4.7	+ 5.5	+ 6.3	+ 7.0	+ 7.8	+ 8.6	+ 9.4	+ 10.2	+ 11.0	+ 11.7	+ 12.5	+ 13.3	+ 14.1	**340**
022	0.8	1.5	2.3	3.1	3.9	4.6	5.4	6.2	7.0	7.7	8.5	9.3	10.0	10.8	11.6	12.4	13.1	13.9	**338**
024	0.8	1.5	2.3	3.0	3.8	4.6	5.3	6.1	6.9	7.6	8.4	9.1	9.9	10.7	11.4	12.2	12.9	13.7	**336**
026	0.7	1.5	2.2	3.0	3.7	4.5	5.2	6.0	6.7	7.5	8.2	9.0	9.7	10.5	11.2	12.0	12.7	13.5	**334**
028	0.7	1.5	2.2	2.9	3.7	4.4	5.2	5.9	6.6	7.4	8.1	8.8	9.6	10.3	11.0	11.8	12.5	13.2	**332**
030	+ 0.7	+ 1.4	+ 2.2	+ 2.9	+ 3.6	+ 4.3	+ 5.1	+ 5.8	+ 6.5	+ 7.2	+ 7.9	+ 8.7	+ 9.4	+ 10.1	+ 10.8	+ 11.5	+ 12.3	+ 13.0	**330**
032	0.7	1.4	2.1	2.8	3.5	4.2	4.9	5.7	6.4	7.1	7.8	8.5	9.2	9.9	10.6	11.3	12.0	12.7	**328**
034	0.7	1.4	2.1	2.8	3.5	4.1	4.8	5.5	6.2	6.9	7.6	8.3	9.0	9.7	10.4	11.1	11.7	12.4	**326**
036	0.7	1.3	2.0	2.7	3.4	4.0	4.7	5.4	6.1	6.7	7.4	8.1	8.8	9.4	10.1	10.8	11.5	12.1	**324**
038	0.7	1.3	2.0	2.6	3.3	3.9	4.6	5.3	5.9	6.6	7.2	7.9	8.5	9.2	9.9	10.5	11.2	11.8	**322**
040	+ 0.6	+ 1.3	+ 1.9	+ 2.6	+ 3.2	+ 3.8	+ 4.5	+ 5.1	+ 5.7	+ 6.4	+ 7.0	+ 7.7	+ 8.3	+ 8.9	+ 9.6	+ 10.2	+ 10.9	+ 11.5	**320**
042	0.6	1.2	1.9	2.5	3.1	3.7	4.3	5.0	5.6	6.2	6.8	7.4	8.1	8.7	9.3	9.9	10.5	11.1	**318**
044	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0	6.6	7.2	7.8	8.4	9.0	9.6	10.2	10.8	**316**
046	0.6	1.2	1.7	2.3	2.9	3.5	4.1	4.6	5.2	5.8	6.4	6.9	7.5	8.1	8.7	9.3	9.8	10.4	**314**
048	0.6	1.1	1.7	2.2	2.8	3.3	3.9	4.5	5.0	5.6	6.1	6.7	7.2	7.8	8.4	8.9	9.5	10.0	**312**
050	+ 0.5	+ 1.1	+ 1.6	+ 2.1	+ 2.7	+ 3.2	+ 3.7	+ 4.3	+ 4.8	+ 5.4	+ 5.9	+ 6.4	+ 7.0	+ 7.5	+ 8.0	+ 8.6	+ 9.1	+ 9.6	**310**
052	0.5	1.0	1.5	2.1	2.6	3.1	3.6	4.1	4.6	5.1	5.6	6.2	6.7	7.2	7.7	8.2	8.7	9.2	**308**
054	0.5	1.0	1.5	2.0	2.4	2.9	3.4	3.9	4.4	4.9	5.4	5.9	6.4	6.9	7.3	7.8	8.3	8.8	**306**
056	0.5	0.9	1.4	1.9	2.3	2.8	3.3	3.7	4.2	4.7	5.1	5.6	6.1	6.5	7.0	7.5	7.9	8.4	**304**
058	0.4	0.9	1.3	1.8	2.2	2.6	3.1	3.5	4.0	4.4	4.9	5.3	5.7	6.2	6.6	7.1	7.5	7.9	**302**
060	+ 0.4	+ 0.8	+ 1.3	+ 1.7	+ 2.1	+ 2.5	+ 2.9	+ 3.3	+ 3.8	+ 4.2	+ 4.6	+ 5.0	+ 5.4	+ 5.8	+ 6.3	+ 6.7	+ 7.1	+ 7.5	**300**
062	0.4	0.8	1.2	1.6	2.0	2.3	2.7	3.1	3.5	3.9	4.3	4.7	5.1	5.5	5.9	6.3	6.7	7.0	**298**
064	0.4	0.7	1.1	1.5	1.8	2.2	2.6	2.9	3.3	3.7	4.0	4.4	4.7	5.1	5.5	5.8	6.2	6.6	**296**
066	0.3	0.7	1.0	1.4	1.7	2.0	2.4	2.7	3.1	3.4	3.7	4.1	4.4	4.7	5.1	5.4	5.8	6.1	**294**
068	0.3	0.6	0.9	1.2	1.6	1.9	2.2	2.5	2.8	3.1	3.4	3.7	4.1	4.4	4.7	5.0	5.3	5.6	**292**
070	+ 0.3	+ 0.6	+ 0.9	+ 1.1	+ 1.4	+ 1.7	+ 2.0	+ 2.3	+ 2.6	+ 2.9	+ 3.1	+ 3.4	+ 3.7	+ 4.0	+ 4.3	+ 4.6	+ 4.8	+ 5.1	**290**
072	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.1	2.3	2.6	2.8	3.1	3.3	3.6	3.9	4.1	4.4	4.6	**288**
074	0.2	0.5	0.7	0.9	1.1	1.4	1.6	1.8	2.1	2.3	2.5	2.8	3.0	3.2	3.4	3.7	3.9	4.1	**286**
076	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	**284**
078	0.2	0.3	0.5	0.7	0.9	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.3	2.4	2.6	2.8	2.9	3.1	**282**
080	+ 0.1	+ 0.3	+ 0.4	+ 0.6	+ 0.7	+ 0.9	+ 1.0	+ 1.2	+ 1.3	+ 1.4	+ 1.6	+ 1.7	+ 1.9	+ 2.0	+ 2.2	+ 2.3	+ 2.5	+ 2.6	**280**
082	0.1	0.2	0.3	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.5	1.6	1.7	1.9	2.0	2.1	**278**
084	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.5	1.6	**276**
086	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	1.0	1.0	**274**
088	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	**272**
090	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	0.0	**270**
092	− 0.0	− 0.1	− 0.1	− 0.1	− 0.1	− 0.2	− 0.2	− 0.2	− 0.3	− 0.3	− 0.3	− 0.3	− 0.4	− 0.4	− 0.4	− 0.5	− 0.5	− 0.5	**268**
094	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9	1.0	1.0	**266**
096	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.5	1.6	**264**
098	0.1	0.2	0.3	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.5	1.6	1.7	1.9	2.0	2.1	**262**
100	0.1	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.3	1.4	1.6	1.7	1.9	2.0	2.2	2.3	2.5	2.6	**260**
102	− 0.2	− 0.3	− 0.5	− 0.7	− 0.9	− 1.0	− 1.2	− 1.4	− 1.6	− 1.7	− 1.9	− 2.1	− 2.3	− 2.4	− 2.6	− 2.8	− 2.9	− 3.1	**258**
104	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	**256**
106	0.2	0.5	0.7	0.9	1.1	1.4	1.6	1.8	2.1	2.3	2.5	2.8	3.0	3.2	3.4	3.7	3.9	4.1	**254**
108	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.1	2.3	2.6	2.8	3.1	3.3	3.6	3.9	4.1	4.4	4.6	**252**
110	0.3	0.6	0.9	1.1	1.4	1.7	2.0	2.3	2.6	2.9	3.1	3.4	3.7	4.0	4.3	4.6	4.8	5.1	**250**
112	− 0.3	− 0.6	− 0.9	− 1.2	− 1.6	− 1.9	− 2.2	− 2.5	− 2.8	− 3.1	− 3.4	− 3.7	− 4.1	− 4.4	− 4.7	− 5.0	− 5.3	− 5.6	**248**
114	0.3	0.7	1.0	1.4	1.7	2.0	2.4	2.7	3.1	3.4	3.7	4.1	4.4	4.7	5.1	5.4	5.8	6.1	**246**
116	0.4	0.7	1.1	1.5	1.8	2.2	2.6	2.9	3.3	3.7	4.0	4.4	4.7	5.1	5.5	5.8	6.2	6.6	**244**
118	0.4	0.8	1.2	1.6	2.0	2.3	2.7	3.1	3.5	3.9	4.3	4.7	5.1	5.5	5.9	6.3	6.7	7.0	**242**
120	0.4	0.8	1.3	1.7	2.1	2.5	2.9	3.3	3.8	4.2	4.6	5.0	5.4	5.8	6.3	6.7	7.1	7.5	**240**
122	− 0.4	− 0.9	− 1.3	− 1.8	− 2.2	− 2.6	− 3.1	− 3.5	− 4.0	− 4.4	− 4.9	− 5.3	− 5.7	− 6.2	− 6.6	− 7.1	− 7.5	− 7.9	**238**
124	0.5	0.9	1.4	1.9	2.3	2.8	3.3	3.7	4.2	4.7	5.1	5.6	6.1	6.5	7.0	7.5	7.9	8.4	**236**
126	0.5	1.0	1.5	2.0	2.4	2.9	3.4	3.9	4.4	4.9	5.4	5.9	6.4	6.9	7.3	7.8	8.3	8.8	**234**
128	0.5	1.0	1.5	2.1	2.6	3.1	3.6	4.1	4.6	5.1	5.6	6.2	6.7	7.2	7.7	8.2	8.7	9.2	**232**
130	0.5	1.1	1.6	2.1	2.7	3.2	3.7	4.3	4.8	5.4	5.9	6.4	7.0	7.5	8.0	8.6	9.1	9.6	**230**
132	− 0.6	− 1.1	− 1.7	− 2.2	− 2.8	− 3.3	− 3.9	− 4.5	− 5.0	− 5.6	− 6.1	− 6.7	− 7.2	− 7.8	− 8.4	− 8.9	− 9.5	− 10.0	**228**
134	0.6	1.2	1.7	2.3	2.9	3.5	4.1	4.6	5.2	5.8	6.4	6.9	7.5	8.1	8.7	9.3	9.8	10.4	**226**
136	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0	6.6	7.2	7.8	8.4	9.0	9.6	10.2	10.8	**224**
138	0.6	1.2	1.9	2.5	3.1	3.7	4.3	5.0	5.6	6.2	6.8	7.4	8.1	8.7	9.3	9.9	10.5	11.1	**222**
140	0.6	1.3	1.9	2.6	3.2	3.8	4.5	5.1	5.7	6.4	7.0	7.7	8.3	8.9	9.6	10.2	10.9	11.5	**220**
142	− 0.7	− 1.3	− 2.0	− 2.6	− 3.3	− 3.9	− 4.6	− 5.3	− 5.9	− 6.6	− 7.2	− 7.9	− 8.5	− 9.2	− 9.9	− 10.5	− 11.2	− 11.8	**218**
144	0.7	1.3	2.0	2.7	3.4	4.0	4.7	5.4	6.1	6.7	7.4	8.1	8.8	9.4	10.1	10.8	11.5	12.1	**216**
146	0.7	1.4	2.1	2.8	3.5	4.1	4.8	5.5	6.2	6.9	7.6	8.3	9.0	9.7	10.4	11.1	11.7	12.4	**214**
148	0.7	1.4	2.1	2.8	3.5	4.2	4.9	5.7	6.4	7.1	7.8	8.5	9.2	9.9	10.6	11.3	12.0	12.7	**212**
150	0.7	1.4	2.2	2.9	3.6	4.3	5.1	5.8	6.5	7.2	7.9	8.7	9.4	10.1	10.8	11.5	12.3	13.0	**210**
152	− 0.7	− 1.5	− 2.2	− 2.9	− 3.7	− 4.4	− 5.2	− 5.9	− 6.6	− 7.4	− 8.1	− 8.8	− 9.6	− 10.3	− 11.0	− 11.8	− 12.5	− 13.2	**208**
154	0.7	1.5	2.2	3.0	3.7	4.5	5.2	6.0	6.7	7.5	8.2	9.0	9.7	10.5	11.2	12.0	12.7	13.5	**206**
156	0.8	1.5	2.3	3.0	3.8	4.6	5.3	6.1	6.9	7.6	8.4	9.1	9.9	10.7	11.4	12.2	12.9	13.7	**204**
158	0.8	1.5	2.3	3.1	3.9	4.6	5.4	6.2	7.0	7.7	8.5	9.3	10.0	10.8	11.6	12.4	13.1	13.9	**202**
160	0.8	1.6	2.3	3.1	3.9	4.7	5.5	6.3	7.0	7.8	8.6	9.4	10.2	11.0	11.7	12.5	13.3	14.1	**200**
162	− 0.8	− 1.6	− 2.4	− 3.2	− 4.0	− 4.8	− 5.5	− 6.3	− 7.1	− 7.9	− 8.7	− 9.5	− 10.3	− 11.1	− 11.9	− 12.7	− 13.5	− 14.3	**198**
164	0.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2	8.0	8.8	9.6	10.4	11.2	12.0	12.8	13.6	14.4	**196**
166	0.8	1.6	2.4	3.2	4.0	4.9	5.7	6.5	7.3	8.1	8.9	9.7	10.5	11.3	12.1	12.9	13.7	14.6	**194**
168	0.8	1.6	2.4	3.3	4.1	4.9	5.7	6.5	7.3	8.2	9.0	9.8	10.6	11.4	12.2	13.0	13.9	14.7	**192**
170	0.8	1.6	2.5	3.3	4.1	4.9	5.7	6.6	7.4	8.2	9.0	9.8	10.7	11.5	12.3	13.1	14.0	14.8	**190**
172	− 0.8	− 1.7	− 2.5	− 3.3	− 4.1	− 5.0	− 5.8	− 6.6	− 7.4	− 8.3	− 9.1	− 9.9	− 10.7	− 11.6	− 12.4	− 13.2	− 14.0	− 14.9	**188**
174	0.8	1.7	2.5	3.3	4.1	5.0	5.8	6.6	7.5	8.3	9.1	9.9	10.8	11.6	12.4	13.3	14.1	14.9	**186**
176	0.8	1.7	2.5	3.3	4.2	5.0	5.8	6.7	7.5	8.3	9.1	10.0	10.8	11.6	12.5	13.3	14.1	15.0	**184**
178	0.8	1.7	2.5	3.3	4.2	5.0	5.8	6.7	7.5	8.3	9.2	10.0	10.8	11.7	12.5	13.3	14.2	15.0	**182**
180	0.8	1.7	2.5	3.3	4.2	5.0	5.8	6.7	7.5	8.3	9.2	10.0	10.8	11.7	12.5	13.3	14.2	15.0	**180**

Time of fix or computation	Sign from 1-min. Table	To observed altitude	To tabulated altitude	To intercept
Later than observation	+	Add	Subtract	Toward
	−	Subtract	Add	Away
Earlier than observation	+	Subtract	Add	Away
	−	Add	Subtract	Toward

Alternative Table 2 — Altitude Correction for Change in Position of Body

Correction for 1 Minute of Time

True Zn	Latitude in Degrees																		True Zn
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	
°	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	°
090	+ 15.0	+ 14.9	+ 14.8	+ 14.5	+ 14.1	+ 13.6	+ 13.0	+ 12.3	+ 11.5	+ 10.6	+ 9.6	+ 8.6	+ 7.5	+ 6.3	+ 5.1	+ 3.9	+ 2.6	+ 1.3	090
092	15.0	14.9	14.8	14.5	14.1	13.6	13.0	12.3	11.5	10.6	9.6	8.6	7.5	6.3	5.1	3.9	2.6	1.3	088
094	15.0	14.9	14.7	14.5	14.1	13.6	13.0	12.3	11.5	10.6	9.6	8.6	7.5	6.3	5.1	3.9	2.6	1.3	086
096	14.9	14.9	14.7	14.4	14.0	13.5	12.9	12.2	11.4	10.5	9.6	8.6	7.5	6.3	5.1	3.9	2.6	1.3	084
098	14.9	14.8	14.6	14.3	14.0	13.5	12.9	12.2	11.4	10.5	9.5	8.5	7.4	6.3	5.1	3.8	2.6	1.3	082
100	+ 14.8	+ 14.7	+ 14.5	+ 14.3	+ 13.9	+ 13.4	+ 12.8	+ 12.1	+ 11.3	+ 10.4	+ 9.5	+ 8.5	+ 7.4	+ 6.2	+ 5.1	+ 3.8	+ 2.6	+ 1.3	080
102	14.7	14.6	14.4	14.2	13.8	13.3	12.7	12.0	11.2	10.4	9.4	8.4	7.3	6.2	5.0	3.8	2.5	1.3	078
104	14.6	14.5	14.3	14.1	13.7	13.2	12.6	11.9	11.1	10.3	9.4	8.3	7.3	6.2	5.0	3.8	2.5	1.3	076
106	14.4	14.4	14.2	13.9	13.5	13.1	12.5	11.8	11.0	10.2	9.3	8.3	7.2	6.1	4.9	3.7	2.5	1.3	074
108	14.3	14.2	14.0	13.8	13.4	12.9	12.4	11.7	10.9	10.1	9.2	8.2	7.1	6.0	4.9	3.7	2.5	1.2	072
110	+ 14.1	+ 14.0	+ 13.9	+ 13.6	+ 13.2	+ 12.8	+ 12.2	+ 11.5	+ 10.8	+ 10.0	+ 9.1	+ 8.1	+ 7.0	+ 6.0	+ 4.8	+ 3.6	+ 2.4	+ 1.2	070
112	13.9	13.9	13.7	13.4	13.1	12.6	12.0	11.4	10.7	9.8	8.9	8.0	7.0	5.9	4.8	3.6	2.4	1.2	068
114	13.7	13.7	13.5	13.2	12.9	12.4	11.9	11.2	10.5	9.7	8.8	7.9	6.9	5.8	4.7	3.5	2.4	1.2	066
116	13.5	13.4	13.3	13.0	12.7	12.2	11.7	11.0	10.3	9.5	8.7	7.7	6.7	5.7	4.6	3.5	2.3	1.2	064
118	13.2	13.2	13.0	12.8	12.4	12.0	11.5	10.8	10.1	9.4	8.5	7.6	6.6	5.6	4.5	3.4	2.3	1.2	062
120	+ 13.0	+ 12.9	+ 12.8	+ 12.5	+ 12.2	+ 11.8	+ 11.3	+ 10.6	+ 10.0	+ 9.2	+ 8.4	+ 7.5	+ 6.5	+ 5.5	+ 4.4	+ 3.4	+ 2.3	+ 1.1	060
122	12.7	12.7	12.5	12.3	12.0	11.5	11.0	10.4	9.7	9.0	8.2	7.3	6.4	5.4	4.4	3.3	2.2	1.1	058
124	12.4	12.4	12.2	12.0	11.7	11.3	10.8	10.2	9.5	8.8	8.0	7.1	6.2	5.3	4.3	3.2	2.2	1.1	056
126	12.1	12.1	12.0	11.7	11.4	11.0	10.5	9.9	9.3	8.6	7.8	7.0	6.1	5.1	4.2	3.1	2.1	1.1	054
128	11.8	11.8	11.6	11.4	11.1	10.7	10.2	9.7	9.1	8.4	7.6	6.8	5.9	5.0	4.0	3.1	2.1	1.0	052
130	+ 11.5	+ 11.4	+ 11.3	+ 11.1	+ 10.8	+ 10.4	+ 10.0	+ 9.4	+ 8.8	+ 8.1	+ 7.4	+ 6.6	+ 5.7	+ 4.9	+ 3.9	+ 3.0	+ 2.0	+ 1.0	050
132	11.1	11.1	11.0	10.8	10.5	10.1	9.7	9.1	8.5	7.9	7.2	6.4	5.6	4.7	3.8	2.9	1.9	1.0	048
134	10.8	10.8	10.6	10.4	10.1	9.8	9.3	8.8	8.3	7.6	6.9	6.2	5.4	4.6	3.7	2.8	1.9	0.9	046
136	10.4	10.4	10.3	10.1	9.8	9.4	9.0	8.5	8.0	7.4	6.7	6.0	5.2	4.4	3.6	2.7	1.8	0.9	044
138	10.0	10.0	9.9	9.7	9.4	9.1	8.7	8.2	7.7	7.1	6.5	5.8	5.0	4.2	3.4	2.6	1.7	0.9	042
140	+ 9.6	+ 9.6	+ 9.5	+ 9.3	+ 9.1	+ 8.7	+ 8.4	+ 7.9	+ 7.4	+ 6.8	+ 6.2	+ 5.5	+ 4.8	+ 4.1	+ 3.3	+ 2.5	+ 1.7	+ 0.8	040
142	9.2	9.2	9.1	8.9	8.7	8.4	8.0	7.6	7.1	6.5	5.9	5.3	4.6	3.9	3.2	2.4	1.6	0.8	038
144	8.8	8.8	8.7	8.5	8.3	8.0	7.6	7.2	6.8	6.2	5.7	5.1	4.4	3.7	3.0	2.3	1.5	0.8	036
146	8.4	8.4	8.3	8.1	7.9	7.6	7.3	6.9	6.4	5.9	5.4	4.8	4.2	3.5	2.9	2.2	1.5	0.7	034
148	7.9	7.9	7.8	7.7	7.5	7.2	6.9	6.5	6.1	5.6	5.1	4.6	4.0	3.4	2.7	2.1	1.4	0.7	032
150	+ 7.5	+ 7.5	+ 7.4	+ 7.2	+ 7.0	+ 6.8	+ 6.5	+ 6.1	+ 5.7	+ 5.3	+ 4.8	+ 4.3	+ 3.8	+ 3.2	+ 2.6	+ 1.9	+ 1.3	+ 0.7	030
152	7.0	7.0	6.9	6.8	6.6	6.4	6.1	5.8	5.4	5.0	4.5	4.0	3.5	3.0	2.4	1.8	1.2	0.6	028
154	6.6	6.6	6.5	6.4	6.2	6.0	5.7	5.4	5.0	4.6	4.2	3.8	3.3	2.8	2.2	1.7	1.1	0.6	026
156	6.1	6.1	6.0	5.9	5.7	5.5	5.3	5.0	4.7	4.3	3.9	3.5	3.1	2.6	2.1	1.6	1.1	0.5	024
158	5.6	5.6	5.5	5.4	5.3	5.1	4.9	4.6	4.3	4.0	3.6	3.2	2.8	2.4	1.9	1.5	1.0	0.5	022
160	+ 5.1	+ 5.1	+ 5.1	+ 5.0	+ 4.8	+ 4.6	+ 4.4	+ 4.2	+ 3.9	+ 3.6	+ 3.3	+ 2.9	+ 2.6	+ 2.2	+ 1.8	+ 1.3	+ 0.9	+ 0.4	020
162	4.6	4.6	4.6	4.5	4.4	4.2	4.0	3.8	3.6	3.3	3.0	2.7	2.3	2.0	1.6	1.2	0.8	0.4	018
164	4.1	4.1	4.1	4.0	3.9	3.7	3.6	3.4	3.2	2.9	2.7	2.4	2.1	1.7	1.4	1.1	0.7	0.4	016
166	3.6	3.6	3.6	3.5	3.4	3.3	3.1	3.0	2.8	2.6	2.3	2.1	1.8	1.5	1.2	0.9	0.6	0.3	014
168	3.1	3.1	3.1	3.0	2.9	2.8	2.7	2.6	2.4	2.2	2.0	1.8	1.6	1.3	1.1	0.8	0.5	0.3	012
170	+ 2.6	+ 2.6	+ 2.6	+ 2.5	+ 2.4	+ 2.4	+ 2.3	+ 2.1	+ 2.0	+ 1.8	+ 1.7	+ 1.5	+ 1.3	+ 1.1	+ 0.9	+ 0.7	+ 0.5	+ 0.2	010
172	2.1	2.1	2.1	2.0	2.0	1.9	1.8	1.7	1.6	1.5	1.3	1.2	1.0	0.9	0.7	0.5	0.4	0.2	008
174	1.6	1.6	1.5	1.5	1.5	1.4	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.5	0.4	0.3	0.1	006
176	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.5	0.4	0.4	0.3	0.2	0.1	004
178	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.0	002
180	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	0.0	000
182	− 0.5	− 0.5	− 0.5	− 0.5	− 0.5	− 0.5	− 0.5	− 0.4	− 0.4	− 0.4	− 0.3	− 0.3	− 0.3	− 0.2	− 0.2	− 0.1	− 0.1	− 0.0	358
184	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.5	0.4	0.4	0.3	0.2	0.1	356
186	1.6	1.6	1.5	1.5	1.5	1.4	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.5	0.4	0.3	0.1	354
188	2.1	2.1	2.1	2.0	2.0	1.9	1.8	1.7	1.6	1.5	1.3	1.2	1.0	0.9	0.7	0.5	0.4	0.2	352
190	2.6	2.6	2.6	2.5	2.4	2.4	2.3	2.1	2.0	1.8	1.7	1.5	1.3	1.1	0.9	0.7	0.5	0.2	350
192	− 3.1	− 3.1	− 3.1	− 3.0	− 2.9	− 2.8	− 2.7	− 2.6	− 2.4	− 2.2	− 2.0	− 1.8	− 1.6	− 1.3	− 1.1	− 0.8	− 0.5	− 0.3	348
194	3.6	3.6	3.6	3.5	3.4	3.3	3.1	3.0	2.8	2.6	2.3	2.1	1.8	1.5	1.2	0.9	0.6	0.3	346
196	4.1	4.1	4.1	4.0	3.9	3.7	3.6	3.4	3.2	2.9	2.7	2.4	2.1	1.7	1.4	1.1	0.7	0.4	344
198	4.6	4.6	4.6	4.5	4.4	4.2	4.0	3.8	3.6	3.3	3.0	2.7	2.3	2.0	1.6	1.2	0.8	0.4	342
200	5.1	5.1	5.1	5.0	4.8	4.6	4.4	4.2	3.9	3.6	3.3	2.9	2.6	2.2	1.8	1.3	0.9	0.4	340
202	− 5.6	− 5.6	− 5.5	− 5.4	− 5.3	− 5.1	− 4.9	− 4.6	− 4.3	− 4.0	− 3.6	− 3.2	− 2.8	− 2.4	− 1.9	− 1.5	− 1.0	− 0.5	338
204	6.1	6.1	6.0	5.9	5.7	5.5	5.3	5.0	4.7	4.3	3.9	3.5	3.1	2.6	2.1	1.6	1.1	0.5	336
206	6.6	6.6	6.5	6.4	6.2	6.0	5.7	5.4	5.0	4.6	4.2	3.8	3.3	2.8	2.2	1.7	1.1	0.6	334
208	7.0	7.0	6.9	6.8	6.6	6.4	6.1	5.8	5.4	5.0	4.5	4.0	3.5	3.0	2.4	1.8	1.2	0.6	332
210	7.5	7.5	7.4	7.2	7.0	6.8	6.5	6.1	5.7	5.3	4.8	4.3	3.8	3.2	2.6	1.9	1.3	0.7	330
212	− 7.9	− 7.9	− 7.8	− 7.7	− 7.5	− 7.2	− 6.9	− 6.5	− 6.1	− 5.6	− 5.1	− 4.6	− 4.0	− 3.4	− 2.7	− 2.1	− 1.4	− 0.7	328
214	8.4	8.4	8.3	8.1	7.9	7.6	7.3	6.9	6.4	5.9	5.4	4.8	4.2	3.5	2.9	2.2	1.5	0.7	326
216	8.8	8.8	8.7	8.5	8.3	8.0	7.6	7.2	6.8	6.2	5.7	5.1	4.4	3.7	3.0	2.3	1.5	0.8	324
218	9.2	9.2	9.1	8.9	8.7	8.4	8.0	7.6	7.1	6.5	5.9	5.3	4.6	3.9	3.2	2.4	1.6	0.8	322
220	9.6	9.6	9.5	9.3	9.1	8.7	8.4	7.9	7.4	6.8	6.2	5.5	4.8	4.1	3.3	2.5	1.7	0.8	320
222	− 10.0	− 10.0	− 9.9	− 9.7	− 9.4	− 9.1	− 8.7	− 8.2	− 7.7	− 7.1	− 6.5	− 5.8	− 5.0	− 4.2	− 3.4	− 2.6	− 1.7	− 0.9	318
224	10.4	10.4	10.3	10.1	9.8	9.4	9.0	8.5	8.0	7.4	6.7	6.0	5.2	4.4	3.6	2.7	1.8	0.9	316
226	10.8	10.8	10.6	10.4	10.1	9.8	9.3	8.8	8.3	7.6	6.9	6.2	5.4	4.6	3.7	2.8	1.9	0.9	314
228	11.1	11.1	11.0	10.8	10.5	10.1	9.7	9.1	8.5	7.9	7.2	6.4	5.6	4.7	3.8	2.9	1.9	1.0	312
230	11.5	11.4	11.3	11.1	10.8	10.4	10.0	9.4	8.8	8.1	7.4	6.6	5.7	4.9	3.9	3.0	2.0	1.0	310
232	− 11.8	− 11.8	− 11.6	− 11.4	− 11.1	− 10.7	− 10.2	− 9.7	− 9.1	− 8.4	− 7.6	− 6.8	− 5.9	− 5.0	− 4.0	− 3.1	− 2.1	− 1.0	308
234	12.1	12.1	12.0	11.7	11.4	11.0	10.5	9.9	9.3	8.6	7.8	7.0	6.1	5.1	4.2	3.1	2.1	1.1	306
236	12.4	12.4	12.2	12.0	11.7	11.3	10.8	10.2	9.5	8.8	8.0	7.1	6.2	5.3	4.3	3.2	2.2	1.1	304
238	12.7	12.7	12.5	12.3	12.0	11.5	11.0	10.4	9.7	9.0	8.2	7.3	6.4	5.4	4.4	3.3	2.2	1.1	302
240	13.0	12.9	12.8	12.5	12.2	11.8	11.3	10.6	10.0	9.2	8.4	7.5	6.5	5.5	4.4	3.4	2.3	1.1	300
242	− 13.2	− 13.2	− 13.0	− 12.8	− 12.4	− 12.0	− 11.5	− 10.8	− 10.1	− 9.4	− 8.5	− 7.6	− 6.6	− 5.6	− 4.5	− 3.4	− 2.3	− 1.2	298
244	13.5	13.4	13.3	13.0	12.7	12.2	11.7	11.0	10.3	9.5	8.7	7.7	6.7	5.7	4.6	3.5	2.3	1.2	296
246	13.7	13.7	13.5	13.2	12.9	12.4	11.9	11.2	10.5	9.7	8.8	7.9	6.9	5.8	4.7	3.5	2.4	1.2	294
248	13.9	13.9	13.7	13.4	13.1	12.6	12.0	11.4	10.7	9.8	8.9	8.0	7.0	5.9	4.8	3.6	2.4	1.2	292
250	14.1	14.0	13.9	13.6	13.2	12.8	12.2	11.5	10.8	10.0	9.1	8.1	7.0	6.0	4.8	3.6	2.4	1.2	290
252	− 14.3	− 14.2	− 14.0	− 13.8	− 13.4	− 12.9	− 12.4	− 11.7	− 10.9	− 10.1	− 9.2	− 8.2	− 7.1	− 6.0	− 4.9	− 3.7	− 2.5	− 1.2	288
254	14.4	14.4	14.2	13.9	13.5	13.1	12.5	11.8	11.0	10.2	9.3	8.3	7.2	6.1	4.9	3.7	2.5	1.3	286
256	14.6	14.5	14.3	14.1	13.7	13.2	12.6	11.9	11.1	10.3	9.4	8.3	7.3	6.2	5.0	3.8	2.5	1.3	284
258	14.7	14.6	14.4	14.2	13.8	13.3	12.7	12.0	11.2	10.4	9.4	8.4	7.3	6.2	5.0	3.8	2.5	1.3	282
260	14.8	14.7	14.5	14.3	13.9	13.4	12.8	12.1	11.3	10.4	9.5	8.5	7.4	6.2	5.1	3.8	2.6	1.3	280
262	− 14.9	− 14.8	− 14.6	− 14.3	− 14.0	− 13.5	− 12.9	− 12.2	− 11.4	− 10.5	− 9.5	− 8.5	− 7.4	− 6.3	− 5.1	− 3.8	− 2.6	− 1.3	278
264	14.9	14.9	14.7	14.4	14.0	13.5	12.9	12.2	11.4	10.5	9.6	8.6	7.5	6.3	5.1	3.9	2.6	1.3	276
266	15.0	14.9	14.7	14.5	14.1	13.6	13.0	12.3	11.5	10.6	9.6	8.6	7.5	6.3	5.1	3.9	2.6	1.3	274
268	15.0	14.9	14.8	14.5	14.1	13.6	13.0	12.3	11.5	10.6	9.6	8.6	7.5	6.3	5.1	3.9	2.6	1.3	272
270	15.0	14.9	14.8	14.5	14.1	13.6	13.0	12.3	11.5	10.6	9.6	8.6	7.5	6.3	5.1	3.9	2.6	1.3	270

To facilitate use of Pub. No. 249, Volume 1, 2, and 3.

Time of fix or computation	Sign from 1-min. Table	To observed altitude	To tabulated altitude	To intercept
Later than observation	+	Add	Subtract	Toward
	−	Subtract	Add	Away
Earlier than observation	+	Subtract	Add	Away
	−	Add	Subtract	Toward

NAVIGATIONAL STARS, EPOCH 2010.0

Alphabetical Order

Name	No.	Magnitude		SHA	Dec
		Visual	S-4		
				° ′	° ′
Acamar	**7**	3.2	3.2	315 20	S 40 16
ACHERNAR	**5**	0.5	0.1	335 29	S 57 11
ACRUX	**30**	1.3	0.5	173 13	S 63 09
**Adhara*	**19**	1.5	1.2	255 15	S 28 59
ALDEBARAN	**10**	0.9	3.1	290 53	N 16 32
Alioth	**32**	1.8	1.5	166 23	N 55 54
Alkaid	**34**	1.9	1.5	153 01	N 49 16
**Al Na'ir*	**55**	1.7	1.8	27 47	S 46 55
**Alnilam*	**15**	1.7	1.3	275 49	S 1 12
Alphard	**25**	2.0	4.4	217 59	S 8 42
Alphecca	**41**	2.2	2.1	126 13	N 26 41
Alpheratz	**1**	2.1	1.8	357 46	N 29 09
ALTAIR	**51**	0.8	1.0	62 11	N 8 54
**Ankaa*	**2**	2.4	3.9	353 18	S 42 15
ANTARES	**42**	1.0	3.7	112 30	S 26 27
ARCTURUS	**37**	0.0	1.9	145 58	N 19 08
**Atria*	**43**	1.9	4.1	107 34	S 69 03
**Avior*	**22**	1.9	3.3	234 19	S 59 33
**Bellatrix*	**13**	1.6	1.2	278 35	N 6 21
BETELGEUSE	**16**	0.1-1.2	2.5-3.6	271 04	N 7 24
CANOPUS	**17**	− 0.7	− 0.8	263 57	S 52 42
CAPELLA	**12**	0.1	1.3	280 39	N 46 01
DENEB	**53**	1.3	1.4	49 33	N 45 19
Denebola	**28**	2.1	2.2	182 36	N 14 31
Diphda	**4**	2.0	3.6	348 59	S 17 56
Dubhe	**27**	1.8	3.4	193 55	N 61 42
**Elnath*	**14**	1.7	1.4	278 16	N 28 37
**Eltanin*	**47**	2.2	4.6	90 47	N 51 29
Enif	**54**	2.4	4.8	33 50	N 9 55
FOMALHAUT	**56**	1.2	1.3	15 27	S 29 34
**Gacrux*	**31**	1.6	4.1	172 04	S 57 10
Gienah	**29**	2.6	2.5	175 55	S 17 36
**HADAR*	**35**	0.6	0.3	148 52	S 60 25
Hamal	**6**	2.0	3.8	328 04	N 23 31
**Kaus Australis*	**48**	1.9	2.0	83 47	S 34 23
Kochab	**40**	2.1	4.3	137 20	N 74 07
**Markab*	**57**	2.5	2.3	13 41	N 15 16
Menkar	**8**	2.5	5.3	314 18	N 4 08
**Menkent*	**36**	2.1	3.5	148 11	S 36 25
Miaplacidus	**24**	1.7	1.8	221 40	S 69 46
Mirfak	**9**	1.8	2.4	308 44	N 49 54
Nunki	**50**	2.0	1.9	76 02	S 26 17
Peacock	**52**	1.9	1.7	53 24	S 56 42
POLLUX	**21**	1.1	2.5	243 31	N 28 00
PROCYON	**20**	0.4	0.8	245 03	N 5 12
Rasalhague	**46**	2.1	2.2	96 09	N 12 33
REGULUS	**26**	1.4	1.0	207 46	N 11 55
RIGEL	**11**	0.1	0.0	281 15	S 8 11
RIGIL KENT.	**38**	− 0.3	0.9	139 54	S 60 53
**Sabik*	**44**	2.4	2.5	102 16	S 15 44
Schedar	**3**	2.2	4.1	349 44	N 56 36
Shaula	**45**	1.6	1.3	96 26	S 37 07
SIRIUS	**18**	− 1.5	− 1.5	258 36	S 16 44
SPICA	**33**	1.0	0.7	158 34	S 11 13
Suhail	**23**	2.2	4.6	222 55	S 43 28
VEGA	**49**	0.0	0.0	80 41	N 38 48
**Zubenelgenubi*	**39**	2.8	3.2	137 08	S 16 05

Order of SHA

Name	No.	Magnitude		SHA	Dec
		Visual	S-4		
				° ′	° ′
**Markab*	**57**	2.5	2.3	13 41	N 15 16
FOMALHAUT	**56**	1.2	1.3	15 27	S 29 34
**Al Na'ir*	**55**	1.7	1.8	27 47	S 46 55
Enif	**54**	2.4	4.8	33 50	N 9 55
DENEB	**53**	1.3	1.4	49 33	N 45 19
Peacock	**52**	1.9	1.7	53 24	S 56 42
ALTAIR	**51**	0.8	1.0	62 11	N 8 54
Nunki	**50**	2.0	1.9	76 02	S 26 17
VEGA	**49**	0.0	0.0	80 41	N 38 48
**Kaus Australis*	**48**	1.9	2.0	83 47	S 34 23
**Eltanin*	**47**	2.2	4.6	90 47	N 51 29
Rasalhague	**46**	2.1	2.2	96 09	N 12 33
Shaula	**45**	1.6	1.3	96 26	S 37 07
**Sabik*	**44**	2.4	2.5	102 16	S 15 44
**Atria*	**43**	1.9	4.1	107 34	S 69 03
ANTARES	**42**	1.0	3.7	112 30	S 26 27
Alphecca	**41**	2.2	2.1	126 13	N 26 41
Kochab	**40**	2.1	4.3	137 20	N 74 07
**Zubenelgenubi*	**39**	2.8	3.2	137 08	S 16 05
RIGIL KENT.	**38**	− 0.3	0.9	139 54	S 60 53
ARCTURUS	**37**	0.0	1.9	145 58	N 19 08
**Menkent*	**36**	2.1	3.5	148 11	S 36 25
**HADAR*	**35**	0.6	0.3	148 52	S 60 25
Alkaid	**34**	1.9	1.5	153 01	N 49 16
SPICA	**33**	1.0	0.7	158 34	S 11 13
Alioth	**32**	1.8	1.5	166 23	N 55 54
**Gacrux*	**31**	1.6	4.1	172 04	S 57 10
ACRUX	**30**	1.3	0.5	173 13	S 63 09
Gienah	**29**	2.6	2.5	175 55	S 17 36
Denebola	**28**	2.1	2.2	182 36	N 14 31
Dubhe	**27**	1.8	3.4	193 55	N 61 42
REGULUS	**26**	1.4	1.0	207 46	N 11 55
Alphard	**25**	2.0	4.4	217 59	S 8 42
Miaplacidus	**24**	1.7	1.8	221 40	S 69 46
Suhail	**23**	2.2	4.6	222 55	S 43 28
**Avior*	**22**	1.9	3.3	234 19	S 59 33
POLLUX	**21**	1.1	2.5	243 31	N 28 00
PROCYON	**20**	0.4	0.8	245 03	N 5 12
**Adhara*	**19**	1.5	1.2	255 15	S 28 59
SIRIUS	**18**	− 1.5	− 1.5	258 36	S 16 44
CANOPUS	**17**	− 0.7	− 0.8	263 57	S 52 42
BETELGEUSE	**16**	0.1-1.2	2.5-3.6	271 04	N 7 24
**Alnilam*	**15**	1.7	1.3	275 49	S 1 12
**Elnath*	**14**	1.7	1.4	278 16	N 28 37
**Bellatrix*	**13**	1.6	1.2	278 35	N 6 21
CAPELLA	**12**	0.1	1.3	280 39	N 46 01
RIGEL	**11**	0.1	0.0	281 15	S 8 11
ALDEBARAN	**10**	0.9	3.1	290 53	N 16 32
Mirfak	**9**	1.8	2.4	308 44	N 49 54
Menkar	**8**	2.5	5.3	314 18	N 4 08
Acamar	**7**	3.2	3.2	315 20	S 40 16
Hamal	**6**	2.0	3.8	328 04	N 23 31
ACHERNAR	**5**	0.5	0.1	335 29	S 57 11
Diphda	**4**	2.0	3.6	348 59	S 17 56
Schedar	**3**	2.2	4.1	349 44	N 56 36
**Ankaa*	**2**	2.4	3.9	353 18	S 42 15
Alpheratz	**1**	2.1	1.8	357 46	N 29 09

The star numbers and names are the same as in *The Air Almanac*.
* Not in tabular pages of Volume 1.

FOREWORD

The *Sight Reduction Tables for Air Navigation* consist of three volumes of comprehensive tables of altitude and azimuth designed for the rapid reduction of astronomical sights in the air. The present volume (Volume **1**) contains tables for selected stars for all latitudes, calculated for the epoch of 2010.0, and replaces the previous edition calculated for the epoch of 2005.0; it is intended for use for about 5 years, when a new edition based on a later epoch will be issued. Volume **2** for latitudes 0°– 40° and Volume **3** for latitudes 39°– 89° are permanent tables for integral degrees of declination. They provide sights for bodies with declinations within 30° north or south of the equator, which includes the Sun, the Moon, the navigational planets and many of the navigational stars.

The time argument in the examples is denoted by UT (Universal Time). It is also known as GMT (Greenwich Mean Time).

Sight Reduction Tables for Air Navigation are published in the USA as Pub. No. 249, and in the UK as *Rapid Sight Reduction Tables for Navigation* AP 3270/NP 303. The National Geospatial-Intelligence Agency (NGA) is responsible for the compilation and composition of these tables. The Nautical Almanac Office of the U.S. Naval Observatory and H.M. Nautical Almanac Office (HMNAO) of the UK Hydrographic Office have cooperated in their design and preparation. Some of the auxiliary tables in this edition were furnished entirely by HMNAO.

The content and format of these three volumes may not be changed without the approval of Working Party 70 of the Air Standardization Coordinating Committee.

Users should refer corrections, additions, and comments for improving this product to:

MARITIME DIVISION
ST D 44
NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY
4600 SANGAMORE ROAD
BETHESDA MD 20816–5003

INTRODUCTION

DESCRIPTION OF THE TABLES

These tables, designated as Volume 1 of the three-volume series of Pub. No. 249, *Sight Reduction Tables for Air Navigation*, contain values of the altitude (to the nearest minute) and the true azimuth (to the nearest degree) of seven selected stars for the complete ranges of latitude and hour angle of Aries. The arrangement provides, for any position and time, the best selection of seven of the stars available for observation and, for these seven stars, data for presetting before observation and for accurate reduction of the sights after observation.

In the calculation of the altitudes and azimuths the mean places of the stars for epoch 2010.0 have been used; corrections for precession and nutation are given in Table 5, but their omission will not give rise to a positional error greater than two miles in the years 2007–2012. No correction for refraction has been included in the tabulated altitudes, so that the full correction must be applied to the sextant altitudes.

Although Pub. No. 249 was designed for air navigation, it is also used extensively for marine navigation. The main differences in the use of Pub. No. 249 for marine navigation are highlighted at the end of this introduction. Volume 1 may be used without reference to an almanac such as *The Air Almanac* or *The Nautical Almanac*. The tables in this volume may be used with a clock, or other device, giving sidereal time. With the normal procedure of plotting a sight from an assumed position, no interpolation is required for the stars tabulated.

ENTERING ARGUMENTS AND ARRANGEMENT

Latitude. Tabulations are given for every whole degree of latitude from 89° north to 89° south. From 69° north to 69° south all data for a single latitude appear on two facing pages; from 70° to the poles, both north and south, the data for a single latitude appear on one page.

LHA Aries. The vertical argument on each page is the local hour angle of the first point of Aries (LHA ♈). It ranges from 0° to 360°; in general the interval is 1°, but between latitudes 70° and the poles it is increased to 2°.

Selected stars. The tabulated (or computed) altitude (Hc) and the true azimuth (Zn) are given for seven selected stars for each latitude and each entry of LHA ♈. The selection of stars is used unchanged for each group of 15 entries of LHA ♈ (30° for latitudes over 69°, 15° for lower latitudes); within each such group the order of arrangement is that of the azimuths corresponding to the first entry. Of each selection of seven stars, three are marked with a diamond symbol (♦) as being suitable for a three-star fix.

A total of 41 stars are used, of which 19 are of the first magnitude (brighter than magnitude 1.5) and 17 of the second magnitude. The names of first-magnitude stars are given in capital letters. A complete list of the 57 stars selected for astronavigation is given in the front of this volume, and an asterisk is printed beside those stars not used within. The adopted names and numbers agree with those used in *The Air Almanac*. The S-4 magnitudes are applicable to astro-trackers employing S-4 photo-sensitive response.

Many factors were considered in selecting the stars, including azimuth, magnitude, altitude and continuity. Continuity was sought in regard to both latitude and hour angle, particularly for latitude where changes are not immediately evident by inspection.

USE OF THE TABLES

The tables are intended for use for two distinct operations—the planning of observations, and their reduction. It is important that full use should be made of the tables for the planning of observations.

Planning of observations. Since only seven stars are given it is essential to refer to the tables before observation, in order to ensure that data will be available for the reduction of the observations. This is done by estimating latitude and LHA ♈ for the proposed time of observation, from a knowledge of the DR position and GHA ♈ from Table 4 or an appropriate almanac, such as *The Air Almanac* or *The Nautical Almanac*. On reference to the tables this information gives immediately

the seven stars available, together with their approximate altitudes and azimuths. From these seven stars, the observer can select those which best suit his particular purpose and the prevailing conditions; the approximate altitudes and azimuths make identification easy, and enable the sextant to be preset to the approximate altitude.

Example. On 2008 January 1, a navigator proposes to observe at $12^h\ 22^m$ UT in DR position N54° 15′, E175° 30′.
From Table 4, for 2008 January 1, (a) = 100° 02′, for 12^h UT on day 1, (b) = 180° 30′, and for 22^m, (c) = 5° 31′.
The sum, (a) + (b) + (c) = GHA ♈ for 2008 January 1 at UT $12^h\ 22^m$.

	°	′
GHA ♈ =	286	03
Longitude, added if east, subtracted if west =	+175	30
Sum, with multiples of 360° removed as necessary LHA ♈ =	101	33

Reference to page 52 for Lat. 54° N, LHA ♈ 102° shows that the selected stars are *Dubhe* (azimuth 051°), ♦*REGULUS* (117°), *PROCYON* (163°), *SIRIUS* (181°), ♦*RIGEL* (205°), *Mirfak* (284°), and ♦*DENEB* (340°), all being at convenient altitudes between 12° and 59°. No change in the selection will take place for about 50 minutes before or 10 minutes after the time proposed, but if the observations are delayed, *PROCYON* and *DENEB* will be replaced by *Denebola* and *ALDEBARAN*; the same stars are used for latitude 55°, though *Hamal* and *Schedar* replace *Mirfak* and *DENEB* in latitude 53°. The navigator will accordingly plan his program of observations from among these stars, bearing in mind that it is only one day before New Moon. It should be noted that this preliminary calculation of LHA ♈ may often be modified to serve as a basis for the reduction of the sights, without further reference to Table 4 or an almanac.

If observations are made of stars other than those selected, they can be reduced by the use of Volumes 2 and 3 of these tables, provided the declinations are less than 30° north or south. A list of such stars, with their positions, is given in those volumes as well as being indicated in the star lists in *The Air Almanac*. Observations of other stars must be reduced by other methods or tables.

Reduction of sights. GHA ♈ is taken from Table 4 or an appropriate almanac, such as *The Air Almanac* or *The Nautical Almanac* for the actual time of observation and combined with an assumed longitude, close to the DR longitude, to make LHA ♈ a whole degree, or an even degree for latitudes above 69°. The tables are entered with the whole degree of latitude nearest to the DR latitude, the value of LHA ♈ found above, and the name of the star observed; they give, without interpolation, the tabulated altitude (Hc) and azimuth (Zn). The intercept is found in the usual way by comparing the corrected sextant altitude (Ho) with the tabulated altitude:

towards the star if the sextant altitude is *greater* than the tabulated altitude;
away from the star if the sextant altitude is *less* than the tabulated altitude.

The sextant reading must be corrected for instrument error, dome refraction (if applicable), and refraction (from Table 8) before being compared with the tabulated altitude. The sight is plotted from the assumed position, defined by the whole degree of latitude and the assumed longitude. This assumed position may previously be adjusted for the effect of Coriolis (see Table 9), advanced or retarded to another time, and (in extreme cases) shifted to allow for precession and nutation (see Table 5); alternatively these corrections may be made to the position line or, in the case of the corrections from Tables 5 and 9, to the final fix. The application of these corrections is considered separately on pages v and vi.

INTRODUCTION

Example. On 2008 January 1 in DR position N54° 17′, E175° 46′ at height 9,000 ft. (3 km), an observation of *PROCYON* is obtained at $12^h\ 21^m\ 25^s$ UT; the sextant reading is 40° 34′ and the correction for the instrument error and dome refraction is –4′.

		° ′		° ′	
From Table 4, for 2008 Jan 1	(a) =	100 02	Sextant altitude	40 34	
for 12^h UT on day 1	(b) =	180 30	Dome refraction, etc.	–4	
for $21^m\ 25^s$	(c) =	5 22	Refraction (Table **8**)	–1	
Sum, GHA ♈ for UT $12^h\ 21^m\ 25^s$	GHA ♈ =	285 54	Corrected Sextant altitude (Ho)	40 29	
Assumed longitude, added because east		+176 06	From the main tables (page 52)		
Sum, less 360°	LHA ♈ =	102	Tabulated altitude (Hc)	40 04	Az. (Zn) 163°
			Intercept	25	*towards*

The assumed latitude is N54°, the assumed longitude is E176° 06′, and the intercept of 25′ is plotted from this position in true bearing 163°. The position line is drawn perpendicular to this direction.

Usually, sights of several stars will be taken in rapid succession to give a fix. The example below illustrates the use of tables for the reduction of a typical set of observations.

Example. On 2008 January 1, in DR position N45° 49′, W25° 35′ (for $23^h\ 47^m$ UT) at height 3,000 ft. (1 km), sights are taken as follows:

Star	UT			Sextant altitude		Instrument error, etc.
	h	m	s	°	′	′
Dubhe	23	44	15	37	43	–5
RIGEL	23	47	33	35	55	–5
Alpheratz	23	51	55	33	19	–6

	Dubhe					*RIGEL*					*Alpheratz*				
	UT			GHA ♈		UT			GHA ♈		UT			GHA ♈	
From Table 4:	h	m	s	°	′	h	m	s	°	′	h	m	s	°	′
For Jan 1 at 23^hUT = (a) + (b), less 360°	23			85	59	23			85	59	23			85	59
Correction for minutes and seconds (c)		44	15	11	06		47	33	11	55		51	55	13	01
Sum = GHA ♈ for given UT	23	44	15	97	05	23	47	33	97	54	23	51	55	99	00
Assumed longitude, subtracted because west				–25	05				–24	54				–25	00
Sum = LHA ♈				72					73					74	

	Altitude		Az.	Altitude		Az.	Altitude		Az.
	°	′		°	′		°	′	
Sextant altitude	37	43		35	55		33	19	
Instrument error and dome refraction		–5			–5			–6	
Refraction (Table 8)		–1			–1			–1	
Corrected sextant altitude (Ho)	37	37		35	49		33	12	
Tables, p. 68 assumed Lat. 46° N and LHA ♈ as above; Hc and Zn	37	35	037°	35	34	173°	32	41	280°
Intercept		2	*towards*		15	*towards*		31	*towards*

In this example, the assumed longitudes for all observations are taken as close as possible to the DR longitude at $23^h\ 47^m$; shorter intercepts can often be obtained by relating the assumed position to the DR position at the time of observation. The intercepts are plotted from the respective assumed positions, latitude N46°, respective longitudes W25° 17′, W25° 06′ and W25° 12′, transferred as necessary for the motion of the aircraft between the time of observation and that of the fix, for the effect of Coriolis acceleration and for precession and nutation. These shifts may be made to the position lines instead of to the assumed positions from which they are constructed, or, for the last two corrections, directly to the fix.

INTRODUCTION

USE OF CORRECTING TABLES

As indicated in the foregoing example, corrections are required for the following, in addition to refraction.

Coriolis acceleration. This correction, which is required for bubble sextant observations, is given in Table 9 on the inside back cover and may be applied either to each individual observation or to the fix reduced from several observations. When applied to individual observations, either the position line or the assumed position from which it is constructed must be shifted by the distance *Z* miles perpendicular to the track. The rule for applying this correction is given at the foot of Table 9.

Precession and nutation. The correction in Table 5 is normally to be ignored. If, in extreme cases, it is necessary to allow for the change in the positions of the stars, the correction may be treated in the same way as the Coriolis correction and applied to the final fix, or to individual position lines or assumed positions. The correction is applicable only to sights reduced with this volume of tables.

Motion of the observer (MOO). If it is desired to get a fix from two or more observations, the resulting position lines must be reduced to a common time, usually the time of one of them. This may be done in two ways: the position lines of observations made earlier or later than this time may be transferred on the plotting chart to allow for the motion of the aircraft in the time-interval concerned, or the corrected sextant altitudes (or intercepts) may be adjusted to allow for the motion of the aircraft in the time-interval concerned.

In the first case, the shift may be applied to the position line or to the assumed position from which it is constructed.

In the second case, the adjustment to corrected sextant altitude may be taken from Table 1 on the inside front cover, interpolating where necessary. Table 1 gives, in the upper part, the correction for a time-interval of 4 minutes, while the lower part enables this to be extended to any time-interval. By reversing the sign of this correction, it may be applied to the tabulated altitude instead of to the corrected sextant altitude, or it may be applied directly to the intercept by the rules given. A small table at the foot of Table 1 gives the sign rules for applying the correction for the different cases.

Example. In the preceding example on page v the aircraft was flying at 400 knots on a track 257°T.

From Table 9 the *Z* correction is found to be 8′ and the assumed positions, position lines or the deduced fix must be shifted a distance 8 miles to the starboard (right) of track (for northern latitude), i.e. in direction 347°T.

From Table 5 the correction for precession and nutation is found to be 1 mile in direction 260°T and is to be applied similarly. Both corrections are made by construction on the plotting chart.

Corrections for the change in position of the aircraft MOO will be applied to the corrected sextant altitudes of the first and third stars, so that the fix will be obtained at the time, $23^h\ 47^m\ 33^s$, of the middle observation.

Body	Azimuth	True Track	Relative Azimuth	Table 1	Time Interval	Correction from lower Part of Table 1 to Sext.	Alt. Intercept	Adjusted Corr. Sext. Alt.	Adjusted Intercept
	°	°	°	′	m s	′	′	° ′	′
Dubhe	037	257	140	–20	+3 18	–17	17 *away*	37 20	15 *away*
Alpheratz	280	257	023	+24	–4 22	–26	26 *away*	32 46	05 *towards*

where Relative Azimuth = Azimuth – True Track, (adding 360° if necessary).

The above table is largely self-explanatory; the value for the time-interval of $4^m\ 22^s$ is found from the lower part of Table 1 by adding the correction for 4^m to that for 22^s or by doubling that for $2^m\ 11^s$. The time of fix was later than the first observation and the sign from Table 1 was –. The correction to the intercept is therefore away. The time of fix was earlier than the last observation and the sign from Table 1 was +. The correction to the intercept is therefore away.

Motion of the body (MOB). If the time of observation differs from that corresponding to the tabular value of LHA ♈, the entry for this value may still be used if a correction for the motion of the body (due to the rotation of the Earth) in the time interval is applied to the altitude (or intercept). Table 2 provides for this correction. It enables observations made at different times to be reduced and plotted from the same assumed position, while using the same common value of LHA ♈. Since the time to which this value of LHA ♈ corresponds is usually that at which the fix is desired, it is convenient to combine the corrections for motion of the body with those for the motion of the observer, as the time intervals are the same.

When both the tables for the changes in position of observer and body are used, the quantities taken from the upper parts of Tables 1 and 2 should be summed and the sum used in entering the lower parts of the tables, (values of the sum less than 60′ being used in the lower part of Table 1 and values greater than 60′ in the lower part of Table 2).

Example. The second example on page v is reduced using Tables 1 and 2, assuming that the aircraft was flying at 400 knots on track 257°T, and that the fix is required for $23^h\ 47^m$; the sights are:

Star	UT			Sextant altitude	
	h	m	s	°	′
Dubhe	23	44	15	37	43
RIGEL	23	47	33	35	55
Alpheratz	23	51	55	33	19

From Table 4:	UT h	UT m	GHA ♈ °	GHA ♈ ′
For Jan 1, 23^h UT = (a) + (b), less 360°	23		85	59
For 47^m, (c)		47	11	47
Sum = (a) + (b) + (c) = GHA ♈ for given UT	23	47	97	46
Assumed longitude (west, subtract)			–24	46
LHA ♈			73	

	Dubhe Altitude °	′	Az.	*RIGEL* Altitude °	′	Az.	*Alpheratz* Altitude °	′	Az.
Sextant altitude	37	43		35	55		33	19	
Instrument error and dome refraction		–5			–5			–6	
Refraction (Table 8)		–1			–1			–1	
Corrected sextant altitude (Ho)	37	37		35	49		33	12	
Tables, p. 68 assumed Lat. 46° N, LHA ♈ 73°	38	08	037°	35	34	173°	33	23	279°
Intercept		31	*away*		15	*towards*		11	*away*

The adjustments to these intercepts, for changes in position of observer and body (MOO + MOB), are found as follows:

Star	Azimuth °	True Track °	Relative Azimuth °	Table 1 ′	Table 2 ′	Sum ′	Time Interval m	s	Corrections to Intercept ′		Adjusted Intercept ′	
Dubhe	037	257	140	–20	+25	+5	+2	45	3	*towards*	28	*away*
RIGEL	173	257	276	+3	+5	+8	–0	33	1	*away*	14	*towards*
Alpheratz	279	257	022	+25	–41	–16	–4	55	20	*towards*	9	*towards*

The time of fix was later than the time that *Dubhe* was observed. From Table 1, the sign of MOO + MOB is +, so intercept is towards. The time of fix is earlier than the time *RIGEL* was observed, MOO + MOB is +, so intercept is away. The time of fix was earlier than the time *Alpheratz* was observed, MOO + MOB is –, so intercept is towards.

INTRODUCTION

POLE STAR TABLES

Table 6 gives the *Q* correction to be applied to the corrected sextant altitude of *Polaris,* in the same form as in *The Air Almanac*; the only difference is that it is based on the position of *Polaris* for epoch 2010.0. Refraction is not included. It should be noted that the table in *The Air Almanac* is re-calculated each year and is therefore slightly more accurate than Table 6.

Table 7 gives the azimuth of *Polaris*, to 0.1°, for latitudes up to N70° and for all hour angles; interpolation in LHA ♈ may sometimes be necessary.

Example. On 2008 January 1 at $02^h\ 43^m\ 32^s$ UT at height 10,000 ft. (3 km), in longitude W48° 06′, an observation was made of the altitude of *Polaris*, sextant reading 54° 51′, instrument error and dome refraction –4′; the latitude is found as follows:

		°	′		°	′
From Table 4:						
For 2008 Jan 1,	(a) =	100	02	Sextant altitude	54	51
For 02^h UT on day 1,	(b) =	30	05	Instrument error, etc.		–4
For $43^m\ 32^s$,	(c) =	10	55	Refraction (Table **8**)		–1
GHA ♈ at $02^h\ 43^m\ 32^s$ UT	GHA ♈ =	141	02	Corrected Sextant altitude (Ho)	54	46
Longitude (west, subtract)		–48	06	(Table **6**, LHA ♈ = 93° 08′)		–25
	LHA ♈ =	92	56	Latitude	54	21

A correction is theoretically necessary for precession and nutation. Table 5 indicates that the deduced position line (here a parallel of latitude) should be shifted a distance of 1 mile in direction 270°; this leaves the latitude unchanged. The position line should, of course, be shifted for Coriolis acceleration.

Entering Table 7 with the nearest latitude (N55°) and the value of LHA ♈ (93°), the azimuth of Polaris is found as 359.0°.

SPECIAL TECHNIQUES

The arrangement of the tabulations in this volume lends itself to the use of special techniques of observation and reduction, designed to save calculation and plotting or to allow for precomputation. These techniques are not fully described here, but the principles upon which they are based are given below; users will doubtless develop methods to suit their own requirements.

1. If the interval between observations is four minutes (4^m), or a multiple of 4^m, LHA ♈ need only be calculated for one of the observations, since GHA ♈ changes by 1° (to within the accuracy of these tables) in 4^m. For the remaining observations, the same value of LHA ♈ can be used and the intercepts plotted from assumed positions adjusted by the appropriate number of whole degrees of longitude; alternatively the same assumed position can be used and the values of LHA ♈ adjusted by the appropriate number of whole degrees. Since the rate of change of GHA ♈ is not exactly 1° in 4^m these procedures are most accurately used for a three-star fix when LHA ♈ is calculated for the middle observation.

For latitudes greater than 69° (for which LHA ♈ is tabulated in even degrees only) the alternative procedure may be used with an 8^m interval between observations, or with a 4^m interval providing that assumed positions are selected which differ by 1° of longitude and which, together with 1° adjustment to LHA ♈ for the 4^m interval, produce values of LHA ♈ in even degrees.

2. By making the observations at predetermined times (“scheduled shooting”), the tabulated altitudes and azimuths can be extracted beforehand and the same values used both for presetting the sextant and for the subsequent reduction of the sights.

3. All corrections, normally applied to the sextant altitude, may be applied to the tabulated altitude (with reversed signs), or to the assumed position, before an observation is made; similarly, corrections for Coriolis acceleration (Table **9**) and precession and nutation (Table 5) may be applied to the assumed position, and the respective azimuth and its reciprocal

drawn from it before an observation is made, thus enabling the intercept to be measured off (along the azimuth line *'towards'* or its reciprocal *'away'*), and the position line to be drawn (perpendicular to the azimuth line, through the end of the intercept) very quickly after the observation.

4. GHA ♈ may, if necessary, be deduced from a suitable almanac such as *The Air Almanac* or *The Nautical Almanac*.

5. In air navigation, the correction to the intercept for the motion of the observer, MOO, is obtained from Table 1 or Alternative Table 1 using Ground Speed and Relative Azimuth for arguments. Marine navigators find that d, the Distance Made Good (in nautical miles), is more readily available than Ground Speed. Alternative Table 1 may be used to find MOO using d, and Relative Azimuth for arguments as follows: Use the column of entries for a Ground Speed of 600 knots, take the tabular value for the appropriate Relative Azimuth, multiply by d and divide by 10 (i.e., shift the decimal point one place to the left).

Example. On 2008 January 1 the DR position at $01^h\ 00^m$ UT of an aircraft flying at a height of 18,000 ft. (5 km), on track 345°T and with a ground speed of 300 knots, is S10° 55′, E47° 17′. It has been decided to use the alternative procedure given in the first special technique described above, and observations are made with an artificial-horizon sextant having no instrument error, as follows:

Star	UT			Sextant altitude	
	h	m	s	°	′
ARCTURUS	00	56	00	30	19
ACRUX	01	00	00	35	21
PROCYON	01	04	00	38	40

From Table 4:		°	′
For 2008 Jan 1,	(a) =	100	02
For 01^h UT on day 1,	(b) =	15	02
GHA ♈ = (a) + (b)	GHA ♈ =	115	04

	ARCTURUS			*ACRUX*				*PROCYON*			
	UT			UT			GHA♈		UT		
	h	m	s	h	m	s	°	′	h	m	s
	00	56	00	01	00	00	115	04	01	04	00
Assumed longitude (east, add)							+47	56			
LHA ♈			162° 00′				163°	00′			164° 00′

	Altitude		Az.	Altitude		Az.	Altitude		Az.
	°	′		°	′		°	′	
Sextant altitude	30	19		35	21		38	40	
Refraction (Table 8)		–1			–1			–1	
Corrected sextant altitude (Ho)	30	18		35	20		38	39	
Tables, p. 182 assumed Lat. 11° S and LHA ♈ as above; Hc and Zn	30	32	060°	35	10	167°	38	34	286°
Intercept		14	*away*		10	*towards*		5	*towards*

In this example, all observations are plotted from latitude S11° 00′, longitude E47° 56′, adjusted for the effect of Coriolis acceleration, precession and nutation, or these corrections may be made to the position lines or to the final fix. The correction to be applied for the effect of Coriolis acceleration (Table 9) is 1 mile to port (left) of track (for southern latitudes), i.e. in the direction 255°T, and that for precession and nutation (Table 5) is 1 mile in direction 300°T.

A widely used method of precomputation, not limited to a specific time-interval between observations, is illustrated in the following example. All observations are made before the desired time of fix, and the corrections from Tables 1 and 2 are applied to the sextant altitudes; thus the signs for these are used as they appear in the tables.

INTRODUCTION

Example. On 2008 January 1 at $03^h\ 00^m$ UT the DR position of an aircraft flying at a height of 30,000 ft. (9 km) is predicted to be S42° 50′, E12° 22′. The aircraft is on track 290°T, with a ground speed of 600 knots, and a three-star fix is desired for $03^h\ 00^m$ UT. The following precomputations are made before any observations are taken:

		°	′
From Table 4:			
For 2008 Jan 1,	(a) =	100	02
For 03^h UT on day 1,	(b) =	45	07
GHA ♈ = (a) + (b)	GHA ♈ =	145	09
Assumed longitude (east, add)		+12	51
	LHA ♈ =	158	00

Entering the tables with an assumed latitude of 43° S, and LHA ♈ 158° (p. 246), it is decided to observe *SPICA*, *ACHERNAR* and *PROCYON*. The respective Hc and Zn for each star is extracted, their respective relative azimuths calculated, and the corrections from Tables 1 and 2 determined for 1 minute of time.

	SPICA		*ACHERNAR*		*PROCYON*	
	°	′	°	′	°	′
Tabulated altitude (Hc)	40	49	17	29	28	04
Azimuth (Zn)	063		204		310	
Relative Azimuth	133		274		020	
Correction for 4^m (Table 1)		–27		+2		+38
Correction for 4^m (Table 2)		+39		–18		–34
Combined correction for 4^m		+12		–16		+4
Combined correction for 1^m		+3.0		–4.0		+1.0

One decimal place is required in the combined correction for 1^m to avoid the introduction of errors when multiplying by the time-interval.

The combined corrections for 1^m may be obtained in a similar manner, but without the division by 4, by use of Alternative Tables 1 and 2, altitude corrections for change in position respectively of observer and body for 1 minute of time, which are included in this volume as an additional bookmark.

After the precomputations above have been completed, observations are made with an artificial-horizon sextant having no instrument error, as follows:

Star	UT			Sextant altitude	
	h	m	s	°	′
SPICA	02	50	00	40	30
ACHERNAR	02	53	00	17	45
PROCYON	02	57	00	28	05

These observations are corrected for refraction (Table 8), and then for the combined corrections from Tables 1 and 2 to advance each observation to $03^h\ 00^m$ UT. *SPICA* is advanced 10^m, so the correction to be applied to *SPICA* is 10 × (+3.0′) = +30′; *ACHERNAR* is advanced 7^m, so the correction is 7 × (–4.0′) = –28′; *PROCYON* is advanced 3^m, so the correction is 3 × (+1.0′) = +3′. The adjusted, corrected sextant altitude (Ho) is then compared with the tabulated altitude (Hc) for each body, and the fix is plotted in the usual manner from the one assumed position (S43° 00′, E12° 39′) which was used to calculate LHA ♈. Corrections for Coriolis acceleration (Table 9), 11 miles to port (left) of track (for southern latitude), i.e. in direction 200°T, and for precession and nutation (Table 5), 1 mile in direction 300°T, may be applied to the assumed position before the intercepts are plotted, to the position lines or to the fix obtained.

	SPICA			*ACHERNAR*			*PROCYON*		
	h m s			h m s			h m s		
UT	02 50 00			02 53 00			02 57 00		
	Altitude		Az.	Altitude		Az.	Altitude		Az.
	°	′		°	′		°	′	
Sextant altitude	40	30		17	45		28	05	
Refraction (Table 8)		0			–1			–1	
Combined correction (Tables 1 and 2)		+30			–28			+3	
Adjusted Ho	41	00		17	16		28	07	
Tables, p. 246 assumed Lat. 43° S and LHA ♈ 158°; Hc and Zn	40	49	063°	17	29	204°	28	04	310°
Intercept		11	*towards*		13	*away*		3	*towards*