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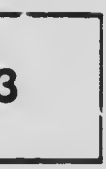

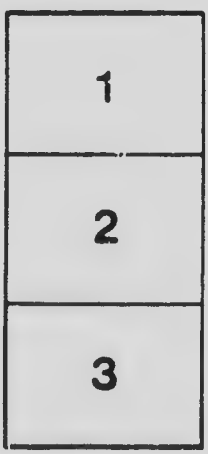

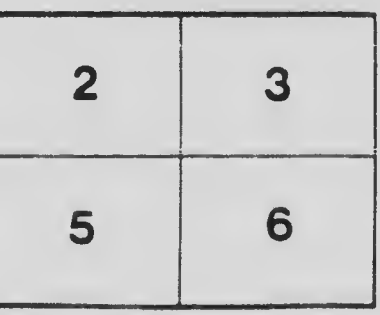

Azimuth Tables

By

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TORONTO
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AZIMUTH TABLES

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The following tables have been calculated to enable Surveyors to ascertain the true astronomical meridian. A watch regulated to sidereal time is supposed to be used.

The error of the watch is ascertained by observing the transit of a star across the meridian. A star of the first magnitude is visible with the ordinary telescope of a surveyor's transit theodolite a little after sunrise or before sunset. The observation is a matter of two or three minutes; it may be taken while the work of the survey is going on and without interfering with it.

When the Surveyor is at leisure in camp he may select a few first magnitude stars passing the meridian at suitable hours and calculate their altitudes. The meridian altitude is the sum of the colatitude (90° − latitude) and of the declination of the star if north; it is the difference of these quantities when the declination is south. The latitude of the centre of the township will do for any observation within the township.

When the Surveyor has his instrument set up for running the lines of the survey, he may a little before the time of transit of one of the stars, direct the telescope on the meridian and adjust it to the altitude of the star; looking through the telescope he will soon see the star coming and crossing the vertical thread. The time shown by the watch at that moment should be the right ascension of the star (sidereal time) the difference (if any) is the error of the watch. There is a difference of a few seconds in the time ascertained at various points of a township, but it may be neglected for azimuth observations on Polaris. It must be remembered that the sidereal time obtained at an observation is only accurate in the longitude of place of observation but, as mentioned above, the time obtained in the limits of a township is close enough.

In case the direction of the meridian is not known, proceed as follows:

By means of the compass set the instrument approximately to read 360° when the telescope is directed to astronomical north, and clamp the lower plate. With the approximate sidereal time take from Table I the azimuth of Polaris and its altitude. The altitude

is obtained by adding to the latitude the "distance above the pole," or subtracting the "distance below the pole." Set the telescope to the azimuth and altitude thus found and clamp the plates. With the slow motion screw of the lower plate (not the vernier plate) turn the instrument to the right and the left until the star appears, and bisect it with the vertical thread. Now move the vernier of the horizontal circle to read 300°, and observe the TIME star as previously explained. With a time star not too far from the zenith the watch correction thus ascertained is sufficiently accurate for the determination of the meridian by Polaris observations.

An azimuth observation on Polaris may be made as follows:

The instrument being in the position which places the vertical circle to the observer's right hand when looking through the telescope, it is directed to the reference object or picket and the verniers read; then to the POLE STAR, noting the time of pointing on the watch, and then reading the verniers. Reversing the instrument by revolving the telescope and turning the upper plate 180° (not the lower) in azimuth, so that the vertical circle is now to the left of the observer, the telescope is directed to the POLE STAR, the time of pointing again taken and the verniers read. Then a reading on the reference object or picket taken.

For this observation as well as for all star observations the instrument must be carefully levelled.

The time by the watch is, in the explanations which follow, assumed to be corrected for the error of the watch, if any.

The mean of the two sets of readings is taken, and the true azimuth of Polaris is obtained by means of Table I. This table is calculated for a right ascension of 1 h. 30 m. and for a declination of 88° 51'; for other values, it has to be used as follows:

1. For sidereal time argument take the corrected watch time to which has been added the excess of 1 h. 30 m. over the right ascension of Polaris.
2. Interpolate for sidereal time.
3. Interpolate for latitude.
4. Apply the correction from Table II for declination of Polaris.

In the following examples "H.C.R." is for "Horizontal circle reading," and "R.O." for "reference object," "R.A." and "D"

TABLE

For finding the Pole Star and the Astr

AZIMUTH OF THE P

Sidereal Time. Read down		Lat. 13°	14°	15°	16°	17°	18	
h.	m	° ′	° ′	° ′	° ′	° ′	° ′	
ABOVE POLE								
1	10	0 12	0 13	0 14	0 14	0 15	0 16	0
2	0	12·5	12·7	13·0	13·2	13·5	13·8	
	20	20·8	21·2	21·6	22·0	22·4	22·7	
	40	28·9	29·4	29·9	30·5	31·1	31·7	
	0	36·7	37·1	38·1	38·8	39·5	40·3	
	20	44·3	45·1	45·9	46·7	47·6	48·6	
	40	51·5	52·4	53·3	54·3	55·1	56·5	
4	0	58·3	59·3	1 0 1	1 1 5	1 2·7	1 3·9	1
	20	1 1·6	1 2·8	6·9	8·2	9·5	10·8	
	40	10·5	11·7	12·9	14·3	15·7	17·2	
5	0	15·7	17·0	18·1	19·8	21·3	22·9	
	20	20·1	21·8	23·2	24·7	26·3	28·0	
	40	24·4	25·8	27·1	29·0	30·8	32·4	
6	0	27·8	29·3	30·9	32·5	34·3	36·4	
	20	30·5	32·0	33·6	35·3	37·1	39·0	
	40	32·5	34·0	35·7	37·1	39·2	41·2	
7	0	33·8	35·3	37·0	38·8	40·6	42·5	
	20	1 34·3	35·9	37·6	39·3	41·2	43·1	
BELOW POLE								
	10	1 34·2	35·7	37·4	39·1	41·0	42·9	
8	0	33·3	31·9	36·5	38·2	40·0	41·9	
	20	31·7	33·3	34·8	36·5	38·3	40·2	
	10	29·5	30·9	32·5	34·1	35·9	37·7	
9	0	26·5	28·0	29·5	31·0	32·7	34·5	
	20	23·0	24·3	25·8	27·3	28·9	30·5	
	40	18·8	20·1	21·4	22·9	24·4	26·0	
10	0	14·0	15·2	16·5	17·8	19·2	20·7	
	20	8·7	9·8	11·0	12·2	13·5	14·9	
	40	2·9	3·9	5·0	6·1	7·3	8·6	
11	0	0 56·6	0 57·5	0 58·5	0 59·5	1·6	2·7	
	20	49·9	50·7	51·6	52·5	0 53·1	0 54·4	0
	40	42·9	43·6	44·3	45·1	45·9	46·7	
12	0	35·5	36·1	36·7	37·3	38·0	38·7	
	20	27·9	28·3	28·8	29·3	29·8	30·4	
	40	20·1	20·4	20·7	21·1	21·5	21·9	
13	0	12·1	12·3	12·5	12·7	12·9	13·2	
	20	4·1	4·1	4·2	4·3	4·3	4·4	

(Western / Long. /

TABLE

Correction for Declinatio

Declination of Polaris		Azimuthal	
		20′	40
°	′	′	′
48	0	0·9	1·4
	10	0·9	1·3
	20	0·8	1·3
	40	0·7	1·2
	30	0·7	1·2
49	0	0·6	1·1
	10	0·6	1·0
	20	0·5	0·9
	30	0·5	0·8
	40	0·4	0·8
	50	0·4	0·7
50	0	0·3	0·6
	10	0·3	0·5
	20	0·2	0·4
	30	0·2	0·3
	40	0·1	0·2
	50	0·1	0·1
51	0	0·0	0·0

ABLE I.

the Astronomical Meridian.

HE POLE STAR

s	49°	50°	51°	52°	53°	Sidereal Time. Reduced h m	Distance of the Pole star above or below the pole
16	0 47	0 48	0 49	0 50	0 52	1 20	69
13 8	11 1	11 1	11 7	15 0	15 4	1 0	68
12 7	23 3	23 8	24 3	24 9	25 5	40	67
31 7	32 1	33 0	33 8	34 6	35 1	20	66
10 3	11 1	12 0	12 9	13 9	15 0	0 0	64
48 6	49 6	50 7	51 8	53 0	54 2	40	61
56 5	57 6	58 9	1 0 2	1 1 6	1 3 0	20	58
33 9	1 5 2	1 6 6	8 1	9 7	11 3	23 0	55
10 8	12 3	13 8	15 5	17 2	19 0	40	51
17 2	18 8	20 4	22 2	24 1	26 1	20	47
22 3	24 6	26 1	28 3	30 3	32 1	22 0	42
28 0	29 8	31 7	33 7	35 9	38 1	40	37
32 1	31 3	36 3	38 1	40 6	43 0	20	32
36 1	38 0	40 1	42 3	44 6	47 0	24 0	26
39 0	41 0	43 1	45 3	47 7	50 2	40	21
41 2	43 2	5 3	17 6	50 0	52 6	20	15
42 5	11 6	6 8	19 1	51 5	54 2	20 0	12
43 4	15 2	17 3	19 6	52 1	1 54 7	40	8
12 9	15 0	47 4	19 1	51 8	54 4	20	5
41 9	44 0	46 1	48 4	50 7	53 3	19 0	2
10 2	12 2	44 3	46 5	48 8	51 3	40	37
37 7	39 6	41 6	43 8	46 0	48 5	20	34
34 5	36 3	38 3	40 3	42 5	44 9	18 0	26
30 5	32 2	34 2	36 1	38 2	40 5	40	22
26 0	27 6	29 1	31 3	33 2	35 3	20	18
20 7	22 3	23 9	25 4	27 5	29 5	17 0	12
14 9	16 1	17 9	19 5	21 2	23 0	40	7
8 6	9 9	11 3	12 8	14 3	16 0	20	1
1 7	2 9	4 1	5 5	6 9	8 4	16 0	55
54 4	0 55 1	0 56 5	0 57 7	0 58 9	1 0 3	40	50
16 7	17 6	48 6	49 6	50 6	0 51 7	20	45
38 7	39 4	40 2	41 0	41 9	42 8	0	39
30 4	31 0	31 6	32 2	32 9	33 6	40	33
21 9	22 3	22 7	23 2	23 7	24 2	20	27
13 2	13 4	13 7	14 0	14 3	14 6	0	21
4 4	4 5	4 6	4 7	4 8	4 9	13 40	15

ABOVE POLE.

BELOW POLE.

† Eastern
‡ Along

TABLE II.

Declination additive to table I

Azimuthal Angle in Table I

10°	40°	80°	100°	120°
1 4	1 3	1 4	4 3	4 2
1 6	1 5	3 2	4 1	4 0
1 5	2 3	3 0	3 8	4 5
1 4	2 2	2 7	3 6	4 3
1 3	2 0	2 6	3 3	4 0
1 2	1 9	2 5	3 1	3 7
1 1	1 7	2 3	2 9	3 5
1 0	1 6	2 1	2 6	3 2
0 9	1 4	1 8	2 4	2 9
0 7	1 3	1 7	2 1	2 6
0 6	1 2	1 5	1 9	2 3
0 5	1 0	1 3	1 7	2 1
0 4	0 8	1 0	1 4	1 7
0 3	0 6	0 8	1 0	1 2
0 3	0 4	0 5	0 7	0 9
0 2	0 3	0 4	0 5	0 6
0 1	0 1	0 2	0 2	0 3
0 0	0 0	0 0	0 0	0 0

are the "Right ascension and declination" of Polaris taken from the Almanac.

EXAMPLE

DATE. June 30, 1906 ..... R.A. 1h. 25m. 19s

PLACE. 9 miles south of 40 mile post on O.L.S. Dec'l 88° 48' 1
Niven's 2nd base line and one mile east on the south boundary of Tp

R.O. Back Picket on S. boundary line of Tp. and 21 chs. 22 lks. west of the instrument.

Latitude 49° 27' 41

Chord Azimuth from N. towards E. ..... 89° 55' 20

Half Convergence ..... 0° 4' 40

The convergence at one mile amounts to 1' 2 which in this example has to be subtracted from the supplement of 89° 55' 20", as the azimuth of the back picket is measured from N. towards W.

Face	H.C.R. on R.O.		H.C.R. on Polaris		Watch Time		
Right	140°	31'	231°	8'	14h.	41m.	10s.
Left	140°	33'	231°	12'	14	44	50
Mean	140°	32'	231°	10'	14	42	50
1h. 30m. R.A.					+	4	41
Sidereal time argument					14	47	31

Tabular Az. for 1h. pom. and lat. 49° (Table I)	0° 31' 0	East
Difference for 7m. 31s.	+ 3.2	
Difference for 27' 41" in latitude.	+ 0.3	
Correction for Declination (Table II	+ 1.3	
	0° 35.8	East
H.C.R. on star	231° 10.0	
True North	230° 34'12	
H.C.R. on R.O.	140° 32' 0	
	90° 2 12	West

Azimuth by account . . . . 9° 3' 38" W.

Correction . . . . . 1' 20"

This shows that the line was bearing too much to the south. To correct this the instrument may be placed a certain number of inches to the north at right angles to the line. This offset is found by multiplying the distance of the back picket by the tangent of the correction, thus:

Log. 792 inches in a chain. . . .	2.8987 constant
Log. tan. of 1° 20".	0.6207
Log. dist. 21 chs. 22 lks. . . .	1.3075
Log. offset.	0.8269
Offset in inches. . . .	6.7

For the convenience of Surveyors the R.A. of Polaris will be found in the calendar of the Canadian Almanac for 1907 and the declination on page 31.

The mean places of the stars on page 32 will be found sufficient for Azimuth work. The column marked "Right Ascension" will be the sidereal time of the stars on the Meridian.

The following approximate formulæ will be found amply sufficient and simple for finding chord azimuths in township work.

$$\text{Tan. } \tfrac{1}{2} \text{ chord Az} = \sqrt{\frac{\sin.(s-a)}{\sin. s}}$$

a = in seconds of arc = chord in chains × 0.65105.

It will never amount to more than a few minutes of arc.

s = colatitude + $\frac{1}{2}a$.

EXAMPLE.

What is the chord azimuth for a chord of 718 chs., this being the length of chord necessary for 9 miles of westships on O.L.S. Niven's 2nd Base line? The northern corners of the townships being in latitude 49° 43' 19". Niven's Base line in latitude 49° 35' 30".

a = 718 chs. × 0.65165 = 7′ 47″.9

Colatitude = 90° − 49° 43′ 19″ = 40° 16′ 41

s = 40° 16′ 41″ + $\frac{7′\ 47″.9}{2}$ = 40° 20′ 35″

$s - a$ = 40° 12′ 47

Log. sin. $(s-a)$ 9.8099851

Log. sin. s 9.8111477

2)9.9988374

Log. tan. $\frac{1}{2}$ Az. 9.9994187

$\frac{1}{2}$ ch. Az. = 44° 57′ 42

2

Ch. Az. 89° 55′ 24 from the N.

90° 0′ 0

$\frac{1}{2}$ Convergence 4′. 36

Similarly the half convergence for townships laid out on the south side of Niven's 2nd Base line is equal to 4′ 40″ and the length of the southern boundaries of the Townships is 7 21 91 links the latitude being 49° 27′ 41″.