COMPUTATIONS FOR ALTITUDE AND AZIMUTH OF POLARIS

by D.H. Richardson

A revised astronomical field table for calculating the altitude and azimuth of the Pole Star was issued this year by the Department of Mines and Technical Surveys, Canada. Although the procedure for observing the position of the star from the reference line has not changed it has required a new form for both the recording of the field notes and the resulting computations.

This article describes a new form for recording the field notes and calculations for the revised table and outlines the calculations required.

Assuming the observation has been completed and the mean values of the watch time and the horizontal circle readings on Polaris and the reference line have been entered the calculations will be as follows:

If the watch time is fast or slow, correct the time of observation and obtain the correct Eastern or Central Standard Time.

The latitude and longitude of the observation station must be obtained and recorded.

On the reverse side of the observation field note paper is a form to be used for changing the corrected Eastern or Central Standard Time to local Sidereal Time.

The longitude, date and correct Standard Time are recorded at the top of the sheet.

The following abbreviations are used in the claculations:

C.S.T. - Central Standard Time
E.S.T. - Eastern Standard Time
G.M.T. - Greenwich Mean Time
G.S.T. - Greenwich Sidereal Time
L.S.T. - Local Sidereal Time

To change E.S.T. to a 24 hour clock basis add 12 hours if the observation is taken after 12 hours noon, e.g., 3:00 p.m. = 15 hrs; 7:30 p.m. = 19 hrs. 30 min.

Add the correction as obtained from Item "A" to obtain G.M.T. (see next page)

Total the E.S.T. and the correction to G.M.T.

If the result is greater than 24 hours, subtract 24 hours from the result and change the date of the observation by adding one day.

Having obtained G.M.T. and the correct date this is converted to G.S.T. by extracting from Item "B" (see next page) the values for the month, day, hour and minutes. Total these values with the G.M.T. and the result will be G.S.T.

Apply the correction for the longitude from Greenwich at 4 minutes a degree. Subtract this result from G.S.T. and obtain L.S.T.

Item "A"

G.M.T. = Nfld. S.T. + 3h 30m
= A.S.T. + 4h
= E.S.T. + 5h
= C.S.T. + 6h
= M.S.T. + 7h
= P.S.T. + 8h
= Y.S.T. + 9h

Item "B"

CORRECTION TO CONVERT GREENWICH MEAN TIME TO GREENWICH SIDEREAL TIME FOR 1964.

MONTH

	h m s		h m s		h m s
Jan	6 34 48.1	May	14 31 51.2	Sep	22 36 47.6
Feb	8 37 01.4	Jun	16 34 04.5	Oct	0 31 07.7
Mar	10 31 21.5	Jul	18 32 21.2	Nov	2 37 17.4
Apr	12 33 34.6	Aug	20 30 37.9	Dec	4 35 34.1

DAY

	h m s		h m s		h m s		h m s
1	0 03 56.6	9	0 35 29.0	17	1 07 01.4	25	1 38 33.9
2	0 07 53.1	10	0 39 25.6	18	1 10 58.0	26	1 42 30.4
3	0 11 49.7	11	0 43 22.1	19	1 14 54.6	27	1 46 27.0
4	0 15 46.2	12	0 47 18.7	20	1 18 51.1	28	1 50 23.6
5	0 19 42.8	13	0 51 15.2	21	1 22 47.7	29	1 54 20.1
6	0 23 39.3	14	0 55 11.8	22	1 26 44.2	30	1 58 16.7
7	0 27 35.9	15	0 59 08.3	23	1 30 40.8	31	2 02 13.2
8	0 31 32.4	16	1 03 04.9	24	1 34 37.3		

HOUR

	m s		m s		m s		m s		m s
1	0 09.9	6	0 59.1	11	1 48.4	16	2 37.7	21	3 27.0
2	0 19.7	7	1 09.0	12	1 58.3	17	2 47.6	22	3 36.8
3	0 29.6	8	1 18.9	13	2 08.1	18	2 57.4	23	3 46.7
4	0 39.4	9	1 28.7	14	2 18.0	19	3 07.3		
5	0 49.3	10	1 38.6	15	2 27.8	20	3 17.1		

MINUTE

	s		s		s		s		s		s		s		s
1	0.2	9	1.5	17	2.8	25	4.1	33	5.4	41	6.7	49	8.0	57	9.4
2	0.3	10	1.6	18	3.0	26	4.3	34	5.6	42	6.9	50	8.2	58	9.5
3	0.5	11	1.8	19	3.1	27	4.4	35	5.8	43	7.1	51	8.4	59	9.7
4	0.7	12	2.0	20	3.3	28	4.6	36	5.9	44	7.2	52	8.5		
5	0.8	13	2.1	21	3.5	29	4.8	37	6.1	45	7.4	53	8.7		
6	1.0	14	2.3	22	3.6	30	4.9	38	6.2	46	7.6	54	8.9		
7	1.2	15	2.5	23	3.8	31	5.1	39	6.4	47	7.7	55	9.0		
8	1.3	16	2.6	24	3.9	32	5.3	40	6.6	48	7.9	56	9.2		

Item "C"

Z_o TABLE

L.S.T.	00m	10m	20m	30m	40m	50m
00h	+26'.77	+24'.70	+22'.58	+20'.42	+18'.22	+15'.98
01	+13.71	+11.42	+09.11	+06.78	+04.43	+02.08
02	-00.27	-02.63	-04.98	-07.32	-09.65	-11.96
03	-14.25	-16.51	-18.73	-20.93	-23.08	-25.19
04	-27.25	-29.25	-31.21	-33.10	-34.93	-36.70
05	-38.39	-40.01	-41.56	-43.02	-44.41	-45.70
06	-46.92	-48.04	-49.07	-50.01	-50.85	-51.60
07	-52.25	-52.80	-53.24	-53.59	-53.83	-53.98
08	-54.02	-53.95	-53.79	-53.52	-53.15	-52.68
09	-52.10	-51.43	-50.66	-49.80	-48.84	-47.79
10	-46.64	-45.41	-44.09	-42.69	-41.20	-39.64
11	-38.00	-36.29	-34.51	-32.66	-30.76	-28.79
12	-26.77	-24.70	-22.58	-20.42	-18.22	-15.98
13	-13.71	-11.42	-09.11	-06.78	-04.43	-02.08
14	+00.27	+02.63	+04.98	+07.32	+09.65	+11.96
15	+14.25	+16.51	+18.73	+20.93	+23.08	+25.19
16	+27.25	+29.25	+31.21	+33.10	+34.93	+36.70
17	+38.39	+40.01	+41.56	+43.02	+44.41	+45.70
18	+46.92	+48.04	+49.07	+50.01	+50.85	+51.60
19	+52.25	+52.80	+53.24	+53.59	+53.83	+53.98
20	+54.02	+53.95	+53.79	+53.52	+53.15	+52.68
21	+52.10	+51.43	+50.66	+49.80	+48.84	+47.79
22	+46.64	+45.41	+44.09	+42.69	+41.20	+39.64
23	+38.00	+36.29	+34.51	+32.66	+30.76	+28.79

Having obtained the L.S.T. the value is entered on the front page of the observation field note paper left side column opposite Local Sidereal Time.

Referring to Item "C" the Zo table will give the tabulated position of Polaris at latitude O°.

In the Zo box enter the value of L.S.T. to the closest ten minutes with the proper algebraic sign. The next box of the column will contain the value of the unit minutes and decimals of a minute arrived at by the interpolation of the closest 10 minute values from Table Zo again applying the proper algebraic sign. In this case the sign may be different than that applied to the value in the preceding box.

Example

Zo for 12 hrs. 30 min. -20.42
3.33 min. + 0.73
-19.69

12 hrs. 30m = -20.42
12 hrs. 40m = -18.22
10m = - 2.20
$3.33m = \frac{2.2}{10} \times 3.33 = 0.73$

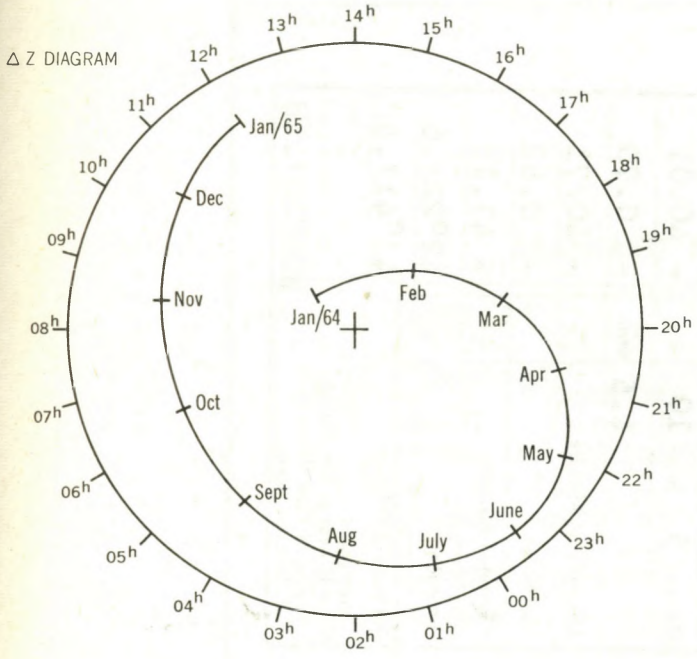
Since the tabulated value of 12 hr. 40m is less than the tabulated value of 12 hr. 30m the algebraic sign applied to 0.73 will be a +.

The algebraic sum of these two boxes will give a value for the uncorrected Zo.

It is now necessary to apply a correction to the Zo value for the true position of Polaris at the instant of observation and for this we use Item "D".

The star card has been supplied with a transparent cursor to obtain a value from the Δ Z diagram. Centre the cursor over the diagram with the arrow pointing to the L.S.T. of the observation on the outer ring of the circle. Locate the date of the observation on the spiral and read the correction to the nearest 0.01 minute with its correct sign. The corrected value of Zo is the sum of the four preceding boxes.

Item "D"



It is now necessary to work out the altitude of Polaris to obtain the true azimuth of Polaris at the instant of observation. This is arrived at by using the right hand column on the front page of the observation field note paper.

In this case the Zo table (Item "C") and the Δ Z diagram (Item "D") are again used but the L.S.T. is decreased by 6 hours. The first box of the right hand column is L.S.T. - 6 hrs. The remainder of the column is self explanatory remembering that the altitude of Polaris is the latitude of the point of observation ± the corrected altitude.

To complete the calculation for the azimuth of Polaris (left hand column) the corrected Zo value is multiplied by the secant of the altitude of the star. The secant value of the altitude is found from the table of secants (Item "E").

Item "E"

TABLE OF SECANTS

°		Differences				
		10′	20′	30′	40′	50′
40	1.3054	32	64	97	130	163
41	1.3250	34	68	102	136	171
42	1.3456	36	71	107	144	180
43	1.3673	38	75	113	151	190
44	1.3902	39	78	118	159	199
45	1.4142	41	83	125	168	210
46	1.4396	43	87	131	176	221
47	1.4663	46	92	139	186	234
48	1.4945	48	97	147	196	247
49	1.5243	51	102	155	207	261
50	1.5557	54	109	164	220	276
51	1.5890	58	115	174	233	293
52	1.6243	60	122	184	246	310
53	1.6616	65	130	196	262	329
54	1.7013	68	138	208	278	349
55	1.7434	73	147	221	296	372
56	1.7883	77	156	235	315	396
57	1.8361	82	166	251	336	422
58	1.8871	88	177	268	359	452
59	1.9416	95	190	287	385	484
60	2.0000	101	204	308	413	519
61	2.0627	109	219	330	443	558
62	2.1301	117	236	356	478	601
63	2.2027	126	255	385	516	650
64	2.2812	137	276	416	559	703
65	2.3662	149	299	452	607	764
66	2.4586	162	326	492	661	833
67	2.5593	177	356	538	723	911
68	2.6695	193	390	590	793	1000
69	2.7904	213	430	651	875	1102

The value of (Zo sec. "h") is the true position of the star and its position East or West of the meridian is indicated by the ± sign.

The correction value is the difference between the assumed azimuth of the star position and the true value of the star position.

The true value is the result of correcting the azimuth of polaris and the azimuth of the reference line.

On the next two pages is an "Observation Paper" form with a sample computation assuming the star at the time of observation was on the true meridian.

Note: Items "A" to "E" incl. reproduced from the 1964 Astronomical Field Tables of the Legal Surveys and Aeronautical Charts Division of the Department of Mines and Technical Surveys, Ottawa.

Observation Paper
(Front of Sheet)

23129 (FRONT)
REV. 6-64.

OBSERVATION PAPER

DATE: May 5, 1964	LATITUDE: N 42° 22'.6	SEC. NO.: J 10 x 20
LOCATION: 90 Meridian Time Twp. X	LONGITUDE: W 92° 58'.3	FILE NO.:
INST. AT: Opposite limit btwn.Lots 4/5	OBSERVED BY: J.D.	PLAN NO.:
REFERENCE POINT: & road btwn. Con. 2/3	REDUCED BY: J.D.	

	H.C.R.	MEAN	CORRECTION	TRUE
R.O.	334°07'	334° 07'	- 47'.4	333° 19'.6
POLARIS	0°00'00"	0°-00'-00"		359° 12'.6
WATCH TIME	8 28 23	8 28 23		

Watch Correction Slow	+ 2'.03
~~xxxx~~ Central Standard Time	8:30:26
Local Sidereal Time	11 14 28.4
Zo for 11 hrs. 10 min.	- 36.29
4.5 min.	+ 0.80
Uncorrected Zo	- 35.49
ΔZ	+ 0.10
Corrected Zo	- 35.39
Sec h	1.33 86
Zo Sec. h	- 47'.4

Altitude of Polaris

Local Sidereal Time — 6 hrs.	5 14 18
Zo for 5 hrs. 10 min.	- 40.01
4.5 min.	- 0.70
Uncorrected Altitude	- 40.71
Correction	- 0.42
Corrected Altitude	- 41.13
Latitude	42°22'.6
Altitude of Polaris	41°41'.5
Convergence ..... Miles ..... (Plus If west of Ref. Merid)	
Bearing of Line Referred To Ref. Or Local Merid.	N26°40'.4W

23129 (BACK)
REV. 6-64.

STANDARD TO SIDEREAL TIME

LONGITUDE W 92° 58' 3"	DATE May 5, 1964
Central STANDARD TIME	8 30 26
CORRECTION TO 24 HOUR BASIS	20 30 26
+ CORRECTION TO G.M.T.	6 00 00
GREENWICH MEAN TIME	2 30 26
DATE	May 6, 1964
+ CONVERSION TO G.S.T.	2 30 26
MONTH	14 31 51.2
DAY	0 23 39.3
HOUR	0 00 19.7
MINUTE	0 00 5.0
GREENWICH SIDEREAL TIME	17 26 21.2
92.97 – CORRECTION FOR LONGITUDE DEGREES AT 4 MIN. =	6 11 52.8
LOCAL SIDEREAL TIME	11 14 28.4