SUPPLEMENT
TO THE
MANUAL
OF INSTRUCTIONS FOR THE
SURVEY OF CANADA LANDS

DEPARTMENT OF
MINES AND TECHNICAL SURVEYS
OTTAWA

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Lands [illegible]

CANADA

SUPPLEMENT

TO THE

Manual of Instructions

FOR THE

Survey of Canada Lands

(DETERMINATION OF THE
ASTRONOMICAL AND MAGNETIC MERIDIANS

PROBLEMS CONNECTED WITH THE
SYSTEMS OF SURVEY)

TABLES

Issued by authority of the Honourable the Minister of
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TABLES

Preface to 1952 edition

In 1930 the Dominion Lands in Manitoba, Saskatchewan, Alberta, and British Columbia were transferred to the respective provinces. In 1950, the Territorial Lands Act, describing the public lands of Yukon Territory and Northwest Territories as "Territorial Lands" was passed and the Dominion Lands Act repealed. In December 1951 the Canada Lands Surveys Act became law and superseded the Dominion Lands Surveys Act which was repealed. The Canada Lands Surveys Act generally applies to the public lands in Yukon and Northwest Territories, National Parks, and surrendered lands and reserves as defined in the Indian Act. This revision of the 1917 Supplement is, therefore, called the Supplement to the Manual of Instructions for the Survey of Canada Lands.

Chapter I has been slightly revised to agree with modern practice and instruments.

To Chapter II has been added a short description of the Wild Double Image Prism Compass.

Chapter III has been considerably revised. Information has been added on modern optical transits, the care of instruments, and the correction for stretch and sag to measurements made by steel tapes.

A table listing the geodetic latitudes and longitudes of section corners has been added to Chapter IV.

The tables have been extended northward to township 244 in latitude 70°17'. Columns in the table tabulating data in degrees and decimals have been omitted since transits with this type of division are no longer in use in Canada. In tables Nos. V, VI, VII, and VIII the convergence of meridians for 100 chains of longitude has been added as a further convenience in certain calculations. Tables have been added for the conversion of time to arc and of mean time intervals to sidereal time intervals.

The table to reduce chains to decimals of a township side has been omitted as it was seldom used.

B. W. Waugh,
Surveyor General.

Preface to 1917 edition

The first Manual of Instructions for the survey of the Dominion Lands, a small 12 mo pamphlet of thirty-two pages, was prepared in 1871 by Col. J. S. Dennis, Surveyor-General; the title was "Manual showing the System of Survey adopted for the Public Lands of Canada in Manitoba and the North-West Territories, with Instructions to Surveyors." It was published by authority of the Honourable the Secretary of State, the Dominion Lands office being then a branch of his department. The Manual contained only one table, "showing the departure in running 81 chains 50 links at any course from 1 to 60 minutes."

The second edition was prepared in 1881, under the direction of Mr. Lindsay Russell, Surveyor-General, by Dr. Deville; it was considerably enlarged, forming a large octavo book of 86 pages. By that time the need of tables specially adapted to the survey of Dominion Lands had become imperative: thirteen tables were calculated by Dr. Deville and Dr. King and were appended to that edition.

A number of editions followed, the fourth, published in 1892, containing six additional tables, or nineteen altogether. The fifth and sixth editions, issued in 1903 and 1905 respectively, contained only eight tables. The tables left out were seldom used and it was considered that when needed they could be consulted in the 1892 edition.

In 1908, when the stock of the fourth edition of the Manual (1892) was exhausted, a reprint of the tables became necessary. They were published as a supplement, and their construction and use fully explained. Problems connected with the system of survey originally published by Dr. King in the Report of the Department of the Interior for 1891, were appended.

For this edition, the Supplement has been completely revised. There have been added two chapters on observing and a chapter briefly describing the instruments kept in stock at the head office, for sale to surveyors employed by the Department. These chapters replace matter which formerly appeared in the Manual of Instructions. The additional chapters and the revision are the work of H. Parry, D. L. S.; he has carefully checked the tables and it is hoped that they will now be found free from errors.

INDEX TO THE NOTATION

a	equatorial semi-diameter of the earth.
b	polar semi-diameter of the earth.
c	earth's compression.
e	eccentricity.
h	altitude of a star.
K	distance.
L	latitude.
l	elevation above sea-level.
M	longitude.
N	length of normal to the meridian.
P	radius of parallel of latitude; also polar distance.
p	polar distance.
R. A.	right ascension.
R	radius of curvature of meridian.
S	radius of curvature.
t	hour angle.
Z	azimuth.

CHAPTER I

DETERMINATION OF THE ASTRONOMICAL MERIDIAN

The reference of lines to an astronomic meridian, in order to determine their direction, or to check the accuracy of their production, is most readily made by observations on the Pole star.

The telescopes of most modern surveying transits are amply powerful for observing Polaris at any time during a clear day with the exception of a few hours before or after noon. Many of them are provided with lighting arrangements to facilitate observations at night. For best results observations should be taken within a few hours before dusk or after dawn when the air is not quivering and accurate pointings on the reference object may be made. For night observing the reference object requires to be well lighted. Directing the headlights of an automobile on a line or traverse picket at short range is effective.

TO FIND THE POLE STAR

Whether observations are made in the daytime or at night the star must first be found. To set the telescope at solar focus, focus the eyepiece so that the cross hairs or diaphragm markings are clear and distinct. Then point the telescope on a well defined object a half mile or more distant and adjust the objective focus until the image of the object is as sharp as possible. By slight movements of the eyepiece and objective focussing screws continue the adjustment until the sharpest possible images are obtained of the object and the cross hairs which will remain in constant relation to each other when the eye is moved from side to side, i. e., when there is no parallax.

With the sidereal time and the latitude of the place as arguments the azimuth of the Pole star may be taken from the Astronomical Field Tables, a sample page of which is shown in Figure I; its altitude may be obtained from the same tables.

If the observation is being taken along a survey line, the azimuth of the line will be known and the transit may be set to read the azimuth of Polaris. Otherwise, it may be necessary to orient it by means of the magnetic compass making due allowance for the magnetic declination of the place of observation. When the horizontal plate is properly set, it is merely necessary to tilt the telescope to the proper altitude in order to bring the star into the telescope's field of view.

Practice and patience are required to discover the star in daylight. A slight to and fro motion of the horizontal tangent screw gives a relative motion to the star which aids in its perception and insures that it is not behind the vertical wire of the diaphragm. Once the star is found, the focus of the telescope may be readjusted if necessary. When the solar focus is properly set it is good practice, where possible, to mark the focussing screw with a knife cut or other device so that it can again be brought to the same setting. On some instruments this is not possible. Correct focus is necessary for finding the star in daytime.

ASTRONOMICAL FIELD TABLES

Altitude of Pole Star		Sidereal Time	AZIMUTH OF POLE STAR									Degrees
			Lat. 44°	Lat. 46°	Lat. 48°	Lat. 50°	Lat. 52°	Lat. 54°	Lat. 56°	Lat. 58°	Lat. 60°	
SUBTRACT FROM LATITUDE	27′	h. m. 18 00	10′0	12′5	15′2	18′2	21′6	25′4	29′7	34′6	40′2	1°
	25	10	11·6	14·1	16·9	20·0	23·5	27·4	31·8	36·8	42·5	
	23	20	13·1	15·6	18·5	21·6	25·2	29·2	33·7	38·8	44·6	
	20	30	14·4	17·0	19·9	23·1	26·7	30·8	35·4	40·6	46·5	
	18	40	15·6	18·2	21·2	24·5	28·1	32·3	37·0	42·2	48·3	
	16	50	16·6	19·3	22·3	25·6	29·4	33·6	38·3	43·7	49·8	
	13	19 00	17·5	20·2	23·3	26·6	30·4	34·7	39·5	44·9	51·2	
	11	10	18·2	21·0	24·1	27·5	31·3	35·6	40·5	46·0	52·3	
	08	20	18·8	21·6	24·7	28·2	32·0	36·4	41·3	46·8	53·2	
	06	30	19·3	22·1	25·2	28·7	32·6	37·0	41·9	47·5	53·9	
	03	40	19·6	22·4	25·5	29·0	33·0	37·4	42·3	48·0	54·4	
	01	50	19·7	22·6	25·7	29·2	33·2	37·6	42·6	48·2	54·7	
ADD TO LATITUDE	02	20 00	19·7	22·6	25·7	29·2	33·2	37·6	42·6	48·2	54·7	
	04	10	19·6	22·4	25·6	29·1	33·0	37·4	42·4	48·1	54·6	
	07	20	19·3	22·1	25·2	28·7	32·7	37·1	42·0	47·7	54·2	
	09	30	18·8	21·6	24·7	28·2	32·2	36·5	41·5	47·2	53·6	
	12	40	18·2	21·0	24·1	27·6	31·5	35·8	40·7	46·4	52·8	
	14	50	17·4	20·2	23·3	26·7	30·6	34·9	39·8	45·4	51·7	
	16	21 00	16·5	19·3	22·3	25·7	29·5	33·8	38·7	44·2	50·5	
	19	10	15·5	18·2	21·2	24·6	28·3	32·6	37·3	42·8	49·0	
	21	20	14·3	16·9	19·9	23·2	26·9	31·1	35·8	41·2	47·3	
	23	30	12·9	15·5	18·5	21·7	25·4	29·5	34·1	39·4	45·4	
	26	40	11·4	14·0	16·9	20·1	23·7	27·7	32·2	37·4	43·3	
	28	50	09·8	12·3	15·1	18·3	21·8	25·7	30·2	35·2	41·0	
	30	22 00	08·0	10·5	13·2	16·3	19·7	23·5	27·9	32·9	38·5	
	32	10	06·1	08·5	11·2	14·2	17·5	21·3	25·5	30·3	35·9	
	34	20	04·1	06·4	09·0	11·9	15·1	18·8	22·9	27·6	33·0	
	36	30	02·0	04·2	06·7	09·5	12·6	16·2	20·2	24·7	29·9	
	38	40	59·7	01·9	04·3	07·0	10·0	13·4	17·2	21·6	26·6	
	40	50	57·3	59·4	01·7	04·3	07·2	10·5	14·1	18·4	23·2	
	42	23 00	54·8	56·8	59·0	01·5	04·3	07·4	10·9	15·0	19·6	
	44	10	52·2	54·1	56·2	58·6	01·2	04·2	07·6	11·4	15·8	
	45	20	49·5	51·3	53·3	55·5	58·0	00·9	04·1	07·7	11·9	
	47	30	46·7	48·4	50·3	52·4	54·7	57·4	00·5	03·9	07·8	0°
	48	40	43·8	45·4	47·1	49·1	51·3	53·8	56·7	59·9	03·6	
	49	50	40·8	42·2	43·9	45·8	47·8	50·2	52·8	55·8	59·3	

ALTITUDE AND AZIMUTH OF POLARIS

November, December 1951
September, October 1952
July, August 1953

FIGURE I

POLE STAR OBSERVATION FOR AZIMUTH

The maximum error in the azimuth of the Pole star, as determined from the field tables, is about 0.5 minutes. Where azimuth observations are required to an accuracy of one or two minutes only, the calculations may be made from the data contained in them.

For all astronomical work, whether for time or azimuth, the instrument must be very firmly set up and carefully levelled. In surveying a lot, subdividing a township, or making a traverse, an observation for azimuth is made with one of the survey lines as a reference line. In each case the bearing by account is generally near enough to the azimuth for the purpose of setting the instrument and finding the star. The reference object should be about one half mile or more distant, so that it can be sighted without parallax when the instrument is at solar focus.

SPECIMEN OBSERVATIONS

Specimen azimuth observations are shown on page 4 The following notes refer to the observation on the upper half of the page.

The observation is supposed to have been made with a double centre transit to determine the bearing of the westerly boundary of lots 14 to 20, range 1, in the townsite of Waskesiu very near the northeast corner of section 8, township 57, range 1, west of the 3rd initial meridian. The bearing of this reference line is to be referred to the astronomical meridian through the centre of the township.

The bearing of the reference line is known to be about 177°08'. Set the vernier of the horizontal circle to read 177°08'. Using the lower clamp and tangent screw, and with the vertical circle to the right, direct the telescope on the reference line. Read verniers A and B and enter their mean under the heading, H.C.R. on Ref. Line, Circle Right (177°08').

From Table X, in this Supplement, note that the latitude of the place is 53°55'; the sidereal watch reads about 19^h 10^m. Entering the Astronomical Field Tables (Figure I), with these arguments, the azimuth of the Pole star is given as 1°35'.6. Loosen the upper clamp and set the vernier of the horizontal plate to read 1°35'.

At sidereal time 19^h 10^{m}it is necessary to subtract 11' from the latitude of the place to obtain the altitude of Polaris (Figure I); therefore, the altitude is 53°55'-11' = 53°44'. Set the telescope at this altitude and Polaris should be in the field of view.

With the vertical tangent screw bring the star to a point immediately above or below the horizontal cross hair, then bisect the star with the vertical cross hair using the upper tangent screw. Note and enter the watch time of the bisection to the nearest second under the heading, Watch Time, Circle Right (19^h 12^{m}16^s).

Since the vertical cross hair will entirely cover the star, it is good practice to make two or three trial pointings before making the final setting, which in this operation as in all others, should be made by

POLE STAR OBSERVATIONS FOR AZIMUTH

Date *Nov. 15th, 1951* Ref. line *W. By. Lots 14 to 20, R. 1*
Place *N.W. Cor. Lot 14, R. 1, Townsite Waskesiu – Approx. Lat. 53° 55'*
Observer *J. Doe* Instrument *Cook T. S. No. 1650*

Circle	H.C.R. on Ref. line	H.C.R. on Polaris	Watch Time
Right	*177° 08'*	*1° 34'*	*19^h 12^m 16^s*
Left	*357 07*	*181 35*	*19 15 24*
Mean	*177 07.5*	*1° 34'.5*	*19 13 50*

Tab. az. for 19 h. 10 m. Lat. 52°	*1° 31'.3*
Difference for 4 m. 02 s.	*+ 0.3*
Difference for 1° 55' Lat.	*+ 4.1*
Azimuth of Polaris	*1° 35'.7*
H.C.R. on Polaris	*1 34.5*
Correction to H.C.R.	*+ 1.2*
H.C.R. on Ref. line	*177 07.5*
Azimuth of Ref. line	*177° 08'.7*
Convergence for 1 mi.	*+ 1.2*
Bearing of Ref. line	*177° 09'.9*

Watch Corr.	*+ 12*
Sid. Time	*19 14 02*

NOTE: If, after observation, any deflection in the line was made, the following information should be supplied.

Amount *Nil* Direction

Place

Date *Dec. 10th, 1951* Ref. line *N. By. Sec. 24, 99, 2, W. 6th*
Place *20 Chs. W. of N.E. Cor. Sec. 24 – Approx. Lat. 57° 37'*
Observer *J. Doe* Instrument *Wild T.S. No. 500*

Circle	H.C.R. on Ref line	H.C.R. on Polaris	Watch Time
Right	*295° 21'*	*23° 49'*	*9^h 58^m 26^s*
Left	*115 19*	*203 50*	*10 01 05*
Mean	*295 20*	*23° 49'.5*	*9 59 45*

Tab. az. for 9 h. 50 m. Lat. 56°	*358° 32'.0*
Difference for 8 m. 35 s.	*+ 2.1*
Difference for 1° 37' Lat.	*– 3.9*
Azimuth of Polaris	*358° 30'.2*
H.C.R. on Polaris	*23 49.5*
Correction to H.C.R.	*– 25 19.3*
H.C.R. on Ref. line	*295 20*
Azimuth of Ref. line	*270° 00'.7*
Convergence for 2¾ mi.	*– 3.7*
Bearing of Ref. line	*269° 57'.0*

Watch Corr.	*– 1 10*
Sid. Time	*9 58 35*

NOTE: If, after observation, any deflection in the line was made, the following information should be supplied.

Amount *3'.0* Direction *N*

Place *N.E. Cor. Sec. 21*

turning the tangent screw in a positive, or clockwise, direction.

Read the horizontal plate verniers A and B and enter the mean under the heading, H. C. R. on Polaris, Circle Right (1°34').

This completes only the first half of the observation because, for azimuth work, it is essential that all observations be made in the two positions of the instrument - circle right, and circle left.

To complete the observation, transit the telescope, set the horizontal circle to read the azimuth of Polaris plus 180°, and reset the altitude in the telescope's new position. Repeat the setting on Polaris as before, entering the Watch Time ($19^{h}\ 15^{m}24^{s}$), and the H. C. R. on Polaris (181°35') in their respective places. Point the telescope on the reference line, read the horizontal circle, and enter under Circle Left (357°07').

The observation is now complete and the next step is to calculate the bearing of the reference line.

First, mean the horizontal circle readings on the reference line (177°07!5), and on Polaris (1°34!5), and mean the watch times ($19^{h}\ 13^{m}50^{s}$). Let the correction to the watch be $+12^{s}$, which makes the sidereal time $19^{h}\ 14^{m}\ 02^{s}$ (methods of determining the watch correction are described in the next section).

From the Field Tables (Figure I), the azimuth of the Pole star at $19^{h}\ 10^{m}$for latitude 52° is 1°31!3, and at $19^{h}\ 20^{m}$it is 1°32!0. By direct proportion, the correction to obtain the azimuth at $19^{h}\ 14^{m}02^{s}$ is +0!3. Similarly, by direct proportion, the correction to obtain the azimuth at latitude 53°55', the latitude of the place, is +4!1. With these corrections, the azimuth of Polaris is 1°35!7 at the mean time of the observation.

The mean H. C. R. on Polaris, as calculated above, is 1°34!5. Therefore, the correction to the horizontal circle readings to give true azimuths is 1°35!7 - 1°34!5 = +1!2. Applying this correction to the mean H. C. R. on the reference line gives the true azimuth as 177°08!7.

The reference meridian for the survey is the meridian through the centre of the township, almost exactly 1 mile east of the observation point. From the convergence scale of the Field Tables (Figure 2), the convergence per mile at latitude 53°55' is 1!2. The bearing of the reference line referred to the central meridian of the township is, therefore, 177°08!7 + 1!2 = 177°09!9, or 177°10'.

Since the observation was taken for the purpose of determining the bearing only of a survey line, no deflection is to be made and the word 'nil' is entered under the proper heading.

The observation on the lower half of page 4 is supposed to have been taken on the north boundary of section 24, Tp. 99, R. 2, W. of the 6th meridian. The chord has been run east from the control meridian and the place of observation was a point 20 chains W. of the N. E.

corner of the section, the reference line lying to the west. Because a single-centre instrument was used, the horizontal plate could not be set to read azimuths.

The bearing of the reference line is known to be about 270°00' making the horizontal circle reading of 295°21' on the line 25°21' greater than the true bearing. From the Astronomical Field Tables (the relevant page is not reproduced here), the azimuth of Polaris for the time and place is about 358°34', to which must be added 25°21' to obtain the setting for the horizontal plate in order to find the star.

The remainder of the proceedings and calculations are the same as in the preceding observation, except that as the bearing of the line is required to be 270°00' it must be corrected by a deflection northward of 3 minutes. Entries recording deflections must never be neglected.

DETERMINATION OF THE WATCH CORRECTION

The watch may be set approximately to local sidereal time by several means. One of these, which involves a knowledge of the local standard time, is given in the Astronomical Field Tables (Figure 2). If the standard time is not known it may be possible to obtain it from radio time signals. Otherwise, an approximation of apparent mean noon and hence of mean noon may be obtained by observing the time of the highest altitude of the sun.

A convenient fact to remember is that around March 21 the local mean time and the local sidereal time are the same, and about September 21 the sidereal time is 12 hours in advance of mean time.

When the sidereal time is known approximately, an observation on the Pole star for azimuth will provide an approximate value of the astronomical meridian on which the time may be observed by the methods that follow. The watch correction thus obtained may be used in re-working the azimuth observation and thus providing a more accurate meridian from which the time may be re-observed. The watch correction should be determined shortly before or after an azimuth observation.

DETERMINATION OF THE WATCH CORRECTION BY THE MERIDIAN TRANSIT OF A STAR

During the progress of a survey the bearings of the lines surveyed are known. By applying the convergence from the reference meridian, the azimuth of the astronomical meridian may be calculated and the instrument set on it. If the telescope is then set at the altitude of a time star, the watch time of its transit of the meridian may be observed. The sidereal times of transit of a number of suitable stars are given in the Astronomical Field Tables (not reproduced here). The magnitudes and Polar distances of the stars are also given. The altitude on the meridian to the south may be calculated by subtracting the Polar distance from the supplement of the latitude. In selecting a time star to be used in daylight, it should be remembered that stars are more difficult to see south of the zenith than north of it, and that this difficulty increases as the altitude decreases.

ASTRONOMICAL FIELD TABLES

SIDEREAL TIME AT NOON, EASTERN STANDARD TIME (75° LONGITUDE)

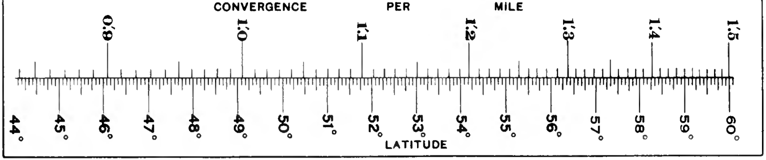
1951	h	m	s	1952	h	m	s	1953	h	m	s
1st November	14	40	42	1st September	10	43	11	1st July	6	37	48
11th November	15	20	07	11th September	11	22	37	11th July	7	17	14
21st November	15	59	33	21st September	12	02	02	21st July	7	56	39
1st December	16	38	58	1st October	12	41	28	31st July	8	36	05
11th December	17	18	24	11th October	13	20	53	10th August	9	15	30
21st December	17	57	49	21st October	14	00	19	20th August	9	54	56
31st December	18	37	15	31st October	14	39	45	30th August	10	34	21

Above table is to enable surveyors to convert Standard Time to Local Sidereal Time. The conversion can be made simply in the following steps:

1. Find Sidereal Time for Noon preceding the time in question. Sidereal Time gains $3^m 56^s.6$ per day on Standard Time.
2. Correct for interval since preceding noon, Eastern Standard Time. (If other than Eastern Standard Time is used the difference between it and Eastern Standard Time must be allowed for.) This interval must be converted to a Sidereal Time interval by adding $9^s.86$ per hour.
3. Correct for Longitude: Add 4 minutes for each 1° of Long. East of Long. 75°; subtract 4 minutes for each 1° of Long. West of Long. 75°.

EXAMPLE—Required the Local Sidereal Time in Longitude 110° 27′ at 3.30 a.m., Mountain Standard Time on October 25, 1952

Sidereal Time at Noon, Eastern Standard Time October 21, 1952	14h	00m	19s
Correction for 3 days = 3 x $3^m 56^s.6$		11	49·8
Sidereal Time at Noon, Eastern Standard Time October 24, 1952	14	12	08·8
Noon, Mountain Time is 2 hours behind Noon Eastern Standard Time. Hence interval from Noon Eastern Standard Time to 3.30 a.m. Mountain Time is 2 h. + 15h. 30m. = 17h. 30m. = $17^h.5$	17	30	00
Acceleration of Sidereal Time on Mean Time = 17.5 x $9^s.86$		2	52·5
	7	45	01·3
Correction for Longitude: 4 minutes per degree for (110°27′ − 75°) = 35° 27′	2	21	48
Local Sidereal Time in Longitude 110° 27′ at 3.30 a.m., Mountain Time October 25, 1952	5	23	13·3



CONVERSION STANDARD TIME
TO LOCAL SIDEREAL TIME
CONVERGENCE

FIGURE 2

For the first specimen of azimuth observation given in the preceding section, a convenient star would be α Aquilae. From the Astronomical Field Tables, its magnitude is 1, so that it should be easy to see; its time of meridian transit, for Nov. 15, 1951, is $19^h 48^m 26^s$, which allows sufficient time to set the transit after completing the azimuth observation.

Its altitude on the meridian is (180°-53°55') - 81°16' (Polar distance) = 44°49'.

The bearing by account of the reference line is 177°08' and the convergence to be subtracted to obtain azimuths is $1\overset{\prime}{.}2$. Set the horizontal circle at 177°07', and sight it on the reference line with the lower horizontal movement. Loosen the upper clamp and turn the transit so that the vernier reads 180°. Set the altitude of the star on the vertical circle. Note the time the star passes the vertical wire of the transit, and calculate the watch correction:

Watch time of meridian transit of α Aquilae	$19^h 48^m 14^s$
Sidereal time of meridian transit of α Aquilae	$19^h 48^m 26^s$
Watch Correction, Nov. 15 (watch slow) .... +	12^s

Since, from the azimuth observation, the bearing by account was in error by about 2 minutes of arc, the setting for the astronomical meridian was also in error by 2 minutes. The error thus introduced into the watch correction can be calculated from the formula 4 x 2 x cos h sec δ in seconds, where h and δ are the altitude and declination of the star respectively. Substituting, we get, 4 x 2 x cos 44°49' sec 8°44' = 5.6 seconds. Since the bearing by account is 2 minutes less than the true bearing, the azimuth of the astronomic meridian set on the transit will actually be 180°02' and the sidereal time of the observation will be $19^h 48^m 32^s$ instead of $19^h 48^m 26^s$ making the watch correction + 18^s.

The effect of the error of the watch correction (5.6 seconds) on the observed azimuth would be less than .01 minute and can be neglected.

To obtain the watch correction for the second specimen azimuth observation, α Leonis, magnitude 1.3, would be suitable although there is a very small interval of time after the completion of the observation to set the transit for the time star. The reading on the horizontal circle when the transit is set on the reference line with circle right is 295°21'. The bearing of the reference line by account is 270°00' and the convergence to the reference meridian is $3\overset{\prime}{.}7$. The azimuth of the reference line is therefore 270°$03\overset{\prime}{.}7$. The angle between the reference line and the astronomic meridian towards the south is 270°$03\overset{\prime}{.}7$ - 180°00' = 90°$03\overset{\prime}{.}7$. To set the transit in the astronomic meridian, the horizontal plate should be made to read 295°21' - 90°$03\overset{\prime}{.}7$ = 205°17'. The altitude setting for the time star is (180°-57°37') - 77°48' = 44°35'.

Watch time of meridian transit of α Leonis	$10^{h}\ 07^{m}00^{s}$
Sidereal time of meridian transit of α Leonis	$10^{h}\ 05^{m}50^{s}$
Watch Correction, Dec. 10 (watch fast)	$-\ 1^{m}\ 10^{s}$

The correction due to the error in azimuth is not calculated.

DETERMINATION OF WATCH CORRECTION BY THE MERIDIAN TRANSIT OF THE SUN

The determination of the watch correction by means of the meridian transit of the sun is convenient for several reasons: the observation is made at a time of the day when the instrument is usually on line and can be readily set in the meridian; there is no difficulty in finding the sun; and it can be observed through light clouds or haze when stars are invisible.

The observation is simple. The telescope is set in the meridian as for a star, and the sun glass is attached to the eyepiece. The watch time when each limb of the sun crosses the vertical thread of the diaphragm is noted, and the mean of the two gives the watch time of the meridian transit. The sidereal time of the observation equals the Apparent Right Ascension of the Sun. It may be calculated from Apparent Right Ascension and Declination of the Sun, in the Astronomical Field Tables - a sample page of which is shown in Figure 3.

An example, based on the first specimen of azimuth observation, follows:

Date - Nov. 15, 1951.
Place - NW. Cor. lot 14, R.1, Waskesiu Townsite,

Watch time, transit of first limb	$15^{h}\ 19^{m}25^{s}$
Watch time, transit of second limb	$15^{h}\ 21^{m}41^{s}$
Mean	$15^{h}\ 20^{m}33^{s}$

From the Astronomical Field Tables (Figure 3), the sun's apparent right ascension at Greenwich apparent noon, on Nov. 15, 1951, is $15^{h}\ 19^{m}33^{s}$, and the variation in 1 hour is + $10^{s}.2$.

The place of observation is near the northeast corner of section 8, township 57, range 1, west of the 3rd initial meridian. The longitude of the third meridian is 106°W. The northeast corner of section 8 is four sixths of a range west of the 3rd meridian, which from Table IV of the Supplement, is 0.1 degrees (05' 57") west, fixing the longitude of the place as 106.1°W.

The elapsed time equivalent to 106.1 degrees of longitude

ASTRONOMICAL FIELD TABLES

THE SUN'S APPARENT RIGHT ASCENSION

at Greenwich apparent noon and variation for one hour.

Day of Month	1951								Day of Month
	September		October		November		December		
	h. m. s.	s.	h. m. s.	s.	h. m. s.	s.	h. m. s.	s.	
1	10 39 33	9·1	12 27 31	9·0	14 23 29	9·8	16 26 58	10·8	**1**
2	10 43 11	9·1	12 31 08	9·1	14 27 24	9·8	16 31 17	10·8	**2**
3	10 46 48	9·1	12 34 46	9·1	14 31 20	9·8	16 35 36	10·8	**3**
4	10 50 25	9·0	12 38 24	9·1	14 35 16	9·9	16 39 57	10·9	**4**
5	10 54 02	9·0	12 42 02	9·1	14 39 14	9·9	16 44 18	10·9	**5**
6	10 57 39	9·0	12 45 41	9·1	14 43 12	9·9	16 48 39	10·9	**6**
7	11 01 15	9·0	12 49 20	9·1	14 47 11	10·0	16 53 01	10·9	**7**
8	11 04 51	9·0	12 52 59	9·1	14 51 11	10·0	16 57 24	10·9	**8**
9	11 08 27	9·0	12 56 39	9·2	14 55 12	10·0	17 01 46	11·0	**9**
10	11 12 03	9·0	13 00 19	9·2	14 59 13	10·1	17 06 10	11·0	**10**
11	11 15 39	9·0	13 03 59	9·2	15 03 15	10·1	17 10 34	11·0	**11**
12	11 19 14	9·0	13 07 40	9·2	15 07 19	10·2	17 14 58	11·0	**12**
13	11 22 49	9·0	13 11 22	9·2	15 11 23	10·2	17 19 22	11·0	**13**
14	11 26 25	9·0	13 15 04	9·3	15 15 28	10·2	17 23 47	11·0	**14**
15	11 30 00	9·0	13 18 46	9·3	15 19 33	10·2	17 28 12	11·1	**15**
16	11 33 35	9·0	13 22 29	9·3	15 23 40	10·3	17 32 38	11·1	**16**
17	11 37 10	9·0	13 26 13	9·3	15 27 47	10·3	17 37 04	11·1	**17**
18	11 40 45	9·0	13 29 57	9·4	15 31 56	10·4	17 41 30	11·1	**18**
19	11 44 20	9·0	13 33 42	9·4	15 36 05	10·4	17 45 56	11·1	**19**
20	11 47 55	9·0	13 37 28	9·4	15 40 15	10·4	17 50 22	11·1	**20**
21	11 51 31	9·0	13 41 14	9·4	15 44 26	10·5	17 54 49	11·1	**21**
22	11 55 06	9·0	13 45 01	9·5	15 48 37	10·5	17 59 15	11·1	**22**
23	11 58 41	9·0	13 48 48	9·5	15 52 50	10·5	18 03 42	11·1	**23**
24	12 02 17	9·0	13 52 36	9·5	15 57 03	10·6	18 08 08	11·1	**24**
25	12 05 53	9·0	13 56 25	9·6	16 01 17	10·6	18 12 35	11·1	**25**
26	12 09 29	9·0	14 00 15	9·6	16 05 32	10·6	18 17 02	11·1	**26**
27	12 13 05	9·0	14 04 05	9·6	16 09 48	10·7	18 21 28	11·1	**27**
28	12 16 41	9·0	14 07 57	9·6	16 14 04	10·7	18 25 54	11·1	**28**
29	12 20 17	9·0	14 11 49	9·7	16 18 21	10·7	18 30 21	11·1	**29**
30	12 23 54	9·0	14 15 41	9·7	16 22 39	10·8	18 34 47	11·1	**30**
31	12 27 31	9·0	14 19 35	9·7	16 26 58	10·8	18 39 12	11·1	**31**
32			14 23 29	9·8			18 43 38	11·1	**32**

FIGURE 3

is equal to $\frac{106.1}{15}$ = 7.07 hours. The variation in the sun's apparent right ascension in 7.07 hours is $7.07 \times 10.2 = +\ 72^s = +\ 1^m\ 12^s$. Hence the sidereal time at apparent noon is $15^h\ 19^m 33^s + 1^m 12^s = 15^h\ 20^m 45^s$, and the watch correction is $15^h\ 20^m 45^s - 15^h\ 20^m 33^s = +\ 12^s$ (watch slow).

An error of 0.1 degrees, or 6 minutes, in longitude would give an error in time of only 1 second.

Another example, based on the second specimen of azimuth observation, follows:

Date - Dec. 10, 1951.
Place - 20 chs. W. of NE. Cor. Sec. 24, Tp. 99, R. 2, W 6th,

Watch time, transit of first limb .... $17^h\ 07^m 36^s$

Watch time, transit of second limb .... $17^h\ 09^m 58^s$

Mean $17^h\ 08^m 47^s$

Sidereal time at apparent noon

$= 17^h\ 06^m 10^s + 11.0 \times \frac{(118 + 0.2)}{15} =$ $17^h\ 07^m 37^s$

Watch correction (watch fast) = $-\ 1^m 10^s$

If, because of clouds or other reason, only one limb can be observed, a correction for the semi-diameter of the sun in sidereal time has to be applied to the observed watch time to give the watch time of transit. The semi-diameter of the sun in sidereal time is given in the Nautical Almanac for every day of the year.

Suppose, for example, that in the above observation the watch time for the first limb only was observed. In that case, it would be necessary to add the semi-diameter in sidereal time, namely $1^m 10^s.86$, to the watch time, $17^h\ 07^m 36^s$, to give the watch time of transit, $17^h\ 08^m 47^s$. If the second limb only were observed the semi-diameter would have to be subtracted.

DETERMINATION OF THE WATCH CORRECTION BY RADIO TIME SIGNALS

Radio time signals are broadcast from a number of stations in Canada and United States on several wave lengths and at various times. The stations which are most used by surveyors in Canada are stations of the CBC network; CHU Ottawa; NSS Washington; NPG San Francisco; and WWV Washington.

As an example of the usage of time signals, suppose the 1 p. m., Eastern Standard Time, radio signal by CBC were to be heard at the place of the first specimen of azimuth observation, longitude 106° 05' 57", on Nov. 15, at watch time $14^h\ 31^m 27^s$.

From the Astronomical Field Tables (Figure 2) the sidereal time at noon Eastern Standard Time, Nov. 11 is	$15^h\ 20^m 07^s$
Correction for 4 days = 4 x $3^m 56^s.6$	$15^m 46^s$
Correction to 1 p.m. = $1 + \frac{1}{24}$ x $3^m 56^s.6$	$1^h\ 00^m 10^s$
Sidereal time of signal, longitude 75°	$16^h\ 36^m 03^s$
Correction for longitude = 106°05' 57" - 75° = 31°05' 57"......	$2^h\ 04^m 24^s$
Sidereal time of signal at place of observation	$14^h\ 31^m 39^s$
Watch time of signal	$14^h\ 31^m 27^s$
Hence, watch correction is +	12^s

THE WATCH RATE

It will be noted in the two specimen observations for azimuth that comparatively large errors in the watch correction have little effect on the resulting azimuth. An influence on the error is the apparent rate of travel of Polaris. In the first specimen, this rate is 0.7 minutes of arc in 10 minutes of time and in the second 2.7 minutes in 10 minutes. At the times of upper and lower culmination, i. e., at about $1^h\ 50^m$ and $13^h\ 50^m$; the rate is about 4.6 minutes of arc for 10 minutes of time, or nearly 30 seconds of arc for 1 minute of time. In the more precise observations for governing surveys where azimuths are calculated to seconds, it is evident that the watch correction is required with considerable accuracy.

It is not always possible to obtain a time observation and the accuracy of a critical azimuth observation may be adversely effected by an inaccurate watch correction. As a precautionary measure it is good practice to observe for time as opportunities occur, and establish a daily rate for the watch. The daily rate of the watch is the number of seconds it gains or loses in 24 hours. This can be done quite simply in surveying a meridian but in all other surveys allowance must be made for changes in longitude.

In the preceding specimen observations for azimuth a watch correction of + 12^s was determined at longitude 106°05' 57" at $15^h 20^m 45^s$ on Nov. 15 (page 8) and again determined as $-1^m\ 10^s$ at longitude 118°10' 12" at $17^h\ 07^m 37^s$ on Dec. 10 (page 9). At the instant of the second determination, the sidereal time at the place of the first observation would be $17^h\ 07^m 37^s + \frac{1}{15}$ (118°10' 12" − 106°05' 57") = $17^h\ 55^m 54^s$. The watch correction would be $17^h\ 55^m 54^s - 17^h\ 08^m 47^s = +\ 0^h\ 47^m 07^s$. This means that the watch has lost $47^m 07^s - 12^s = 46^m 55^s$ in $25 + (17^h\ 55^m - 15^h\ 20^m)\frac{1}{24}$ = 25.1 days, giving a daily rate of $-46^m 55^s \div 25.1$ or $-1^m 52^s.1$

It is not probable that the watch would maintain an even daily loss of $1^{m}52^{s}.1$ over such a long period as 25 days. In order to establish a reliable rate, time should be observed at intervals not exceeding three or four days.

To illustrate the usage of the daily rate, suppose an azimuth observation was taken at $20^{h}30^{m}$ on Dec. 12 at longitude 119°06' 12", and that it is required to know the watch correction at the time of the observation.

Watch correction, longitude 118°10'12" at $17^{h}\,07^{m}$, Dec. 10	$-\ 1^{m}10^{s}$
Daily rate, $-\ 1^{m}52^{s}.1$; elapsed time, 2.1 days; watch loss	$3^{m}55^{s}$
Watch correction at time of observation	$+\ 2^{m}45^{s}$
Correction for longitude = $\dfrac{119°06'12" - 118°10'12"}{15}$	$= -\ 3^{m}44^{s}$
Hence, required watch correction is	$-\ 0^{m}59^{s}$

OBSERVATION OF THE SUN FOR AZIMUTH

It may happen that star observations are prevented by smoke, haze, or light clouds, and the only method available for the determination of azimuth will be observation on the sun.

The method is not recommended when Polaris can be observed because it is not as accurate and, as it involves more calculation, is subject to a greater number of errors.

The following explanation is based on the use of the inverted eyepiece.

The instrument, carefully set up at the station and levelled, is directed on the reference line, and the horizontal circle is read and recorded, as usual, under the heading H. C. R. on Ref. Line. A sun glass must then be attached to the eyepiece and the instrument directed on the sun.

The next few steps are easy enough if performed methodically. In general, they consist of placing the image of the sun in the angle formed by the cross hairs of the diaphragm, first in the upper left quadrant with the instrument in circle right position, second in the lower right quadrant with the instrument in the circle left position (Figure 4). This procedure should be followed for an observation in the forenoon. In the afternoon, the other two remaining quadrants, as shown in Figure 5 should be used. In each case, when the cross hairs are tangent to the limbs of the sun's image, the circle readings and the approximate time should be taken.

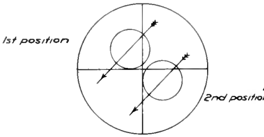


FIGURE 4

Observation of the sun in the forenoon with an inverting eyepiece.

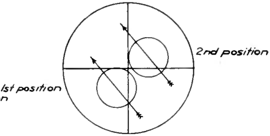


FIGURE 5

Observation of the sun in the afternoon with an inverting eyepiece.

Rules for Observing:

1. Commence with the sun on the left of the vertical thread and impinging upon it, above the horizontal thread in the forenoon and below in the afternoon.
2. Follow the sun with the slow motion screw of the vertical circle until the vertical thread also becomes tangent to the disc. The rules are reversed in the second position of the instrument.
3. Place the sun on the right of the vertical thread and impinging upon the horizontal thread, below it in the forenoon and above it in the afternoon.
4. Follow the sun with the slow motion screw of the upper plate until the horizontal thread also becomes tangent to the disc.

The readings of the vertical circle on the sun, and of the horizontal circle on both the sun and the reference object, generally one of the line pickets, must be taken in both positions of the instrument and the approximate time of the observation noted.

COMPUTATION FOR THE SUN OBSERVATION

The following formula may be used for the calculation:

$$\cos \frac{a}{2} = \sqrt{\cos S \cos (S - P) \sec L \sec h}$$

where $S = \dfrac{h + L + P}{2}$

h = sun's true altitude,

P = sun's polar distance,

L = latitude of observation station,

a = angle sun makes with the meridian east or west from the north.

Then the azimuth from the north through the east, south and west is the same as "a" for forenoon observations, and is "360-a" for afternoon observations.

The latitude, and the logarithm of its secant, are given in Table X for the north side of every section.

The first step in the reduction of the observation is to calculate the means of the time, H. C. R. on Reference Line, Sun's altitude, and H. C. R. on Sun. Sample observations are shown on pages 16 and 17.

The sun's true altitude is the mean of the observed altitudes corrected for refraction and parallax. A table of the combined mean refraction and parallax is given in the Astronomical Field Tables, a sample page of which is shown in Figure 6. The table also gives the corrections which should be applied for temperature and pressure, in order to find the mean refraction and parallax for the atmospheric conditions at the time of observation. The mean of the observed altitudes is 28°51'.5 (Page 16). The combined refraction and parallax for this altitude is given as 1'.6 (Figure 6). For a barometric pressure of 29 inches a correction of -0'.1 must be applied. For a temperature of 70°F a correction of -0'.1 is required. Hence the resultant correction for refraction and parallax is 1'.4 - a correction which must always be subtracted from the observed altitude. The sun's true altitude, therefore, is 28°50'.1. The means of the Times, H. C. R. on Ref. Line, and H. C. R. on Sun, can be written in directly.

The next step is to find the sun's Polar distance. The Astronomical Field Tables (Figure 7) give the sun's declination for 0^h Greenwich civil time, and the variation for one hour. We must therefore know the time after 0^h Greenwich civil time at which the observation was taken. This is obtained by adding the local standard time to the longitude of the reference meridian at the time zone, expressed in time. Thus in the example, the observation was taken at 7^h 19^ma. m., mountain standard time*, which is the local time for longitude 105°W, and is 7^h behind Greenwich civil time. The Greenwich civil time of the observation is therefore $7^h\ 19^m + 7^h = 14^h\ 19^m = 14^h.3$. From the table (Figure 7) the sun's declination at 0^h on June 1, 1951, is N 21°54'.9, and the variation for one hour, + 0'.36. For $14^h.3$ the variation is 5'.1. Thus, the declination North is 22°0'.0, that is, a Polar distance of 68°00'.0.

The observation sheet (page 16) shows a convenient method of working out the formula. The reduction of the observation then proceeds as for the observation on the Pole star, and needs no further explanation.

The best time for observing is when the sun is on the prime vertical, as an error in the altitude has then the least effect upon the azimuth. Useful observations, however, may be made at other times within certain limits set by practical considerations. For instance, it is considered that for an altitude lower than eight degrees the refraction correction is too uncertain in value. Again, the altitude should not be greater than that at which the rate of change of the azimuth is double the rate of change of the altitude because at higher altitudes, an error in altitude would produce too large an error in azimuth.

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* When local time is used, as in the observation on page 17 the approximate longitude of the place is required.

SUN OBSERVATIONS FOR AZIMUTH

Date *June 1st*, 1951 Ref. line *W. By Lots 14 to 20, R.1*

Place *N.W. Cor Lot 14, Waskesiu Townsite, Lat. 53°55'.2 Long. 106°06'*

Circle	Watch	H.C.R. on Ref. line	Sun's Altitude	H.C.R. on Sun
R.	7^h17^mam	177° 08'	29° 27'	91° 33'
L.	7.21	08	28 16	91 48
Mean	7^h19^m	177 08.0	28 51.5	91 40.5

Obs. Alt. Sun's Cent	28° 51'.5	Sun's Dec. G. 0^h	N 21° 54'.9
Refraction –		Var. for 14.3 hrs.	+ 5.1
Parallax +	– 1.4	Dec. at 7^h19^mam	N 22° 00'.0
True Sun's Alt. (h)	28 50.1	Sun's Pol. Dist. (P)	68° 00'.0

Local Std. Time	7^h 19^mam	$\cos\frac{a}{2} = \{\cos S \cos(S-P) \sec L \sec h\}^{\frac{1}{2}}$
Longitude	7	P = Polar Dist. h = True Alt. Sun's Centre
Greenwich C. Time	14 19	L = Latitude $S = \frac{1}{2}(P+L+h)$

$h = 28° \; 50'.1$	$\log \sec h = 0.05749$	$\log \cos h = 9.94251$
$L = 53 \; 55.2$	$\log \sec L = 0.22995$	$\log \sec h = 0.05749$
$P = 68 \; 00.0$	$\log \cos S = 9.40215$	
$2S = 150 \; 45.3$	$\log \cos(S-P) = 9.99639$	$\log \cos L = 9.97005$
$S = 75 \; 22.7$	$\log \cos^2 \frac{a}{2} = 9.68598$	$\log \sec L = 0.22995$
$S-P = 7 \; 22.7$	$\log \cos \frac{a}{2} = 9.84299$	

$\frac{a}{2} = 45° \; 50'.7$

$a = 91 \; 41.4$

Azimuth of Sun = 91 41.4

Convergence for 1 mile = + 1.2

Bearing ref. to Cent. Mer. = 91 42.6

H.C.R. on Sun = 91 40.5

Correction to H.C.R. on Sun = + 2.1

H.C.R. on Ref. line = 177 08.0

Bearing of Ref line = 177 10.1

NOTE: If after observation, any deflection in the line was made the following information should be supplied.

Amount *Nil* Direction

Place

Bar. *29 inches*

Temp. *70° F.*

SUN OBSERVATIONS FOR AZIMUTH

Date *July 15th* 1951 Ref. line *W. By Sec. 24, 99, 2 W. 6th*

Place *20 Chs. W. N.E. Cor. Sec. 24, Lat. 57°36'.8, Long. 118°10'.2*

Circle	Watch	H.C.R. on Ref. line	Sun's Altitude	H.C.R on Sun
R	*4h 55m pm*	*270° 00'*	*26° 33'*	*267° 06'*
L	*4 59*	*01*	*27 47*	*268 32*
Mean	*4 57*	*270 00.5*	*27 10.0*	*267 49.0*

Obs. Alt. Sun's Cent.	*27° 10'.0*	Sun's Dec. G. 0^h	*N 21° 32'.5*
Refraction –		Var. for *0.8* hrs.	*– 0.3*
Parallax +	*– 1.6*	Dec. at *4h 57m*	*N 21° 32'.2*
True Sun's Alt. (h)	*27° 08'.4*	Sun's Pol. Dist. (P)	*68° 27'.8*

Local Time *4h 57m pm*

Longitude *7 53*

Greenwich C. Time *24 50*
0 50 July 16th

$$\cos\frac{a}{2} = \{\cos S \cos(S-P) \sec L \sec h\}^{\frac{1}{2}}$$

P=Polar Dist. h=True Alt. Sun's Centre

L= Latitude $S=\frac{1}{2}(P+L+h)$

h = *27° 08'.4*	log sec h = *0.05066*	log cos h = *9.94934*
L = *57 36.8*	log sec L = *0.27113*	log sec h = *0.05066*
P = *68 27.8*	log cos S = *9.36475*	
$2S$ = *153 13.0*	log cos($S-P$) = *9.99560*	log cos L = *9.72887*
S = *76 36.5*	log $\cos^2\frac{a}{2}$ = *9.68214*	log sec L = *0.27113*
$S-P$ = *8 08.7*	log $\cos\frac{a}{2}$ = *9.84107*	

$\frac{a}{2}$ = *46° 05'.4*

a = *92 10.8*

Azimuth of Sun = *267 49.2*

Convergence for 2¾ mile = *– 3.7*

Bearing ref. to Cent. Mer. = *267 45.5*

H.C.R. on Sun = *267 49.0*

Correction to H.C.R. on Sun = *– 3.5*

H.C.R. on Ref. line = *270 00.5*

Bearing of Ref. line = *269 57.0*

NOTE: If after observation, any deflection in the line was made the following information should be supplied.

Amount *3'* Direction *N.*

Place *N.E. Cor. Sec. 21*

Bar. *28.0 inches*

Temp. *60° F.*

ASTRONOMICAL FIELD TABLES

Table of corrections to Apparent Altitude of sun for REFRACTION and PARALLAX

Mean Refraction and Sun's Parallax Bar. 30″ Tem. 50°F		Correction to the Mean Refraction.											
		For Height of Barometer						For Height of Thermometer					
App. Alt.	Refr. and Par.	Barometer Reading (inches)						Thermometer Reading (Fahr.)					
		26	27	28	29	30	31	-10°	10°	30°	50°	70°	90°
6°	8′.4	-1′.1	-0′.8	-0′.6	-0′.3	0′.0	+0′.3	+1′.1	+0′.7	+0′.3	0′.0	-0′.3	-0′.6
7	7.3	-1.0	0.7	0.5	0.3	0.0	+0.3	+1.0	0.6	0.3	0.0	-0.3	0.5
8	6.4	-0.9	0.6	0.4	0.2	0.0	+0.2	+0.9	0.6	0.3	0.0	-0.2	0.5
9	5.7	-0.8	0.6	0.4	0.2	0.0	+0.2	+0.8	0.5	0.2	0.0	-0.2	0.4
10	5.2	-0.7	0.5	0.4	0.2	0.0	+0.2	+0.7	0.5	0.2	0.0	-0.2	0.4
11	4.7	-0.6	0.5	0.3	0.2	0.0	+0.2	+0.6	0.4	0.2	0.0	-0.2	0.4
12	4.3	-0.6	0.4	0.3	0.2	0.0	+0.2	+0.6	0.4	0.2	0.0	-0.2	0.3
13	4.0	-0.5	0.4	0.3	0.1	0.0	+0.1	+0.5	0.4	0.2	0.0	-0.2	0.3
14	3.7	-0.5	0.4	0.3	0.1	0.0	+0.1	+0.5	0.3	0.2	0.0	-0.1	0.3
15	3.4	-0.5	0.3	0.2	0.1	0.0	+0.1	+0.5	0.3	0.2	0.0	-0.1	0.3
16	3.2	-0.4	0.3	0.2	0.1	0.0	+0.1	+0.4	0.3	0.1	0.0	-0.1	0.3
17	3.0	-0.4	0.3	0.2	0.1	0.0	+0.1	+0.4	0.3	0.1	0.0	-0.1	0.2
18	2.8	-0.4	0.3	0.2	0.1	0.0	+0.1	+0.4	0.3	0.1	0.0	-0.1	0.2
19	2.7	-0.4	0.3	0.2	0.1	0.0	+0.1	+0.4	0.2	0.1	0.0	-0.1	0.2
20	2.5	-0.3	0.3	0.2	0.1	0.0	+0.1	+0.3	0.2	0.1	0.0	-0.1	0.2
25	1.9	-0.3	0.2	0.1	0.1	0.0	+0.1	+0.3	0.2	0.1	0.0	-0.1	0.2
30	1.5	-0.2	0.2	0.1	0.1	0.0	+0.1	+0.2	0.2	0.1	0.0	-0.1	0.1
35	1.3	-0.2	0.1	0.1	0.0	0.0	+0.0	+0.2	0.1	0.1	0.0	-0.1	0.1
40	1.0	-0.1	0.1	0.1	0.0	0.0	+0.0	+0.1	0.1	0.1	0.0	-0.0	0.1
45	0.9	-0.1	-0.1	-0.1	-0.0	0.0	+0.0	+0.1	+0.1	+0.0	0.0	-0.0	-0.1

FIGURE 6

ASTRONOMICAL FIELD TABLES

THE SUN'S APPARENT DECLINATION

FOR 0h GREENWICH CIVIL TIME AND VARIATION FOR ONE HOUR

(0h Greenwich Civil Time is twelve hours before Greenwich Mean Noon of the same date)

Day of Month	1951								Day of Month
	May		June		July		August		
1	N.14° 45′·8	0′·77	N.21° 54′·9	0′·36	N.23° 11′·0	0′·15	N.18° 17′·2	0′·62	1
2	15 04·1	0·76	22 03·2	0·34	23 07·2	0·17	18 02·3	0·63	2
3	15 22·1	0·75	22 11·2	0·32	23 03·0	0·18	17 47·0	0·64	3
4	15 39·9	0·74	22 18·8	0·31	22 58·4	0·20	17 31·5	0·65	4
5	15 57·5	0·72	22 26·0	0·29	22 53·4	0·22	17 15·7	0·66	5
6	16 14·7	0·71	22 32·8	0·28	22 48·0	0·23	16 59·6	0·68	6
7	16 31·7	0·70	22 39·3	0·26	22 42·2	0·25	16 43·2	0·69	7
8	16 48·4	0·69	22 45·3	0·24	22 35·9	0·27	16 26·6	0·70	8
9	17 04·9	0·68	22 50·9	0·23	22 29·3	0·28	16 09·7	0·71	9
10	17 21·0	0·67	22 56·1	0·21	22 22·4	0·30	16 52·5	0·72	10
11	17 36·9	0·65	23 00·9	0·20	22 15·0	0·32	15 35·1	0·73	11
12	17 52·5	0·64	23 05·3	0·18	22 07·2	0·33	15 17·4	0·74	12
13	18 07·7	0·63	23 09·3	0·16	21 59·1	0·35	14 59·5	0·75	13
14	18 22·7	0·62	23 12·9	0·14	21 50·6	0·36	14 41·4	0·76	14
15	18 37·4	0·61	23 16·1	0·12	21 41·7	0·38	14 23·0	0·77	15
16	18 51·7	0·59	23 18·9	0·11	21 32·5	0·39	14 04·4	0·78	16
17	19 05·7	0·58	23 21·2	0·09	21 22·8	0·41	13 45·6	0·79	17
18	19 19·4	0·56	23 23·2	0·07	21 12·9	0·42	13 26·5	0·80	18
19	19 32·8	0·55	23 24·7	0·06	21 02·5	0·44	13 07·3	0·81	19
20	19 45·8	0·54	23 25·8	0·04	20 51·8	0·44	12 47·8	0·82	20
21	19 58·5	0·52	23 26·6	0·02	20 40·8	0·47	12 28·1	0·82	21
22	20 10·8	0·51	23 26·9	0·01	20 29·4	0·48	12 08·3	0·83	22
23	20 22·9	0·49	23 26·8	0·01	20 17·7	0·50	11 48·2	0·84	23
24	20 34·5	0·48	23 26·2	0·03	20 05·6	0·51	11 28·0	0·85	24
25	20 45·8	0·46	23 25·3	0·05	19 53·2	0·52	11 07·5	0·86	25
26	20 56·8	0·45	23 23·9	0·06	19 40·4	0·54	10 46·9	0·86	26
27	21 07·4	0·43	23 22·2	0·08	19 27·4	0·55	10 26·1	0·87	27
28	21 17·6	0·42	23 20·0	0·10	19 14·0	0·56	10 05·2	0·88	28
29	21 27·5	0·40	23 17·4	0·12	19 00·2	0·58	9 44·1	0·88	29
30	21 37·0	0·39	23 14·4	0·13	18 46·2	0·59	9 22·8	0·89	30
31	21 46·1	0·37	N.23 11·0	0·15	18 31·9	0·60	9 01·4	0·90	31
32	N.21 54·9	0·36			N.18 17·2	0·62	N. 8 39·8	0·90	32

FIGURE 7

In a sun observation for azimuth, the ordinary surveyor's transit reading to one minute cannot be expected to give results with an accuracy better than three or four minutes. Recently, however, a Solar Prism Attachment* has been developed, and when placed over the object glass, it enables the observer to make more accurate pointings on the sun. With a good modern instrument, reading to one second in altitude and in azimuth and without a striding level, azimuths may be determined with an accuracy of about 20 seconds, or less, under good conditions. For results of this accuracy, forward and reverse determinations must be calculated separately, i.e., the altitudes and horizontal circle readings on the sun cannot be meaned, and the sun's declination should be obtained from the Nautical Almanac. The latitude of the place should be known within a tolerance of about 5 seconds.

OBSERVATION OF POLARIS FOR AZIMUTH ON GOVERNING SURVEYS

On governing surveys where great precision is required, the observation for azimuth is made with a six-inch transit theodolite, and the degree of accuracy required makes the observation somewhat more complex in all its details than the methods previously described. Some of the special precautions and refinements are mentioned below.

For accurate work a good solid set-up for the instrument is essential.

When it is intended to read the angle between two pointings on the horizontal circle, care should be taken, on turning the instrument in azimuth, to use the same forward or backward motion for each such pair. This tends to neutralize the effect of any yield in the instrument stand caused by that part of the impulse of revolution which passes down through the foot screws to the stand head.

Loose foot screws are a source of similar error. The pinch screws should always be tightened before finally adjusting the levelling screws, so that the latter turn stiffly in their nuts. Even though this may be less convenient to the observer in bringing quickly, and with nicety, the level bubbles to the desired position, it will eliminate with certainty one source of error.

The tangent and micrometer screws should always be turned so as to push against the counteracting spring, because, in turning in the opposite direction, the spring might fail to bring back the plate until some time in the interval between the observation and the reading of the drum.

The reference object for azimuth work should be, if possible, at such a distance that the telescope is at solar focus when the pointing is made on the reference object.

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* For a description of the Solar Prism Attachment see Astronomy Applied to Land Surveying by R. Roclofs, 1950, N.V. Wed. J. Ahrend & Zoon - Amsterdam, Holland.

In observing for azimuth on governing surveys the following program is recommended:

1. Level the instrument very carefully using the striding level for this purpose, so that the level correction may be small.
2. Point on the reference object and read the microscopes three times each on forward and backward graduations.
3. Point approximately on Polaris and place the striding level in position (zero of graduation to the right, or east). Point accurately on Polaris noting the time by sidereal watch. Read the striding level, reverse it, and read it again. Read the microscopes three times each on forward and backward graduations.
4. Reverse the telescope in altitude, turn the instrument 180° in azimuth, and repeat as in No.3. The striding level must, of course, be removed while the telescope is being transited.
5. Same as No. 2.

Such an observation, under favourable conditions, will give a result correct to within a few seconds. However, observations in the field are seldom taken under ideal conditions and it is recommended strongly that two or more observations be taken at a station whenever weather conditions will allow. This precaution should always be adopted when the bearing of the line is much in doubt; the range of results will then provide some criterion of the accuracy of observation.

It will be found convenient, in order to prevent mistakes, always to begin the observation with the same position of the instrument.

WATCH CORRECTION

The watch correction should be known with more than usual precision. In observing Polaris near upper or lower transit an error of one second of time corresponds, in the latitude of the western provinces, to an error in azimuth of about half a second of arc.

An observation for time should be taken either shortly before or shortly after every azimuth observation. The instrument should be carefully levelled and the observed transit corrected for azimuth error according to the formula $\Delta t = 4 \times \Delta a \cos h \sec \delta$, where Δt is the correction in seconds to the observed time, Δa the azimuth error in minutes of arc, and h and δ the altitude and declination of the star. The correction is added for all stars south of the zenith if the azimuth correction is plus and subtracted if minus.

The result of observations for time must always be entered in the form at the front of the record book of astronomical observations.

CORRECTION FOR STRIDING LEVEL

The striding level is graduated from zero at one end, continuously upwards to the other end. Representing by w and e the readings of the west or left and east or right extremities of the bubble respectively when the zero of the graduation is at the east or right end and by w' and e', the corresponding west and east readings after the level is reversed, that is to say, when the zero of the graduation is at the west or left end, d being the value of one division in seconds of arc, the level correction is:

$$\frac{d}{4}\left\{(w-w')+(e-e')\right\}\tan h$$

Tan h, the inclination factor for Polaris, is tabulated in the azimuth observation book.

The level correction is applied to the horizontal circle readings according to sign. The level vials are usually chambered and the length of the bubble should be adjusted to about twenty divisions prior to the observation.

The determination of the value of one division of the level in seconds of arc is ordinarily made by the National Research Council. If, however, the surveyor has no knowledge of his level value and wishes to determine it in the field, he may adopt the following method:

> The level is placed on the upper plate, parallel to the plane of revolution of the telescope, and a mark is set up in the direction of one of the foot screws and at a distance such that the telescope may be in solar focus. By turning the foot screw, the bubble is brought close to one end of its run. The telescope is pointed approximately on the mark and firmly clamped.
>
> A more careful pointing is now made with the movable thread of the eyepiece micrometer, and the readings of the micrometer and level are noted.
>
> The foot screw is then turned until the bubble is close to the other end of its run; the drum of the eyepiece micrometer is turned until the movable thread bisects the mark; and the micrometer and level readings are again noted. The difference of micrometer readings gives the angular displacement from which the value of one division of the level may be derived. The operation should be repeated several times. The level may be reversed end for end during the course of the determination if desired.
>
> Instead of a distant point, the pointings may be made on the telescope of a transit or level used as a collimator.

DETERMINATION OF THE VALUE OF ONE TURN OF THE MICROMETER

To reduce the micrometer readings to arc, the value of one turn is required. This is ordinarily determined for solar focus by the National Research Council. If, however, the surveyor has no knowledge of this value, he may determine it by methods described in standard text books on astronomy.

The following method will be found convenient:

> Set the movable wire of the micrometer close to one end of its run

and move the upper part of the instrument by means of the tangent screw until the movable wire bisects some distant object (solar focus) at the same level as the transit; read the micrometer once and the horizontal circle microscopes three times. Now bring the movable wire close to the other end of its run and again bisect the same object by means of the tangent screw, reading the micrometer and circle microscopes as before. The horizontal angle, as shown by the microscope readings, divided by the difference of micrometer turns gives the value of one turn of the micrometer.

The operation should be repeated a number of times and, in order to decrease the effect of periodic errors of the circle graduation, the instrument should be revolved, by means of the shifting head on the stand, to give readings on different parts of the circle.

The uniformity of the micrometer screw may be tested by measuring the value of one turn over different parts of the screw.

Another transit or a level may be used as a collimator and gives a better reference object than a distant point. Set up the collimator a few feet from the transit to be tested, so that the two telescopes are at the same level. Adjust both to solar focus, and point on the object glass of the transit. Looking now at the collimator through the telescope of the transit, the cross wires or points of the collimator telescope will be seen as at an infinite distance. These cross wires or points make an excellent reference object.

COMPUTATION FOR AZIMUTH OBSERVATION

When the above observation for azimuth has been taken with due attention to the special precautions, it can be reduced by the following formula:

$$\tan Z = -\frac{\tan P \sec L \sin t}{1 - \tan P \tan L \cos t}$$

where Z, P, L, t, are azimuth, polar distance, latitude and hour angle, respectively.*

Writing m for tan P tan L cos t the formula may be written

$$\tan Z = -\left(\frac{1}{1-m}\right)\tan P \sec L \sin t$$

Table XIII gives the values of $\log \frac{1}{1-m}$ tabulated with log m as argument. In using this table attention must be paid to the sign of m which is the same as that of cos t; when t lies between 0^h and 6^h, or 18^h and 24^h, m is positive and the half of the table as given on pages 150,

---

* The formula may be deduced as follows:

In the spherical triangle defined by the star, the zenith and the pole, the hour angle t is measured from upper culmination, and the azimuth Z is positive or negative according as the star is east or west of the meridian.

152 and 154 must be used; when t lies between 6^h and 18^h, m is negative and the half of the table as given on pages 151, 153 and 155 must be used.

Since m is always less than unity, $\frac{1}{1 - m}$ is always positive, and therefore tan Z is always of opposite sign to tan P sec L sin t. Hence when t is between 0^h and 12^h, tan Z is negative, indicating that Polaris is west of the meridian; and when t is between 12^h and 24^h, tan Z is positive, indicating that Polaris is east of the meridian. In the specimen observations (page 26), the suffix 'n' has been added to log $\frac{1}{1 - m}$ thus representing log $-\left(\frac{1}{1 - m}\right)$ in the above formula.

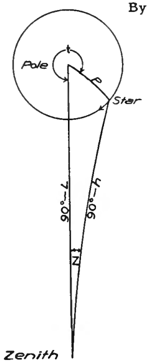
Denoting by a the angle which Polaris makes with the meridian east or west from north, then log a (in seconds) is obtained directly from log tan Z by the use of Table XII, and Polaris is east or west of the meridian according as a is positive or negative.

The logarithms of secant and tangent L are given in Tables IX and X for the north side of every section. For points outside the township system, the latitudes can usually be determined with sufficient accuracy from available maps.

A table giving the Right Ascension and log tan P for Polaris for every ten days, is pasted in each record book of astronomical observations sent out to surveyors.

The observations on pages 26 to 29 show the form of record and method of computation.

In the form, R.O. is for reference object; H.C.R. for horizontal circle reading; coll. for collimation; R.A. for right ascension;



By the ordinary formulae of spherical trigonometry

$$\frac{\sin Z}{\sin t} = -\frac{\sin P}{\cos h}$$

$$\cos Z = \frac{\cos P - \sin h \sin L}{\cos h \cos L}$$

$$\text{whence } \tan Z = -\frac{\sin P \cos L \sin t}{\cos P - \sin h \sin L}$$

Eliminating the altitude h by

$$\sin h = \cos P \sin L + \sin P \cos L \cos t$$

after reduction

$$\tan Z = -\frac{\sin t}{\cot P \cos L - \cos t \sin L}$$

which may also be written

$$\tan Z = -\frac{\tan P \sec L \sin t}{1 - \tan P \tan L \cos t}$$

and F. and B. for forward and backward readings of the microscopes.

The specimen observations are taken on a base line according to the program laid down.

The correction for run* of the microscopes in each case is deduced from the means of the forward and backward readings and applied to the forward reading.

In reducing observations taken on base lines, the convergence must be applied to the mean azimuth to reduce it to a bearing as required by the Manual. For observations taken on initial meridians the results may be left as azimuths, for convenience.

A correction in the direction of a survey line, found necessary from the azimuth observation, may be made most easily by offsetting the transit stations in the required direction perpendicular to the line. The amount of the offsets are obtained by multiplying the tangent of the deflection angle by the distances of the transit stations from the point of deflection.

With modern instruments in which the microscopes are automatically meaned, single entries only will be made in the record form under the headings, Microscope A, and Microscope B. For good results three readings should be made and entered for each pointing.

An azimuth observation less in accuracy than that described above may be obtained without a striding level. The program of observing is slightly altered to secure the best results. First sight Polaris approximately. Then bring the plate bubble perpendicular to the line of sight to accurate centre and make the pointing to the star. Next read the reference object, transit the telescope, and repeat the operation. The resulting azimuth, calculated by the method used in governing surveys, will have an accuracy dependent on the sensitivity of the plate bubble. If the calculations are made from the Astronomical Field Tables results

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* Let F = forward or apparent left reading

B = backward or apparent right reading

Then distance between readings $= 5' + F - B$

Error of run $= F - B$

$$\text{Correction to } F = -F \times \frac{F - B}{5' + F - B}$$

$$\text{Corrected reading} = F \times \frac{5'}{5' + F - B}$$

When $F - B$ is not larger than, say, ten seconds, this formula may be written in a more convenient form, without appreciable error. Thus,

$$\text{Corrected reading} = F - \frac{F}{5}\ (F - B)$$

AZIMUTH OBSERVATION

Place Sta. 68 - $\overset{\text{chs}}{61.52}$ W. of N.E. cor. sec. 34 tp. 84-1-5

R.O. Sta. 70-60.80 " " " " 33 " "

Date 12-7-11 Observer J. Smith D.L.S.

Position	Pointing No.	Horizontal Circle Readings											
		Reference Object						Polaris					
		Microscope A			Micro. B			Microscope A			Micro. B		
			F.	B.		F.	B.		F.	B.		F.	B.
Circle Right Drum Right	1	359°21′	39″	36″	22′	55″	58″	87°25′	07″	07″	26′	28″	30″
	2		36	37		56	58		08	07		26	32
	3		38	35		54	59		09	07		27	32
Mean		359°21′	37″·1		22′	56″·9		87° 25′ 08″·0			26′ 28″·2		
Circle Left Drum Left	1	179°22′	45″	48″	24′	11″	05″	267°23′	55″	60″	25′	17″	21″
	2		45	48		09	08		58	61		19	21
	3		46	48		11	06		59	60		18	22
Mean		179° 22′ 46″. 8			24′ 07″·0			267° 23′ 59″·7			25′ 18″.2		

	Circle Right	Circle Left	
Mean H.C.R. of Pol.	87° 25′ 48″	267° 24′ 39″	Mean watch time
Level correction	+ 5	+ 9	Watch corr.
Corrected H.C.R. of Pol.	87 25 53	267 24 48	Sidereal time
" H.C.R. of R.O.	359 22 17	179 23 27	R.A. of Polaris
Angle Pol. to R.O.	88 03 36 W	88 01 21 W	t in time
			t in arc
Pol. from collimation ... log.			Log tan P
One turn micrometer ... log.			Log tan & sec. L
Altitude Pol. .... log. sec.			Log cos & sin t
Sum			Sum
Pol. fr. coll. reduced to horiz'al			Log $-\frac{1}{1-m}$
Level correction			Log tan Z
Microm. angle Pol. fr. coll.			Log T
R.O. from collimation ....log.			Log a (sec's.)
One turn micrometer ....log.			Azimuth of Pol.
Altitude R.O. .... log. sec.			Angle Pol. to R.O.
Sum			Azimuth of R.O.
Microm. angle R.O. from coll.			Mean
Angle Pol. to R.O.			Convergence
			Bearing of R.O.
Direction of deflection		Amount.	

FOR GOVERNING SURVEYS

Instrument #112

One turn of micrometer 166".36

One division of striding level 4".0

Watch Time	Micrometer Readings		Level		
	Polaris	R.O.	W.	E.	Corrn.
$5^h\ 34^m\ 16^s$			25.7 6.4	8.1 24.0	+ 3.4 × 1.0 × 1.54
			+ 19.3	− 15.9	= + 5"
$5^h\ 43^m\ 46^s$			26.8 6.0	9.0 23.8	+ 6.0 × 1.0 × 1.54
			+ 20.8	− 14.8	= + 9"

Circle Right		Circle Left	
$5^h\ 34^m\ 16^s$ + 6 12		$5^h\ 43^m\ 46^s$ + 6 12	
5 40 28 1 27 08		5 49 58 1 27 08	
4 13 20 63° 20' 00"		4 22 50 65° 42' 30"	
$\bar{2}$.31083 0.17649 $\bar{1}$.65205	$\bar{2}$.31083 0.25622 $\bar{1}$.95116	$\bar{2}$.31083 0.17649 $\bar{1}$.61425	$\bar{2}$.31083 0.25622 $\bar{1}$.95974
$\bar{2}$.13937	$\bar{2}$.51821 0.00603 n	$\bar{2}$.10157	$\bar{2}$.52679 0.00552 n
	$\bar{2}$.52424 n 5.31426		$\bar{2}$.53231 n 5.31426
	3.83850 n		3.84657 n
	358° 05' 05" 88 03 36 W		358° 02' 56" 88 01 21 W
	270 01 29		270 01 35 270 01 32 − 19 270° 01' 13"

Place Line re-run from township corner

AZIMUTH OBSERVATION

Place Sta. 76 - 66.71 chs W. of N.E. cor. sec. 33 tp. 84-2-5

R.O. Sta. 74 - 74.10 " " " " 34 " "

Date 20-7-11 Observer J. Smith D.L.S.

Position	Pointing No.	Horizontal Circle Readings											
		Reference Object						Polaris					
		Microscope A			Micro. B			Microscope A			Micro. B		
			F.	B.		F.	B.		F.	B.		F.	B.
Circle Right Drum Right	1	359°09'	23"	23"	11'	04"	02"	270°04'	45"	47"	06'	09"	11"
	2		23	25		06	05		45	48		09	11
	3		21	25		05	02		45	50		10	12
Mean		359° 09' 24".0			11' 04".6			270° 04' 48".1			06' 09".7		
Circle Left Drum Left	1	179°10'	17"	15"	11'	47"	50"	90°09'	14"	18"	10'	43"	40"
	2		18	16		49	49		17	18		43	40
	3		17	17		49	50		14	18		43	41
Mean		179° 10' 17".2			11' 48".8			90° 09' 17".6			10' 42".6		

	Circle Right	Circle Left	
Mean H.C.R. of Pol.	270° 05' 29"	90° 10' 00"	Mean watch time
Level correction	+ 1	− 6	Watch corr.
Corrected H.C.R. of Pol.	270 05 30	90 09 54	Sidereal time
" H.C.R. of R.O.	359 10 14	179 11 03	R.A. of Polaris
Angle Pol. to R.O.	89 04 44 E	89 01 09 E	t in time
			t in arc
Pol. from collimation log.			Log tan P
One turn micrometer log.			Log tan & sec. L
Altitude Pol. log. sec.			Log cos & sin t
Sum			Sum
Pol. fr. coll. reduced to horiz'al			Log - $\frac{1}{1-m}$
Level correction			Log tan Z
Microm. angle Pol. fr. coll.			Log T
R.O. from collimation log.			Log a (sec's.)
One turn micrometer log.			Azimuth of Pol.
Altitude R.O. log. sec.			Angle Pol. to R.O.
Sum			Azimuth of R.O.
Microm. angle R.O. from coll.			Mean
Angle Pol. to R.O.			Convergence
			Bearing of R.O.
Direction of deflection		Amount. No correction	

FOR GOVERNING SURVEYS

Instrument # 511

One turn of micrometer 164.″07

One division of striding level 2.″6

Watch Time	Micrometer Readings		Level		
	Polaris	R. O.	W.	E.	Corrn.
15^h 14^m 20^s			34.1 13.6	14.0 33.5	+1.0×0.65 ×1.45
			+20.5	−19.5	= +1″
15^h 22^m 04^s			31.8 15.0	12.0 35.0	−6.2×0.65 ×1.45
			+16.8	−23.0	= −6″

Circle Right		Circle Left	
15^h 14^m 20^s − 3 15		15^h 22^m 04^s − 3 15	
15 11 05 1 27 17		15 18 49 1 27 17	
13 43 48 205° 57′ 00″		13 51 32 207° 53′ 00″	
$\bar{2}$.31077 0.17649 $\bar{1}$.95384 n	$\bar{2}$.31077 0.25622 $\bar{1}$.64106 n	$\bar{2}$.31077 0.17649 $\bar{1}$.94640 n	$\bar{2}$.31077 0.25622 $\bar{1}$.66994 n
$\bar{2}$.44110 n	$\bar{2}$.20805 n $\bar{1}$.98817 n	$\bar{2}$.43366 n	$\bar{2}$.23693 n $\bar{1}$.98837 n
	$\bar{2}$.19622 5.31439		$\bar{2}$.22530 5.31438
	3.51061		3.53968
	0° 54′ 00″ 89 04 44 E		0° 57′ 45″ 89 01 09 E
	89 58 44		89 58 54 89 58 49 + 1 05 89° 59′ 54″
Place			

will be less accurate because values are given to a tenth of a minute only and since errors may result in interpolation.

GENERAL REMARKS ON OBSERVING

The instrument should be firmly set up with sufficient clearance to permit the unrestricted movement of the observer, and it should be in good adjustment. In azimuth observation on governing surveys, a recorder is necessary to speed the operation and to read the watch at the instant of pointing on the star. The observation point should be protected from wind, and the transit from direct sunlight. When determining the solar focus, the reference object should be one-half mile or more distant and atmospheric conditions should be such that the air is not quivering. When possible a set should include at least three complete observations.

An observation for time should be made as near as possible to the time of observation. The necessity for having an accurate watch correction increases with the nearness of Polaris to the meridian.

CHAPTER II

DETERMINATION OF THE MAGNETIC MERIDIAN

Although the compass is not allowed for establishing lines of Canada lands surveys, it is employed for other purposes and a knowledge of the direction of the magnetic meridian or of the magnetic declination is useful. For the determination of this direction, transit theodolites are fitted with especially sensitive needles. As the observation can be made in a few minutes and with very little trouble, it is desired that all surveyors should observe whenever they can do so without inconvenience.

The observation and the recording form are arranged for the determination of the azimuth of the magnetic needle instead of the magnetic declination. The arrangement is made for the sake of simplicity in observing and recording, the bearing in question being, subject to instrumental corrections, the angle read on the horizontal circle of the transit. Moreover, it is not liable to errors of sign, as in adding or subtracting the declination.

DIRECTIONS FOR OBSERVING

1. Place the instrument on a survey line, and after adjustment, set the vernier to read the bearing of the line.

2. Release the lower clamp, direct the telescope on the line, and fasten the lower clamp.

3. Release the vernier clamp, and turn the vernier plate until the north end of the magnetic needle observed with a magnifying glass, is seen exactly opposite the zero mark. Tap the trough lightly with the pencil, or preferably rit the milled part of one of the footscrews with the finger nail, to be sure that the needle has taken the position of rest. Note the reading of the horizontal circle. Take several readings by repeating the operation.

4. Repeat operation No. 3 for the south end of the needle.

5. Enter in the notes the place of observation, date, hour of the day, kind of time used, nature of the weather and any other remarks deemed necessary. It is important to record auroras occurring within 24 hours of the time of observation.

GENERAL REMARKS

For saving trouble and calculations, it is suggested that observations be made on any line of which the azimuth is known.

The direction of the magnetic needle is subject to a daily fluctuation called the diurnal variation. During the greater part of the night the direction is not far from normal. In the early morning, the north end of the needle in Canada moves toward the east, reaching its maximum deflection about 7 or 8 a. m. The motion is now reversed, the north end travelling westwards, and crossing the normal direction about 10 or 11 a. m. The extreme western position is reached in the afternoon and then the needle comes back to its normal position at some time after 5 or 6 p. m. This march is subject to wide variations during magnetic storms. The magnitude of the diurnal variation is not constant. In the inhabited parts of Canada, it may exceed 20 minutes. Observations at both eastern and western elongations of the needle on the same day, that is between 7 and 8 a. m. and between 1 and 2 p. m. give the best results, and it is desirable that when convenient they may be taken then. This gives not only the best value for the declination, but also the diurnal variation which it is most useful to know. Failing this, however, the best time to observe is after 5 p. m., when the needle is about in its normal position. It is true that the normal position is crossed generally between 10 and 11 a. m., but the motion being very rapid and the time of crossing uncertain, the afternoon observation is preferable.

Usually when the instruments are sent out from the office the magnetic needle is balanced for Ottawa and the index correction known. If at any time the needle should require rebalancing, the surveyor should proceed as follows:

> Raise the needle with the lifter and remove the brass cover. This cover is secured to the trough by four screws, two on each side; when these screws are removed the cover may be lifted off. Now remove the end cover glasses. To do this scrape off the white lead putty around the edges, slide the cover glasses toward the centre and lift them out. The needle may now be taken out of the trough and the counterweight shifted. Then the lifter being still raised, place the needle upon it and lower the lifter gently. If the needle is not yet balanced repeat the operation until a satisfactory balance is obtained. A carefully balanced needle should give no parallax in reading.

The steel pivot on which the needle swings during observations is made of hard steel shaped to a very sharp point. At the centre of the needle a cupped piece of agate is inserted. Although the needle is made as light as possible, the actual intensity of the pressure between the pivot and agate is probably many tons per square inch, and it is not surprising that in the majority of cases sluggishness in the needle is traceable to a damaged jewel or pivot. Therefore great care must be observed in lowering the needle very gently on the pivot. On no account should the compass be carried with the needle resting on its pivot.

In taking the needle out of the trough whether to rebalance the needle or to clean the agate, care should be taken to see that it is put back in its proper position. If replaced in the reverse position the index correction would be altered. For this reason, to safeguard against error, the position of the compass, whether "compass west" or "compass east" should be entered in the remarks after each observation when observing.

If the needle is sluggish, the observation cannot be accurate. The sluggishness is generally due to a dull pivot or a scratched cap. To keep both in proper condition, the needle must always be lowered gently on its pivot and never be allowed to play, except when actually in use.

There are instances of the polarity of the needle being reversed by transporting an instrument on an electric car. It is difficult to conceive that a needle may be brought into such an intense magnetic field as that of an electric car without its magnetism being affected in some way; therefore, it is preferable to avoid this mode of transportation.

The place of observation must be at least three or four hundred yards away from wires carrying direct electric current. There must be no iron near the instrument. The observer must scrutinize his clothing and make sure that he has no iron or nickel on his person. Iron is found in buttons, as wire in hat brims, in some forms of neckties, in watches, chains and other articles of jewellery. The pivot in folding reading glasses is frequently made of iron. In case of doubt, the object may be tried close to the compass, measuring the distance at which an appreciable deflection is first produced. If the object is not brought closer than fifteen or twenty times this distance, the effect on the needle is negligible in observations of this kind.

The needle may be deflected by static electricity developed in cleaning the glass cover of the compass trough or the rubber frame of the reading glass. This electricity is dissipated by breathing on the glass or rubber frame.

When the telescope points to magnetic north, the needle should, if the instrument were accurately constructed, be exactly opposite its zero mark, but it seldom is. The deviation of the needle from the zero mark is the magnetic index correction; it is positive or + when the north end of the needle is to the left or west of the zero mark; when on the right or east, it is negative or −.

With the needle opposite the zero mark, the telescope points in a direction which, in the following explanation, is called "compass north." To bring the telescope into the direction of the magnetic north, it must, if the index correction is positive, be turned to the right by an angle equal to the correction - hence the rule that the index correction is to be algebraically added to the azimuth of compass north in order to obtain the azimuth of magnetic north (azimuth reckoned from 0° to 360°). Inv rsely, the index correction must be algebraically subtracted from the azimuth of magnetic north, such for instance as is taken from a magnetic map, in order to obtain the azimuth of compass north.

The index correction is ascertained by comparison with a standard unifilar magnetometer at the Dominion Observatory. When possible, it is well to have it determined both at the beginning and at the end of a survey.

EXPLANATION OF SPECIMEN OBSERVATION

(a) H. C. R. of compass north.

This is the average of the mean north and south end readings. The transit was adjusted to read correctly the bearing of the survey line, so that the horizontal circle reading of compass north is the

SPECIMEN OBSERVATION

OBSERVATION FOR MAGNETIC DECLINATION

Date *19th July, 1908* Observer *G. J. Lonergan, D.L.S.*

Place *40* Chs. *W.* of the *N. E.* Cor. of Sec. *33*

Tp. *49* Rge. *20* W. of *4th* Mer.

Time *7.15 p.m.* Instrument No. *2216*

Bearing of reference line *89° 59′*

H.C.R. FOR DIRECTION OF MAGNETIC NEEDLE

NORTH END			SOUTH END	
(1)	*27°*	*15′*	*27°*	*17′*
(2)		*11*		*16*
(3)		*12*		*10*
(4)		*11*		*10*
(5)		*10*		*12*
Mean of North End *27° 11′.8*			Mean of South End *27° 13′.0*	

(a) H.C.R. of compass north *27° 12′.4*

(b) Cor. for convergence *− 00.6*

(c) Azimuth of compass north *27 11.8*

(d) Index correction *− 05.8*

(e) Azimuth of magnetic north *27° 06′*

REMARKS

A few clouds — Windy.

No aurora.

Circle E — compass W.

Mean local time

bearing of compass north. If the transit had not been so adjusted a correction to this reading would have been required.

(b) Correction for convergence.

The correction for convergence is applied in order to reduce the bearing read on the horizontal circle to an azimuth. The value of the correction is taken from the diagram in the Astronomical Field Tables. It is added when the point of observation is to the east of the reference meridian and subtracted if to the west. The rule given in the Manual to convert an azimuth to a bearing is here reversed, the object in this case being to convert a bearing to an azimuth.

(c) Azimuth of compass north.

The bearing has now been reduced to an azimuth.

(d) Index correction.

In the example given, the index correction being negative is subtracted from the azimuth of compass north to obtain the azimuth of magnetic north. If the index correction were positive, it would be added to the azimuth of compass north. The index correction is furnished with each instrument after comparison with the unifilar magnetometer.

(e) Azimuth of magnetic north.

The azimuth of magnetic north is the angle formed by the astronomical and magnetic meridians.

SETTING A TRANSIT BY MEANS OF THE COMPASS

In connection with surveys of Canada lands, the most frequent use of the compass is for checking the courses of a traverse or for setting up the transit to read azimuths.

In the first case, it is sufficient to make sure that there is no abnormal change in the reading of the compass north: any sudden change indicates a probable mistake in some of the last courses.

The second case arises when it is desired to observe the Pole star in day time at a place where there is no line of known azimuth. The problem consists in setting up the transit so that it shall read azimuths. If the surveyor has already ascertained the azimuth of compass north with his instrument, he merely sets his vernier to read this azimuth, releases the lower clamp, turns the whole instrument till the needle is exactly opposite the zero mark, fastens the lower clamp and releases the vernier clamp. With the instrument (No.2216) used for the specimen observation and anywhere near the place where the observation was taken, the vernier would be set to read 27°11'.8 or rather 27°12'.

It may be, however, that the surveyor has not ascertained the azimuth of compass north with his own instrument and has to resort to the azimuth of magnetic north taken from a map or determined by another surveyor. Then the surveyor must, from the azimuth of magnetic north, deduce the azimuth of compass north by applying the index correction of his own instrument after changing the sign. Starting with 27°06!0 for azimuth of magnetic north in the case already cited, and the index correction being—5.8, the surveyor would add 5.8 to 27°06!0, which would give him 27°11!8 for the azimuth of compass north. He would then proceed as already explained.

All these corrections, it may be observed, are generally small and in practice are frequently disregarded.

The above remarks apply particularly to instruments supplied with the trough pattern of compass.

COMPASS OF COOKE TRANSIT

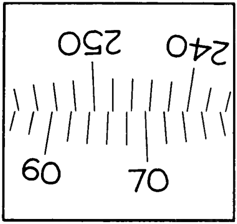
Some Cooke instruments are fitted with a compass of telescopic pattern which may be briefly described. The outer shell of the compass is a brass tube on one end of which an ordinary Ramsden eyepiece is attached. There is a glass diaphragm on which are etched two close parallel vertical lines. The needle is of the regular edge bar type with one end bent up at right angles and ground to a very fine edge. This end swings sufficiently close to the glass diaphragm to give a good definition of the bent up edge of the needle when the eyepiece is focussed on the lines of the diaphragm. A pointing is made by bisecting the space between the two vertical lines with the needle. Only one end of the needle can of course be read. It is found however that this is more than compensated for by the increased accuracy of the readings. The needle lifter is operated by means of a milled head screw at the end of the compass remote from the eyepiece. The method of fastening this compass to the standard is an improvement on that used with the trough compass and assures better permanency of the index correction.

To rebalance the needle or clean the agate loosen the three small central screws and slide the tube apart. Unscrew the large central screw which ordinarily serves to keep the needle on the pivot. The needle may now be removed for balancing or cleaning. The same precautions and delicacy of handling must be observed as with the trough pattern of compass.

THE WILD DOUBLE IMAGE PRISM COMPASS

Because the Wild transit has a steel centre a separate compass has been made available which may be attached to the tripod when the transit is removed. The attachment has a small telescope for sighting the reference object, a clamp and tangent screw for horizontal movement, and a ball and socket levelling device with a circular plate bubble.

The compass circle is graduated in divisions of two degrees of arc. Both sides of the circle are visible through the viewer in the relation shown below. The compass may be read to the nearest degree, and tenths of a degree may be estimated.



Reading 67.3 degrees.

To read the compass the first upright figure on the left is the tens of degrees (60). The number of full divisions to the right from this division to the inverted image of its supplementary angular value (60° + 180° = 240°) gives the digits of the reading (7). The tenths of a degree may be estimated more accurately in the centre of the image (0.3). The full reading of 67.3 degrees is the compass azimuth of the reference object. Ten readings should be taken at each observation point. The azimuth of compass north is obtained by subtracting the compass azimuth from the astronomic azimuth, or the astronomic azimuth plus 360 degrees. The index correction must then be applied to obtain the azimuth of magnetic north.

The compass may be balanced by loosening, and moving radially, the balancing screws placed on the face of the circle. The same care must be exercised to protect the steel pivot as with other compasses.

CHAPTER III

INSTRUMENTS

Survey instruments are no longer specially designed for the requirements of Canadian lands surveys. This chapter is therefore confined to certain general observations on the care of instruments likely to be used.

TRANSIT THEODOLITE FOR GOVERNING SURVEYS

For the survey of governing lines no entirely satisfactory replacement has yet been developed for the six-inch micrometer transit theodolite of 1912. A full description of it is given in Topographical Survey Bulletin No. 34.

These transits are no longer made and, as those still in use become worn, the features most likely to give trouble are the footscrews and the horizontal circle clamp. Wear in these parts may introduce sighting errors when the elevation of the telescope is changed. A check may be made by pressing the telescope sidewise with the finger. The telescope should spring back to the original sight line when the pressure is released. Should an appreciable error be revealed, its source can often be found by pressing in turn the tribach, clamp, standard, etc., and noticing the effect. If the footscrews show looseness, they can sometimes be tightened by more vigorous action on the small binding screws. Otherwise they should be returned to the shop for repair.

Another test, which is particularly useful in the case of clamp trouble, is to sight the telescope on a point and then move it up and down in altitude once or twice, afterwards checking to see if the point is still on the vertical crosswire. If the error reverses after the horizontal tangent screw has been used in opposite senses, it indicates a worn centre pivot, tangent=screw, or clamp. In such cases the instrument should be sent to a competent instrument maker for repair.

Care should be taken that the micrometer screw drum spindles do not become slightly bent causing the drum to touch the index. Serious errors in angle measurement will be introduced if this occurs.

"OPTICAL" THEODOLITES

Many "optical" theodolites are now on the market, all more or less based on the designs made for the Zeiss firm by Wild. These instruments have more factory adjustments and fewer field ones than in the case of the older types. Striding levels for these instruments have not yet been sufficiently refined for accurate azimuth observation; the best available has a value of about five seconds of arc per division. The length of the bubble cannot be adjusted.

The "optical" theodolites are characterized by accurately graduated circles, cut on glass, with a device for optically bringing into the field of the micrometer microscope the images of two diametrically opposite points on the circle, or, in some more recent designs, cut on two circles simultaneously. The various types of micrometer used with this eccentricity-compensating device permit very rapid circle reading with little or no eyestrain.

Due to the complicated nature of the optical trains inside these instruments, and the use of factory adjustments, totally enclosed bearings, etc., very little can be done in the field to effect repairs after damage or other trouble. On no account should an attempt be made by the surveyor to dissect any part of an optical theodolite unless he has had previous experience in taking it apart under office conditions. Unless the function of each screw is known, there is grave risk of seriously injuring the instrument, or losing some of the small parts.

INSTRUMENTS FOR USE ON WINTER SURVEYS

Certain greases, originally developed for military purposes and suitable for use over a wide temperature range, are now being used in instruments likely to be required on winter surveys. Before lubricating an instrument with low-temperature grease, all trace of the old lubricant must be removed from every surface by means of ether, or other solvent. All micrometer screws and nuts must be so cleaned, as otherwise a film of the old grease may remain and cause binding at very low temperatures. If a cold chamber is available, the instrument, after being winterized, should be left in it for several hours and all movements checked before removal.

Instruments which have been subjected to extreme cold should never be quickly exposed to warmth because this results in the condensation of moisture which may be particularly harmful in "optical" theodolites having steel parts. If an instrument has to be transferred suddenly from cold to heat, the best course is to pack it first in its box or other fairly air-tight container, and leave it for several hours before removal. In this way the instrument will reach room temperature without an excessive amount of saturated air coming into contact with it.

Most motions of an instrument, even when winterized, will be stiffer at low temperatures. In some examples of the current models (1951) of the Wild theodolite, stiffness at sub-zero points occurs to such a degree, due to differential contraction between the trunnions and their bearings, as to render the instrument unusable.

When an instrument shows excessive stiffness at any temperature, on no account should force be used, as serious damage may result. The only safe treatment is to dismantle the parts carefully, if facilities are available, and find the cause of the trouble.

GENERAL

Extreme care should always be exercised in handling both transits and levels. Sudden jars may break delicate parts or disturb fine adjustments. No weight should be placed on an instrument box whether an instrument is within it or not and the instrument boxes should always be kept in a safe place. It is preferable to box a transit in moving from one instrument station to another. Otherwise the centre may be strained or the instrument may be damaged through a fall or by parts becoming entangled in tree limbs.

The instruments should be kept dry, clean, and freshly oiled at all times using a fine watch oil. The interval between overhauls should not exceed two years. Lenses should be cleaned with a brush or very lightly rubbed with a clean cloth or tissue to prevent scratching the surface. Clamps should never be excessively tight. In boxing an instrument they should never be tightened more than just sufficient to prevent movement. Tripod head screws should be loosened when the instrument is not in use.

In winter operations the transitman should avoid breathing on the eyepieces of verniers. If the object glass becomes frosted on the inside the frost may sometimes be removed by pointing the telescope towards the sun.

In camp, instruments and instrument boxes must always be kept in a safe place and should never be handled except by, or under the direction of, a competent instrument man.

SIDEREAL WATCH

The sidereal watch is an 18-size 19-jewel movement in an open face nickel case. The dial is divided into twenty-four hours.

Before being accepted, each watch is tested at the Dominion Observatory to ascertain if the adjustments have been made with the necessary accuracy.

No timepiece will give good service without reasonable care. Great changes of temperature must be avoided; this can be accomplished by carrying it constantly in an inner pocket where it is maintained at an even temperature by the heat of the body. The pocket must be clean and reserved exclusively for the watch which should be inserted always in the same position. It is a good plan, as a protection against dust, to keep the watch in a tight-fitting case of chamois skin. If exposed to a very low temperature, it may not only stop, but be injured permanently. It must be kept away from electric motors or dynamos, which might magnetize the balance. Winding every day as nearly as possible at the same hour is essential; this is to be done by turning the crown or the key and not by turning the watch. A watch must be cleaned and oiled at least every fourth year. A watch, particularly of a higher grade, may be ruined easily by an incompetent workman; too much care cannot be exercised in selecting the man to whom it is entrusted. When repairs are required, it is best to have them made through the head office.

STEEL TAPES

The steel tapes most commonly used are 0.″25 wide by 0.″02 thick and in lengths of 400 links, 500 links, or 300 feet. Each tape has its correct length in terms of the Dominion measure of length determined by the National Research Council on the flat (fully supported), under a tension of twenty pounds, and at a temperature of 68°F. The coefficient of thermal expansion is about 0.000,006 per 1°F., so that the correction for a 10°F. change in temperature is about 0.006 feet per 100 feet. The weight per 100 feet is 1.68 pounds. Due to variation in cross section the tapes actually in use vary from 1.3 to 1.7 pounds per 100 feet. Young's modulus of elasticity, E, is 30,000,000 per square inch. Cards giving temperature corrections in tabulated form are available at head office. Sag (catenary) and stretch corrections are calculated from the above data.

The formulae are:

$$\text{Stretch} = \frac{L \times (P - P_{\bullet})}{A \times E}$$

Where L is the original length of the tape section, P the tension applied in pounds, $P_{\bullet}$ the tension applied in standardizing the tape (20 lbs.), A the area of the cross section of the tape in square inches (0."25 x 0."02) and E the modulus of elasticity of the tape (30,000,000).

$$\text{Correction for sag} = \frac{W^2 L}{24\ P^2}$$

Where W = weight of length of tape section in pounds, L the length of the tape section, and P the tension applied in pounds.

Measurements made with steel tapes are subject to correction for temperature, slope, stretch, and sag. The accuracy required in a survey will determine whether any or all of the corrections should be applied. In governing surveys all four corrections should be used.

Steel tapes require considerable care in the field. When not in use they should either be reeled up or put in a safe place to one side of the survey line. To avoid breaks, tapes should never be jerked for straightening purposes, and the chainman should always be on the alert for kinks. At frequent intervals they should be cleaned with an oily rag. In the vicinity of salt water this should be done every evening to prevent pitting. At the close of the season, they should be cleaned thoroughly and fairly heavily greased with vaseline. Repair kits for breakages should always be available.

STADIA RODS

Stadia rods are fifteen feet in length and three inches wide. They fold in the middle. They are graduated in feet and tenths. There are no figures on the rod, the colour scheme being so arranged that they are unnecessary. A folding level is attached to the back of the rod as an aid for holding it vertical.

The stadia wires of the transit theodolite are set by the makers in the supposed ratio of 1:100 between outside wires and 1:200 between middle and outer wires. As a matter of fact, however, they are rarely in this exact ratio. The true ratios are furnished for each diaphragm. These ratios are used for calculating a table of the corrections to be applied to the distances read on the rod. If the surveyor should be without the true stadia constants, he can prepare his table of corrections by chaining a base on level ground and measuring with the stadia the distance of a number of points on the base; the difference between the two measurements gives the correction for each distance. The table is completed by interpolation. The measurement must be made when the air is quite steady and the conditions favourable.

With modern internal focussing instruments the formula, $k\ r\ \cos^2 V + (f + c) \cos V$, becomes $k\ r\ \cos^2 V$, since $f + c$ may be neglected and the formula for the vertical component becomes $k\ r\ \cos V \sin V$, or $1/2\ k\ r\ \sin 2V$, where k is the stadia constant, r the rod intercept, and V the angle of inclination of the sight.

In making stadia measurements the stadia rod must be held vertical by centering the cross bubbles in the level attached to the rear of the rod. The bubbles may be adjusted by erecting the rod in a vertical position by means of a long plumb line and centering the bubbles by the adjusting screws. When the rod is being held for sighting it should be turned to catch as much sunlight as possible and yet present sufficient surface to the instrument man on which to make the reading. For best results, the lengths of measurements should not exceed 1,000 feet; the full intercept between the outside stadia lines should be read, and then checked by the summation of the two one-half intercepts; the line of sight through the lower stadia line should always clear the intervening ground by at least three feet.

CLINOMETER

The clinometer, or abney level, is used to measure the slope of the tape. In governing surveys, both front and rear chainman should measure and record the slope. All slopes greater than 7 degrees should be measured with a transit.

CHAPTER IV

PROBLEMS CONNECTED WITH THE SYSTEM OF SURVEY

CORRECTION FOR HEIGHT ABOVE SEA-LEVEL

The tables have been calculated from the dimensions of the earth's surface at sea-level.

The township sides are actually measured on surfaces elevated above sea-level, and therefore the differences of latitude and longitude calculated from the tables are greater than those actually covered by the township sides.

Any measured distance may be reduced to sea-level by subtracting the correction $\frac{l}{S}x$, x being the distance, l the elevation above sea-level, and S the radius of curvature of the line under consideration.

In general N (see Table I) can be used instead of S.

Base lines when the system of survey is exactly followed are established by direct measurement from the 49th parallel, northward along an initial meridian.

Hence the latitude of a base line should be less than that given in the table by $(L - 49°)\frac{l}{R}$, where l is the mean elevation of the initial meridian between the 49th parallel and the base under consideration.

Many base lines, however, have been established, not by this direct measurement, but by the survey of township meridians from other bases. If the actual latitudes of these base lines are required, account must be taken of the elevations of all the north and south lines through which the connection with the 49th parallel has been made. It is obvious, however, that the average elevation of the country above the sea will give a sufficiently accurate result, since the small errors due to difference of elevation are masked by errors of survey.

On the base lines the effect of elevation above sea-level is to decrease the difference of longitude covered by one range, and this must be allowed for in establishing an initial meridian by means of chainage along a base line or in estimating the accuracy of measurement of a base line by its closing on an initial meridian, since the initial meridians, except the first, have been placed approximately on even degrees of longitude (every fourth degree). The longitude covered by one range at an elevation l, may be obtained by multiplying the differences of longitude given in Tables III and IV by $(1 - \frac{l}{N})$.

The correction for elevation above sea-level is, in latitude 51°, 0.00382 chains for one mile distance at an elevation of 1,000 feet, and varies directly as the elevation and distance. It changes somewhat with the latitude, but slightly, and the correction in any particular case may be taken as the same as that for latitude 51°. If extreme accuracy be required, the formula given above, $\frac{l}{S}x$, may be used.

The error in the length of township chords of course involves an error in deflection angles and azimuths, but this is too small to be appreciable.

LATITUDES AND LONGITUDES OF POINTS IN THE SYSTEM

By "points in the system" is meant the corners of specified sections, or points referred to them by connecting lines. In the latter case the lines, if short, may be reduced to latitude and longitude by means of "latitude and departure" from a traverse table, and by using Table XI.

Thus the problem is reduced to the determination of the latitude and longitude of any section corner.

LATITUDE

The latitude of a section corner can be taken directly from Table IX and Table X.

Since the section corners are presumed to be at a distance of even sections from the north and south boundaries of the township, being established by survey from those boundaries, the latitude found as above must, when the section corner is not on the meridian outline of the township, be increased by the correction given by Table XI.

In the first system the sections are not measured on meridians from the north or south boundary of the township, but on lines parallel to the eastern boundary of the township. Hence, theoretically, the difference of latitude between the given corner and the township outline should be decreased in the ratio of cosine azimuth of the section line to unity; but this correction is insignificant.

The correction for sea-level may also be applied.

LONGITUDE, THIRD SYSTEM

In the second and third systems, the section lines are true meridians from the base line north and south two townships. Hence the longitude of a section corner is the same as that of the corresponding corner on the base line from which the township has been surveyed.

Then if dM be the longitude covered by one range on that base line, and if n be the number of the range in which the section lies, m the number of sections lying between the given section and the eastern boundary of the township, the number of ranges which intervene between the initial meridian and the eastern boundary of the given section is $n-1+\frac{m}{6}$ and the difference in longitude between it and the initial meridian is $(n-1+\frac{m}{6})dM$. This added to the longitude of the initial meridian gives the longitude of the eastern boundary of the section.

The longitude of the Principal or First meridian is $97^\circ 27' 28''.4$.

The longitudes of the Second, Third, Fourth, etc., meridians are 102°, 106°, 110°, etc., subject to certain errors of survey, which cannot be discussed at present.

The difference of longitude should be corrected for height above sea-level if precision is required. This can be done by multiplying it by $(1 - \frac{h}{N})$.

For example:

The NE corner of sec.16, tp.23, r.17, W. of the Fourth meridian (third system of survey). Here n = 17, m = 3, and the township is surveyed from the 7th base, for which we find from Table IV, $dM = 8'\,22''.411 = 502''.411$. Therefore longitude of the section line

$$= 110° + (502''.411 \times 16\ {}^{3}\!/_{6}) = 112°18'\,09''.78.$$

The NE corner of sec. 16 is in approximately the same latitude as the NE corner of Sec. 13, and is 3 sections distant from the bounding meridian of the township.

Latitude of NE cor. sec. 13 tp. 23 (Table X)	50°57' 56".05
Correction for 3 sections (Table XI)......	0".07
Latitude of NE cor. sec. 16 tp. 23.........	50°57' 56".12

LONGITUDE, FIRST SYSTEM

In the first system the procedure for the longitude is a little different. The section lines are drawn parallel to the east side of the township, so that the difference of longitude between the section line and the east boundary of the township is not the same as on the base line, but is equal to the actual distance from the boundary of the township divided by P sin 1", P sin 1" being taken from Table I for the actual latitude of the section post. Thus using the same notation as before

difference of longitude from initial meridian

$$= (n-1)dM + \frac{81.50\,m}{P \sin 1''}$$

dM being taken from Table III (1st system) for the governing base line, or it may be calculated by the equivalent formula difference of longitude

$$= \left(n - 1 + \frac{m}{6}\right)dM + \frac{Q}{P \sin 1''}$$

where $Q = 2m(40-w)$, w being the width of quarter sections as taken from the last column of Table IX.

LONGITUDE, SECOND AND FOURTH SYSTEMS

Longitudes in the second system are calculated in the same way as those in the third, taking dM from Table III instead of Table IV. In the fourth system the process is the same as for the third system, and the same table is used - Table IV.

EFFECT OF ERRORS OF SURVEY

An error in the latitude of the base line, or an error in the longitude of the initial meridian, of course increases or decreases by the amount of error in the latitude or longitude of the section corner. Similarly, a chainage error on the base line affects the longitude directly. In the computation all known errors of this kind must be allowed for.

An error in the latitude of the base line also affects the longitude covered by 486 chains (or 489 chains) measured along the base line, since 486 chains covers a greater longitude if the base line be moved north. The manner in which the effect of an error of this kind may be estimated is shown in the following example.

> Suppose the 6th base line (third system) to be placed 10 chains too far north, we find from Table IV
>
> dM for 6th base line = 498″.662
> dM for 6th correction line = 500″.527

The 6th correction line is two townships, i.e. 966 chains north of the 6th base line, and the difference in dM for these lines is 1″.865. Therefore, dM for the actual position of the 6th base line, 10 chains north of its theoretical position, is

$$498''.662 + 1''.865 \times \frac{10}{966} = 498''.681$$

The correction, in the case supposed, to dM for one range is 0″.019, and in 29 ranges (about the distance apart of two initial meridians) it amounts to 0″.019 x 29 = 0″.55, or 54 links.

GIVEN THE LATITUDE AND LONGITUDE OF A POINT, TO FIND ITS POSITION WITH REGARD TO THE SURVEY SYSTEM, i.e. to find in what section it is, and the township and range, and its distance from the NE corner of the section.

SECOND, THIRD AND FOURTH SYSTEMS

This is the converse of the preceding problem. The first step is to find, from Table IX or X, the latitude of the section line next north of the given latitude. The difference between these two latitudes is reduced to chains by Table I. This gives the distance (x) in chains to be measured from the point to find the north boundary of the section. For great accuracy the small corrections for altitude and from Table XI may be applied to x.

The number of sections by which the section line is north of the southern boundary of the township in which it lies is to be noted. Call this number a, and the number of the township t.

We also know the number of the nearest base line, i.e., the base line on which depends the survey of township t. From Table IV we take out dM for this base line.

From the given longitude of the point subtract the longitude of the initial meridian. Divide the difference by dM, with quotient n and remainder r. Divide r by $\frac{dM}{6}$ with quotient b and remainder s. Then s, reduced from seconds of longitude to chains by Table I, with argument, latitude of the given point, gives the distance (y) to be measured east from the point to find the eastern line of the section.

We now know that the given point is x chains south and y chains west of the north-east corner of some section in township No. t and range No.(n + 1) west of the initial meridian; and also that the northern boundary of the section is a sections north of the southern boundary of the township, and that the eastern boundary is b sections west of the eastern boundary of the township.

It is now easy by means of a skeleton township diagram to determine the number of the section, e.g., if a = 5, b = 3, the section is 28.

Without a township diagram, the section number can be found from the formula

$$\text{No. of section} = \tfrac{1}{2}\ \{12a - 5 \pm (2b-5)\}$$

The upper sign is taken when a is odd, and the lower when a is even. These two rules are comprised in the general formula

$$\text{No. of section} = \tfrac{1}{2}\ \{(12a-5) - (-1)^a(2b-5)\}$$

The calculation for the second system is the same as above, using the proper tables for that system. It is also the same for the fourth system.

In this manner have been computed the positions of a great many section corners in British Columbia (fourth system of survey) with reference to points along the line of the Canadian Pacific Railway, the latitudes and longitudes of these points having been first determined by a traverse survey.

FIRST SYSTEM OF SURVEY

The procedure in this system is the same as above, except that the total difference of longitude from the eastern boundary of the township (instead of the nearest section line) must be reduced to chains, and from the distance in chains must be subtracted the nearest multiple of 81.50.

FRACTIONAL TOWNSHIP OR RANGE BETWEEN PARTS OF THE COUNTRY SURVEYED UNDER DIFFERENT SYSTEMS OF SURVEY

Townships of the first and second systems adjoin each other without overlap or deficiency, since the townships in these two systems are of the same dimensions. Similarly of the third and fourth systems.

But where townships surveyed under the latter systems abut on townships of the first or second system, a fractional township or range occurs. It is only necessary to consider the case of the third system abutting on the first or second, since the fourth does not occur in juxtaposition with these latter systems.

FRACTIONAL TOWNSHIP

Townships of the third system are 6 chains shorter, measured north and south than the others. The townships in both cases are measured north from the 49th parallel, and hence the third system falls short of the other by 6 chains for each township, and the northern boundary of a township of the third system is therefore south of the northern boundary of the same township of the first or second system by 6 chains multiplied by the number of the township.

Thus the 5th correction line (tp. 18), as surveyed under the third system, is 6 x 18 = 108 chains south of its position under the second system. For twelve ranges west of the Second meridian, the territory from the 5th correction line northward to the 8th correction line was surveyed under the second system, while the country south of the former line has been surveyed under the third system. There is therefore an additional township (measuring 108 chains from north to south) lying between township 18 of the third system and township 19 of the second system. (This fractional township is called township 19A, and is subdivided according to the third system. See Manual of Surveys.)

FRACTIONAL RANGE

Townships of the third system are 3 chains narrower (measured east and west along the base line) than those of the first and second systems. The overlap of the latter systems over the third, however, is not equal to 3 chains multiplied by the number of ranges, but exceeds this, since the widths are laid off along base lines which lie in different latitudes, and hence the convergence of meridians comes into play.

The readiest method of calculating this overlap is as follows:

Let dM_1 be the longitude covered by one range of the base line in the first or second system as found from Table III.

Let dM be the same quantity for the base line of the third system (from Table IV)

Then $dM_1 - dM$ is the difference of the longitude between the exterior meridians of range one, as surveyed under the two systems.

The difference of longitude at the eastern boundary of the nth range will be

$$(n - 1)\,(dM_1 - dM)$$

This reduced to chains is

$$(n - 1)\,(dM_1 - dM)\,P \sin 1''$$

$P \sin 1''$ being taken from the proper table for the latitude of the base or section line on which the overlap is required.

FIRST EXAMPLE

The meridian outline between ranges 12 and 13, west of the Second meridian, from township 19 to township 22, inclusive, is the western boundary of a tract of country surveyed under the second system of survey. Required: the width of range 13, as surveyed under the third system, on the northern boundaries of townships 19, 20, 21 and 22.

The base line on which this meridian outline is based is th
6th base line, or northern boundary of township 20.

From Table III, dM_1 = 8' 21."972
" " IV, dM = 8' 18."662
whence $dM_1 - dM$ = 3."310

and at the eastern boundary of the thirteenth range, the difference of longitude is 3.310 x 12 = 39."72.

We have then for the northern boundary of township 19 (third system):

Log 39.72 = 1.5990092
Table IV, Log P sin 1" = 9.9896352
1.5886444
Nat. number = 38.783

For the northern boundary of township 20:

Log 39.72 = 1.5990092
Log P sin 1" = 9.9888297
1.5878389
Nat. number = 38.711

For the northern boundary of township 21:

Log 39.72 = 1.5990092
Log P sin 1" = 9.9880192
1.5870284
Nat. number = 38.639

For the northern boundary of township 22:

Log 39.72 = 1.5990092
Log P sin 1" = 9.9872086
1.5862178
Nat. number = 38.567

Hence townships 19, 20, 21 and 22, surveyed under the third system in range 13, have their eastern tiers of sections narrowed by 38.783, 38.711, 38.639 and 38.567 chains respectively, along the north boundaries of the different townships.

Now, the full widths of these sections when regular is got from Table X, by multiplying the "width of quarter section" by two.

Thus, the width of the eastern tier of sections in range 13 is:

Along N. boundary of tp. 19, 80.15 − 38.78 = 41.37 chains
" " 20, 80.00 − 38.71 = 41.29 "
" " 21, 79.85 − 38.64 = 41.21 "
" " 22, 79.69 − 38.57 = 41.12 "

These widths must be increased by one chain for road, if the widths from post to post are required.

For the township lines to the north of the correction line, viz.: 23, 24, 25 and 26, the width of range 13 may be found in the same way, using the dM from Tables III and IV for the 7th instead of the 6th base line.

If the width of the fractional section on the north side of the 6th correction line is required, that is, the south boundary of township 23, it must be remembered that here, on account of the correction line being thrown south, from the less depth of the townships of the new system, the southern boundary of township 23 of the third system, which is brought from the 7th base line, intersects the second system south of the correction line, i.e., on a line brought from the 6th base line.

Therefore we have

For the second system, Table III, dM_1 6th base = $8'21''.972$
" third " " IV, dM 7th base = $8'22''.411$

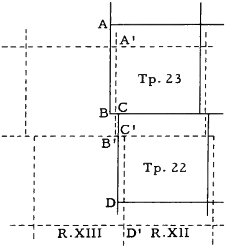
$dM_1 - dM$ = $-0''.439$

and for twelve ranges, $12\,(dM_1 - dM)$ = $-5''.268$

With the difference of longitude, $5''.268$, and the $P \sin 1''$ for the 6th correction line, third system, we get the required jog.

It will be noticed that the overlap is negative, i.e., instead of there being a fractional township there is a surplus.

The heavy lines represent the second system, the dotted ones the third. The line A' B' is the one which we have just considered; it falls to the east of AB, but to the west of CD.



The lines in the figure are all township lines. Thus it will be seen that there is a small piece of land, B' C', which is in fact a township of itself. Its designation would be township 23A, range 12A.

SECOND EXAMPLE

Required: the depth, north and south, of township 27, range 19, west of the principal meridian.

The north boundary of township 26 is the northern boundary of a tract of country surveyed under the first system.

Since each township of the third system is 6 chains shorter north and south than one of the first system, the northern boundary of township 26 in the third system is 6 x 26 = 156 chains south of the same boundary under the first system.

Therefore the distance from the north boundary of township 26, first system, to the northeast corner of section 12, township 27, third system, is 161 – 156 = 5 chains.

Since 1.50 chains must be allowed for road, 3.50 chains is the available width of the strip of land.

FRACTIONAL SECTIONS ADJOINING AN INITIAL MERIDIAN

The longitude of the Principal meridian at the intersection of the 4th base line is 97°27'28".4.

The Second, Third, etc., meridians were laid down by survey from the Principal Meridian, with the intention to place them at every fourth degree of longitude - 102°, 106°, 110°, etc. There is also the Second meridian east of the Principal meridian, laid down by survey from it, in approximate longitude 94°.

The actual longitudes, by astronomical observation, of such as have been determined are:

Second meridian at the north boundary of sec. 13, tp.15, 102°00'16".5.
Third meridian at the north boundary of sec. 13, tp.46, 106°00'10".1.
Fourth meridian at the north boundary of sec. 36, tp.49, 110°00'18".0.
Fifth meridian at the north boundary of sec. 36, tp.52, 114°00'07".7.

The discrepancies from the intended values are due in part to error in the assumed longitude of the Principal meridian, in part to errors of survey. The longitudes of these meridians at points other than those stated, will of course vary with the azimuthal error in surveying the meridians.

The width of the last range in seconds, on a given base line, when closing on an initial meridian is got by subtracting from the difference in longitude (in seconds) between the initial meridians, the nearest integral multiple of dM from Table III or Table IV (according to the system of survey in question).

Thus for the width of the last range on the 18th base line between the Third and Fourth meridians (third system of survey) we have from Table IV, dM = 549".123 for one range. Assuming the Third and Fourth meridians to be in the above stated longitudes at the 18th base line, we divide the difference of longitude 4°00'07".9 or 14407".9 by 549".123 with quotient 26 and remainder 130".7. That is, the width of range 27 on the 18th base line or the difference of longitude between the meridian forming the eastern boundary of townships 67, 68, 69 and 70, range 27 and the Fourth meridian is 130".7.

A better result could be obtained by considering the actual latitude of the base line, and its elevation above sea-level. Thus it is known that the 18th base line between the Third and Fourth meridians is approximately six chains south of its latitude as given in the tables, and has a mean elevation of about 1,700 feet. Using these figures and proceeding as already explained on pages 43 and 45, correcting for latitude displacement

$$dM = 549''.123 - \frac{6}{966} x\ 2''.365 = 549''.108$$

and correcting for altitude

$$dM = 549''.108\ (1 - \frac{l}{N}) = 549''.064$$

Proceeding now as before using $549''.064$ as the longitude covered by one range we find the width of range 27 to be $132''.2$. This difference of longitude can be converted into chains by multiplying by P sin 1'' for the section line whose length is required, whether the southern boundary of township 67, or the northern boundary of township 70, or any of the intermediate township or section lines.

If the width of the last broken section be required, then if dealing with the third system of survey, integral multiples of 1/6 dM (difference of longitude covered by one section) must be subtracted from the width of the fractional township until the remainder is less than 1/6 dM. This remainder may then be converted to chains by multiplying by P sin 1'' taken out of the table for the latitude of the line under consideration. The reason for this is that the widths in seconds of longitude are the same for all sections from the base line to the correction line (second and third systems).

GEODETIC POSITIONS

Owing to the unequal distribution of mass and density in local areas of the earth's surface, the normal to the spheroid does not coincide with the plumb line vertical. In consequence the latitude and longitude of a point determined by astronomical observations may differ from the latitude and longitude as determined by geodetic measurements. Since the amount of the plumb line deflection varies from place to place the distance between any two points calculated from their astronomical positions may not agree with the distance actually measured on the ground. It is therefore desirable that positions in the Canada Lands surveys systems should be geodetic rather than astronomic.

A number of section corners have been tied into the Geodetic Survey of Canada's networks of triangulation and the resulting spheroidal co-ordinates (1927 North American Datum) are listed in the following table. As the networks are extended further ties will be made and the results tabulated.

Spheroidal Co-ordinates of Section Corners as Determined by the Geodetic Survey of Canada (1927 North American Datum)

West of Principal Meridian.

Tp.	R.	Section	Latitude	Longitude
1	10	22, 1/4 N. By.	49°03' 32".73	98°43' 41".22
1	17	10, 1/4 E. By.	49 01 17.40	99 39 37.95
1	27	26, 1/4 E. By.	49 03 57.93	100 58 52.01
1	28	28, 1/4 E. By.	49 03 58.05	101 09 37.41
1	30	15, N.E. Cor.	49 02 38.59	101 24 24.27
1	33	28, 1/4 E. By.	49 03 56.42	101 49 55.55
2	1	10, N.E. Cor.	49 07 05.37	97 30 16.51
2	3	23, 1/4 E. By.	49 08 27.30	97 45 04.16
2	14	29, N.E. Cor.	49 09 45.63	99 18 06.86
2	16	12, N.E. Cor.	49 07 03.78	99 28 52.04
3	5	2, N.E. Cor.	49 11 32.19	98 01 24.67
3	7	19, N.E. Cor.	49 14 12.51	98 23 07.88
3	18	8, 1/4 E. By.	49 12 01.51	99 51 20.95
7	17	31, N.E. Cor.	49 37 14.60	99 45 24.77
11	18	35, N.E. Cor.	49 58 29.92	99 49 12.79

West of Second Meridian

Tp.	R.	Section	Latitude	Longitude
1	1	16, 1/4 N. By.	49°02' 35".32	102°05' 03".51
1	3	12, 1/4 E. By.	49 01 16.00	102 16 29.49
1	5	1, 1/4 S. By.	48 59 57.18	102 33 16.10
1	6	13, 1/4 E. By.	49 02 09.83	102 40 40.32
1	12	24, 1/4 N. By.	49 03 26.95	103 29 10.91
1	13	10, 1/4 N. By.	49 01 41.84	103 39 50.62
1	14	8, 1/4 N. By.	49 01 42.87	103 50 33.82
1	16	26, N.E. Cor.	49 04 23.28	104 01 54.93
1	18	28, N.E. Cor.	49 04 20.68	104 20 35.05
1	23	17, 1/4 E. By.	49 02 08.65	105 01 58.66
1	27	7, 1/4 E. By.	49 01 17.63	105 35 21.87
2	7	8, 1/4 N. By.	49 07 01.64	102 54 45.67
2	10	10, N.E. Cor.	49 06 56.90	103 15 09.83
2	26	12, 1/4 N. By.	49 06 57.34	105 21 20.10
2	29	22, N.E. Cor.	49 08 43.11	105 47 22.72
5	29	14, N.E. Cor.	49 23 30.21	105 47 38.56
6	26	25, 1/4 S. By.	49 29 37.41	105 22 46.01
16	23	24, N.E. Cor.	50 22 03.34	105 01 48.25
16	29	33, 1/4 E. By.	50 23 22.45	105 55 25.86
17	20	14, 1/4 E. By.	50 25 59.75	104 38 25.97
18	24	23, 1/4 E. By.	50 32 06.50	105 11 27.43
20	26	20, N.E. Cor.	50 43 01.67	105 33 45.75
21	24	34, N.E. Cor.	50 50 01.05	105 14 20.97
22	28	24, N.E. Cor.	50 53 30.48	105 44 50.34
26	26	6, N.E. Cor.	51 11 51.27	105 36 45.77
28	26	7, 1/4 N. By.	51 23 13.37	105 39 02.66
28	27	34, N.E. Cor.	51 26 43.03	105 42 34.06
29	22	32, N.E. Cor.	51 31 57.18	105 03 11.40

Tp.	R.	Section	Latitude	Longitude
41	27	27, N.E. Cor.	52 33 56.08	105 47 38.98
45	20	23, N.W. Cor.	52 53 59.84	104 48 31.98
45	22	22, N.E. Cor.	52 56 54.41	105 07 19.81
45	22	18, 1/4 W. By.	52 55 35.27	105 13 08.93
45	24	23, 1/4 E. By.	52 53 34.20	105 21 54.30
46	20	22, N.E. Cor.	52 59 14.18	104 48 33.09
47	22	31, 1/4 E. By.	53 05 47.57	105 11 47.74

West of Third Meridian

Tp.	R.	Section	Latitude	Longitude
1	14	4, 1/4 E. By.	49°00' 25".42	107°48' 32".63
1	22	34, N.E. Cor.	49 05 12.37	108 51 17.34
2	3	12, N.E. Cor.	49 06 59.32	106 16 25.29
2	5	33, N.E. Cor.	49 10 28.07	106 36 26.39
2	9	20, 1/4 E. By.	49 08 17.34	107 09 49.58
2	16	31, N.E. Cor.	49 10 27.53	108 07 14.09
2	19	4, 1/4 E. By.	49 05 39.48	108 28 34.96
2	24	33, N.E. Cor.	49 10 27.37	109 08 39.63
2	25	34, N.E. Cor.	49 10 27.21	109 15 20.54
3	1	3, 1/4 E. By.	49 10 54.44	106 03 00.62
3	7	2, S.E. Cor.	49 10 28.40	106 50 07.99
3	18	9, N.E. Cor.	49 12 12.24	108 21 34.24
3	20	14, N.E. Cor.	49 13 04.75	108 35 01.35
4	10	11, 1/4 W. By.	49 17 27.72	107 15 00.88
4	22	21, N.E. Cor.	49 19 11.37	108 53 51.33
7	1	36, N.E. Cor.	49 36 39.40	106 00 13.50
10	1	36, S.E. Cor.	49 51 30.72	106 00 16.65
10	1	36, N.E. Cor.	49 52 22.91	106 00 16.60
40	4	33, N.E. Cor.	52 29 34.49	106 30 26.70
40	6	23, N.E. Cor.	52 27 49.57	106 44 50.33
41	4	31, N.E. Cor.	52 34 48.60	106 33 19.43
42	2	26, 1/4 E. By.	52 38 45.40	106 10 16.66
42	3	22, N.E. Cor.	52 38 18.61	106 20 21.55
42	5	21, N.E. Cor.	52 38 18.28	106 39 04.72
43	15	28, N.E. Cor.	52 44 24.42	108 06 28.70
44	10	21, N.E. Cor.	52 48 45.48	107 22 56.48
44	12	36, N.E. Cor.	52 50 30.59	107 35 59.68
46	20	19, N.E. Cor.	52 59 14.19	108 52 56.06
47	24	15, N.W. Cor.	53 03 34.56	109 26 30.14
50	1	12, 1/4 E. By.	53 17 59.38	106 00 12.97
50	26	3, N.E. Cor.	53 17 32.86	109 42 37.01

West of Fourth Meridian

Tp.	R.	Section	Latitude	Longitude
8	3	5, 1/4 E. By.	49°37' 05".82	110°21' 55".71
8	7	11, 1/4 E. By.	49 37 57.77	110 50 22.29
9	10	32, 1/4 N. By.	49 47 09.50	111 19 28.44
10	10	25, 1/4 N. By.	49 51 32.36	111 14 03.98
14	10	7, 1/4 N. By.	50 09 51.73	111 21 25.77
15	4	5, 1/4 E. By.	50 13 47.53	110 30 28.92

Tp.	R.	Section	Latitude	Longitude
17	10	23, 1/4 N. By.	50 27 19.42	111 16 30.61
19	10	36, N.E. Cor.	50 39 33.93	111 14 59.60
18	13	3, 1/4 N. By.	50 29 57.27	111 42 37.90
18	14	18, 1/4 E. By.	50 31 15.84	111 54 20.02
20	15	23, 1/4 E. By.	50 42 36.78	111 57 57.02
21	18	25, N.E. Cor.	50 49 09.95	112 21 29.92
22	27	22, N.E. Cor.	50 53 32.36	113 39 04.55
22	29	24, N.E. Cor.	50 53 31.88	113 52 55.32
23	20	22, N.E. Cor.	50 58 46.49	112 42 07.04
23	23	9, N.E. Cor.	50 57 01.48	113 08 37.40
23	26	3, S.E. Cor.	50 55 17.60	113 32 20.72
40	26	24, N.E. Cor.	52 27 46.51	113 36 09.38
43	26	27, 1/4 N. By.	52 44 29.45	113 41 29.03
47	25	12, N.E. Cor.	53 02 48.51	113 30 42.77
47	26	27, N.E. Cor.	53 05 25.08	113 42 25.24
48	25	22, N.E. Cor.	53 09 47.36	113 33 38.56
48	25	22, 1/4 N. By.	53 09 47.10	113 34 21.89
48	4	36, N.E. Cor.	53 11 26.76	110 26 32.63
48	27	34, N.E. Cor.	53 11 31.87	113 51 11.57
49	8	31, N.E. Cor.	53 16 38.94	111 09 00.13
50	1	36, 1/4 E. By.	53 21 28.65	110 00 17.42
50	2	20, N.E. Cor.	53 20 10.02	110 14 54.93
50	3	22, 1/4 N. By.	53 20 09.68	110 21 28.90
50	5	1, N.E. Cor.	53 17 32.61	110 35 23.41
50	7	1, N.E. Cor.	53 17 31.83	110 52 56.04
50	24	26, N.E. Cor.	53 21 08.01	113 23 22.91
51	1	8, 1/4 E. By.	53 23 16.38	110 06 11.64
51	3	16, 1/4 E. By.	53 24 09.01	110 22 25.25
51	6	29, N.E. Cor.	53 26 19.69	110 50 28.12
51	8	31, 1/4 N. By.	53 27 14.66	111 10 08.24
51	11	24, 1/4 N. By.	53 25 29.68	111 29 15.62
51	25	12, N.E. Cor.	53 23 44.31	113 32 24.08
52	13	9, 1/4 E. By.	53 28 33.49	111 50 39.43
52	19	35, N.E. Cor.	53 32 28.88	112 40 48.34
52	23	14, 1/4 E. By.	53 29 24.45	113 16 13.46
52	24	8, 1/4 N. By.	53 28 58.62	113 30 11.60
52	27	19, N.E. Cor.	53 30 42.65	113 57 29.56
53	11	30, 1/4 N. By.	53 36 50.22	111 36 38.66
53	12	19, N.E. Cor.	53 35 57.65	111 44 45.84
53	16	20, 1/4 N. By.	53 35 58.48	112 19 23.50
53	24	27, 1/4 E. By.	53 36 24.62	113 26 31.12
53	25	21, N.E. Cor.	53 35 57.54	113 36 50.80
53	28	24, 1/4 N. By.	53 35 57.01	114 00 00.16
54	14	28, N.E. Cor.	53 42 05.31	111 59 30.37
55	16	8, N.E. Cor.	53 44 39.03	112 19 51.88
55	18	22, 1/4 E. By.	53 46 00.59	112 34 41.55
55	20	9, N.E. Cor.	53 44 42.28	112 54 02.59
56	19	34, 1/4 N. By.	53 53 25.95	112 44 21.86
56	22	28, 1/4 N. By.	53 52 34.53	113 12 37.27

West of Fifth Meridian

Tp.	R.	Section	Latitude	Longitude
27	2	23, N.E. Cor.	51°19'44".94	114°09'53".86
31	4	10, N.E. Cor.	51 38 57.67	114 28 23.83
33	1	8, N.E. Cor.	51 49 26.42	114 05 43.57
34	1	28, 1/4 N. By.	51 57 18.47	114 05 00.74
51	4	32, 1/4 E. By.	53 26 48.21	114 32 29.07
51	23	21, N.E. Cor.	53 25 29.15	117 19 01.44
52	1	8, 1/4 N. By.	53 28 58.63	114 06 40.53
52	3	14, N.E. Cor.	53 29 51.11	114 19 12.62
52	24	31, N.E. Cor.	53 32 27.39	117 30 47.86
53	1	24, N.E. Cor.	53 35 56.94	114 00 03.48
53	2	1, N.E. Cor.	53 33 20.25	114 08 54.74
53	1	36, N.E. Cor.	53 37 41.74	114 00 03.50
53	8	11, 1/4 E. By.	53 33 48.05	115 03 25.10
53	12	23, N.E. Cor.	53 35 56.66	115 38 46.64
53	13	17, N.E. Cor.	53 35 04.92	115 52 04.11
54	6	32, 1/4 N. By.	53 42 55.97	114 50 53.00
54	7	30, 1/4 N. By.	53 42 03.16	115 01 09.90
54	9	17, N.E. Cor.	53 40 19.52	115 16 40.54
54	12	9, N.E. Cor.	53 39 26.92	115 41 45.22
54	13	8, N.E. Cor.	53 39 26.47	115 52 04.21
54	18	2, N.E. Cor.	53 38 33.94	116 31 52.02
55	11	32, 1/4 E. By.	53 47 44.26	115 35 11.89
55	20	19, N.E. Cor.	53 46 25.60	116 56 54.19
56	18	19, 1/4 N. By.	53 51 39.31	116 39 48.23

West of Sixth Meridian

45	1	9, N.E. Cor.	52 52 19.26	118 04 17.13

CHAPTER V

CONSTRUCTION AND USE OF THE TABLES

The geodetic tables of the Supplement have been based on the dimensions given by Col. Clarke (1866) for the figure of the earth.

In the computation of the tables, no account has been taken of the irregularities and errors of survey, or of the altitude above sea-level at which the surveys are made. The surveys are considered as based on a parallel of latitude of 49°, and the different townships and sections as having their theoretic dimensions.

The tables therefore, do not strictly represent the geodetic quantities for the different points of the Canada lands system. The method of applying corrections for altitude and known errors of survey is briefly treated on pages 43 and 45 . The actual errors of survey and the imperfections of all geodetical assumptions are too complicated for treatment here.

These discrepancies, however, are always small, and will exert no appreciable influence on the field work of a surveyor. With the exception of the latitudes and differences of longitudes, the errors of the tables are negligible.

TABLE I

LENGTHS OF ARCS OF MERIDIANS, PARALLELS, ETC., IN DIFFERENT LATITUDES

According to Col. A. R. Clarke, R. E., in his "Comparison of Standards of Length" (1866), the spheroid of revolution most nearly approaching the form of the earth has for its major or equatorial semi-axis 20,926,062 feet, and for its minor or polar semi-axis 20,855,121 feet.

Representing the semi-major and semi-minor axis by a and b respectively, we have for the compression

$c = \frac{a - b}{a} = \frac{1}{294.98}$, and the eccentricity e is given by the formula

$$e^2 = \frac{a^2 - b^2}{a^2} = 0.0067686$$

The unit of measure in the Canada lands surveys is the Gunter's, or 66-foot chain. The equatorial semi-axis in chains is 317,061.545.

Representing by L the geographical latitude of a place, or the angle which its vertical line makes with the plane of the equator, we have for the radius of curvature of the meridian

$$R = \frac{a(1 - e^2)}{(1 - e^2 \sin^2 L)^{3/2}}$$

for the length of the normal to the meridian terminated by the minor axis

$$N = \frac{a}{(1 - e^2 \sin^2 L)^{1/2}}$$

and for the radius of the parallel of latitude L

$$P = N \cos L.$$

The length in chains of one second of latitude is equal to R sin 1"; one second of the great circle perpendicular to the meridian is equal to N sin 1"; and one second of longitude is equal to P sin 1". The logarithms of these quantities are placed in the second, third and fourth columns of Table I. They have been calculated by means of the logarithmic expansions of R and N.

Thus putting n for $\frac{a-b}{a+b}$ we have

$$\log (R \sin 1'') = \log\left[a(1-n)^2(1+n)\sin 1''\right] - 3\mu n \cos 2L + {}^3\!/_2\, \mu n^2 \cos 4L - \text{etc.}$$

where μ is the modulus of the common system of logarithms, and powers of n higher than the second are neglected as being insensible in the eighth decimal place.

Substituting the value of a in chains, as given above, and taking

$$n = \frac{a-b}{a+b} = \frac{1}{588.96}\text{ , we get}$$

$$\log (R \sin 1'') = 0.18597916 - 0.00221218 \cos 2L + 0.00000188 \cos 4L.$$

In calculating the last two terms by logarithms five places are sufficient.

For N sin 1" we have

$$\log (N \sin 1'') = {}^1\!/_3 \log (R \sin 1'') + {}^2\!/_3 \left\{\log a + \log \sin 1'' + 2\mu n\right\}$$
$$= {}^1\!/_3 \log (R \sin 1'') + 0.12546215,$$

and for P sin 1"

$$\log (P \sin 1'') = \log (N \sin 1'') + \log \cos L.$$

The calculation has been made to eight places of decimals to ensure accuracy in the seventh place. In tabulating the eighth figure has been dropped.

The calculation of the logarithms of R sin 1" and N sin 1" has also been made directly from the formulæ for R and N, by the use of a subsidiary angle.

Thus, finding an angle ψ such that $\sin \psi = e \sin L$, we have

$$R \sin 1'' = a(1-e^2)\sec^3 \psi \sin 1''$$
$$N \sin 1'' = a \sec \psi \sin 1''$$

Seven figure logarithms were used, and consequently the results could not be depended upon to the seventh figure, but they have been serviceable as a check upon the series computation.

Log N sin 1", log P sin 1" and log R sin 1" are given in the table for every 10' of latitude from 42° to 70°. Their values for intermediate latitudes can be obtained by simple interpolation. Where, however, log P sin 1" is required with accuracy for an intermediate latitude, it is better first to obtain log N sin 1" for the latitude by interpolation from the table and then to add log cos L.

Under the heading 'Chains in 1"' are given the natural numbers corresponding to the logarithms of R sin 1" and P sin 1". These natural numbers are useful in reducing small differences of latitude and longitude to chains by simple multiplication, being preferable in many cases to the logarithms.

The converse operation of reducing short distances north and south or east and west to seconds of latitude or longitude may be performed by multiplying by the quantities in the two columns headed "Seconds in one Chain." These columns contain the reciprocals of the quantities in the columns "Chains in 1"".

In the last two columns of the table are given the lengths of one degree of latitude and longitude in English miles.

RADIUS OF CURVATURE OF A SECTION OF THE SPHEROID INCLINED AT ANY ANGLE TO A MERIDIAN

In some operations it is necessary to find the radius of curvature of the trace on the earth's surface of a "straight" or "transit" line, making a given angle with the meridian.

Representing this radius of curvature by S, and θ being the angle with the meridian, we have the formula

$$\frac{1}{S} = \frac{\cos^2 \theta}{R} + \frac{\sin^2 \theta}{N}$$

and introducing an auxiliary angle X determined by the formula

$$\tan X = \sqrt{\frac{R \sin 1''}{N \sin 1''}} \tan \theta, \quad \text{we have}$$

$$S \sin 1'' = N \sin 1'' \frac{\sin^2 X}{\sin^2 \theta}$$

a formula adapted for ready calculation by logarithms.

RADIUS OF SPHERICAL CURVATURE

The mean of the values of S when θ is given all possible values is $\sqrt{NR}$. This is the radius of curvature of the surface or the radius of the sphere to the surface at a given point. Its logarithm is readily found from Table I, being the arithmetical mean of the logarithms of N and R.

TABLE II

CORRECTIONS TO TABLE I FOR CHANGE IN ELEMENTS OF FIGURE OF EARTH

In Table I the data used are Clarke's 1866 values, viz.:

$$a = 20{,}926{,}062 \text{ feet}$$

$$n = \frac{1}{588.96}$$

and all the following tables are based on Table I, and therefore on these values. Clarke's later values (Geodesy, 1880) are,

$$a = 20{,}926{,}202 \text{ feet}$$

$$n = \frac{1}{585.93}$$

If, for any purpose, it is desired to use these values, Table I can be corrected by means of Table II, which has been computed thus:

Differentiating the formulae,

log R sin 1''

$$= \log a + \log \sin 1'' - \mu\,(n + \tfrac{3}{2}n^2) - 3\mu n \cos 2L + \tfrac{3}{2}\mu n^2 \cos 4L$$

log N sin 1''

$$= \log a + \log \sin 1'' + \mu\,(n - 1/2n^2) - \mu n \cos 2L + \tfrac{1}{2}\mu n^2 \cos 4L$$

and putting $\frac{1}{n} = p$, we have

$$d(\log R \sin 1'') = \mu \frac{da}{a} + \mu n^2 dp + 3\mu n^2 \cos 2L dp$$

$$d(\log N \sin 1'') = \mu \frac{da}{a} - \mu n^2 dp + \mu n^2 \cos 2 L dp$$

μ being the modulus of the common system of logarithms. Terms involving the cubes and higher powers of n are insensible and may be neglected.

To change Clarke's earlier to his later values, we have

$$da = +\ 140 \text{ (feet)}$$

$$dp = -\ 3.024$$

$$a = 20926062 \text{ (feet)}$$

$$n = \frac{1}{588.96}$$

$$\text{and } \mu = 0.43429448$$

whence $d \log (R \sin 1'') = -.00000088 - .00001136 \cos 2L$

$d \log (N \sin 1'') = +.00000669 - .00000379 \cos 2L$

These quantities are tabulated in Table II, with the proper signs of application to log R sin 1'' and log N sin 1'' in Table I.

TABLE III

LATITUDES OF BASE AND CORRECTION LINES AND LENGTHS OF ARCS OF MERIDIANS, PARALLELS, ETC., FOR FIRST AND SECOND SYSTEMS OF SURVEY

This table is constructed for the first and second systems of survey only. It accordingly stops at the 13th base, township 48, north of which there are no surveys under these systems.

Each township measuring 489 chains each way, the 1st correction line is 978 chains north of the 49th parallel.

The latitude of the 1st correction line is therefore

$$49° + \frac{978}{R \sin 1''}$$

Here R sin 1'' must be taken from Table 1 for the middle latitude between the 1st base and the 1st correction line. For accuracy it is necessary therefore to compute an approximate difference of latitude, using an approximate value of R sin 1''. For instance R sin 1'' may be taken from the table for latitude 49°.

The approximate difference of latitude being thus determined, the middle latitude is found from it (this being a sufficiently close approximation), and the final R sin 1" is taken from Table I for that latitude. Then dividing 978 by this we have a very close approximation to the difference of latitude between the base and the correction line.

From the latitude of the 1st correction line, that of the 2nd base line is found by a similar process, and so on in succession as far as the table extends.

The table is checked by applying the same process to a longer distance than 978 chains. For example, the latitude of the 6th base can be directly determined from that of the first by using 9,780 chains instead of 978. When long distances are thus taken, a second approximation to the middle latitude may become necessary.

The columns log N sin 1" and log R sin 1" are taken from Table I by interpolation, and log P sin 1" is found by adding log cos L to log N sin 1".

The width of a township along a base line is 489 chains. The longitude corresponding to this length measured along the parallel of latitude is given in the column headed "Longitude covered by 489 chains of westing", not only for the base lines but also for the correction lines.

The longitude for 489 chains, along a base line, is the longitude covered by one range of townships. Along a correction line it does not correspond to the longitude covered by a range, since the width of a township along a correction line is greater or less than 489 chains according as the township north or south of the correction line is considered. The tabulated quantity, however, for correction lines can be used to calculate the narrowing or widening of sections at the correction lines.

The township width, 489 chains, is measured along the base line which has such azimuth that its terminal point falls in the same latitude as its initial point.

Thus every township corner along a base line has the same latitude, and the base line is a succession of chords of the latitude circle.

The difference of longitude between one township corner and the next is given by the formula

$$dM = \frac{489}{P \sin 1''}$$

It is assumed here that the chord of the arc of the latitude circle is equal to the arc. That the difference between the chord and the arc is inappreciable may be shown thus:

By spherical trigonometry

$$\sin \frac{\text{chord}}{2N} = \sin \frac{dM}{2} \cos L$$

$$\text{whence chord} = N \cos L \; dM - N \cos L \sin^2 L \frac{dM^3}{24}$$

$$= \text{arc} - \text{arc} \times \frac{dM^2}{24} \sin^2 L$$

so that the difference between the chord and the arc is equal to

$$\text{arc} \times \frac{dM^2}{24} \sin^2 L$$

dM being in circular measure.

For any township chord this amounts to less than one fiftieth of a link.

The chord always lies north of the arc. The distance between them is greatest at their middle points, amounting there to about 10 links. Hence, at the international boundary line, which is the first base line, since the actual territorial boundary is the curve, and the base line a series of chords, the road allowance which lies along the north side of this base is increased in width by 10 links at the middle of the chords.

The non-coincidence of the chord and arc also has the effect of increasing and decreasing the widths of roads on correction lines, since on account of the jog, the township corners north and south of the road are not opposite one another. The increase or decrease in the width of the road along correction lines, when required, may be easily found by an application of Table XI.

In the first column of Table III are given, for convenience, the numbers of the townships corresponding to the several base and correction lines. Thus the 6th base is the northern boundary of township 20, and so on.

TABLE IV

LATITUDES OF BASE AND CORRECTION LINES, ETC., FOR THIRD AND FOURTH SYSTEMS OF SURVEY

This table is similar to Table III, except that it is made for the third system of survey, where the widths of townships are 486 instead of 489 chains, and their depths, in a north and south direction, 483 instead of 489 chains.

The table also applies, without change, to the fourth system (British Columbia).

In this table, as well as in Table III, the latitudes given are those of the line of posts on the south side of the road allowance. To get the latitude of the posts north of the road on correction lines, the latitude of the correction line, as given in the table, must be corrected by adding the equivalent in latitude of the width of the road, i.e., one chain and a-half for the first and second systems (Table III), and one chain for the third system (Table IV).

TABLE V

CHORD AZIMUTHS, ETC., FOR BASE LINES, FIRST AND SECOND SYSTEMS OF SURVEY

The extremities of the township chord, as above stated, are in the same latitude. Hence the chord is equally inclined to the meridians passing through its terminal points, and its azimuth, east or west of north, is equal to the complement of half the change in azimuth, that is, of half the "convergence of meridians."

Let dZ represent the change in azimuth or convergence of meridians, dM the difference of longitude, and L the latitude.

Then, by spherical trigonometry

$$\tan \tfrac{1}{2}\, dZ = \tan \tfrac{1}{2}\, dM \sin L$$

whence, by expansion of the tangents in terms of the arcs,

$$dZ = dM \sin L + \frac{dM^3}{12} \sin L \cos^2 L$$

or, if dZ and dM be expressed in seconds,

$$dZ = dM \sin L + \frac{dM^3}{12} \sin L \cos^2 L \sin^2 1''$$

The second term is inappreciable, amounting in latitude 51° to less than one ten-thousandth of a second.

$$\therefore dZ = dM \sin L$$

The convergence or "deflection" (dZ), given in Table V, is thus calculated from the difference of longitude (dM) in Table III.

The "chord azimuth" is the complement of half the deflection.

The chord azimuth,convergence for 100 chains and the deflection are given in the table in degrees, minutes and seconds.

In the survey of a base line, the surveyor, when he arrives at a township corner, deflects his line to the north through an angle equal to the "deflection," and thus establishes in azimuth the chord across the next range of townships.

This deflection angle may be turned with the instrument, but more readily by the use of the "deflection offsets" in the table. The tabulated offset is the linear distance in inches between one of the chords and the prolongation of the other, at one chain from the township corner.

Their distance apart at any point is found by multiplying the tabulated offset by the distance, expressed in chains, of the point from the township corner.

For example, if the instrument stand on the prolongation of the first chord at 15 chains past the corner, and the back picket at 40 chains on the other side of the corner, that is, behind the corner, then the instrument must be moved north fifteen times, and the back picket south forty times, the "deflection offset for one chain". The line of the instrument and picket will then be in the correct bearing for the prolongation of the base line.

The angle is thus turned as accurately as a straight line can be produced with the instrument, and much more accurately than the angle can be measured with the graduated arc, while the setting of the instrument at the corner (which may be in low ground, unsuitable for accurate line production) is rendered unnecessary.

"Longitude covered by one range" in the seventh column is merely the longitude in the seventh column of Table III, reduced to time by dividing by 15. This gives the number of seconds which a watch will gain or lose on local time in being carried across a range. The gain or loss in travelling over any other distance along the base line is proportional to the distance. The column is added for astronomical purposes , especially the determination of azimuth by observation of Polaris at any hour angle.

Table V applies to the first and second systems of survey.

TABLE VI

CHORD AZIMUTHS, ETC., FOR BASE LINES, THIRD AND FOURTH SYSTEMS OF SURVEY

This table is similar to Table V, but is made for the third system of survey.

The calculation is made by the same formulæ, changing only the width of the range, which is 486 instead of 489 chains, and using the latitudes of the base lines from Table IV, instead of those from Table III.

$$dM = \frac{486}{P \sin 1''}, \quad dZ = dM \sin L$$

The table also applies to the fourth system.

TABLE VII

CHORD AZIMUTHS, JOGS, ETC., FOR CORRECTION LINES, FIRST AND SECOND SYSTEMS OF SURVEY

This table gives quantities for correction lines similar to those given in Table V for base lines. It applies to the first and second systems of survey.

The correction lines are posted on both sides of the road. The chord azimuths and deflections are given for the south side of the road, which is that side for which the latitudes of correction lines are given in Table III.

The calculation of the chord azimuth for correction lines is somewhat different from that for base lines.

For the base lines we have

$$dM = \frac{489}{P \sin 1''}$$

$$\text{deflection} = dM \sin L$$

For the correction lines, one range is not 489 chains, but the distance between meridians which include 489 chains on the nearest base line.

Hence in the formulæ: -

$$dM = \frac{489}{P \sin 1''}$$

$$\text{and deflection} = dM \sin L = \frac{489}{P \sin 1''} \sin L$$

we must take P sin 1'' for the next base line south of the correction line, if the difference of longitude and the deflection for the south side of the correction line road are required; while for the north side of that road we must take P sin 1'' for the next base line north. L of course, is the latitude of the correction line itself.

The length of one range on the correction line is $dM \times P \sin 1''$.

If, then, P_1 and P_2 represent the radii of parallels for the base lines next north and south, respectively, and P that for the correction line itself; then

$$dM_1 = \frac{489}{P_1 \sin 1''}, \quad dM_2 = \frac{489}{P_2 \sin 1''}$$

and we have for the length of one range on the correction line: -

$$\text{North side} = \frac{489}{P_1 \sin 1''} \times P \sin 1''$$

$$\text{South side} = \frac{489}{P_2 \sin 1''} \times P \sin 1''$$

The values of these quantities are tabulated in the sixth and seventh columns of Table VII.

For extreme accuracy P sin 1" for the north side of the road should be taken out for a latitude greater by 1.50 chains, or $0''.98$ greater than that tabulated in Table III; but the difference in the result would be almost inappreciable, being less than one quarter of a link per township.

The difference of lengths of the township lines north and south of the correction line road gives the overlap or jog.

The jog for one range is given in the eighth column of the table. As this jog occurs in each range of townships, its value at any range is the product of the jog for one range by the number of ranges.

The excess of the length of the north side over, or the defect of the south side from 489 chains, is the linear divergence or convergence of the township lines. Since there are twelve half sections in a township side, the convergence or divergence for one half section is one-twelfth of the convergence or divergence for the township, or one twenty-fourth of the jog, the excess of the north side and the defect of the south side being very nearly, though not quite, equal.

This convergence or divergence for one half section is entered in the ninth column of the table. It is used in the second system, where the surplus or deficiency caused by the convergence of meridians is divided equally among all the quarter-sections, Hence, in surveying a correction line under the second system, the width of each quarter section (exclusive of the roads) is forty chains plus or minus this tabulated quantity. The surplus or deficiency on the township line midway between the base and the correction line is half of that on the correction line.

In the first system the whole of the surplus or deficiency is thrown into the western tier of quarter sections. This surplus or deficiency is the difference between 489 chains and the quantities in the sixth and seventh columns of Table VII. For example, on the north side of the road on the 1st correction line the surplus is 1.75 chains, and the westerly quarter section of the township is therefore 41.75, all the others being 40 chains.

It is to be observed that in all cases the whole divergence or convergence is applied to the section itself, and that the road allowance retains its width of 1 chain or 1 1/2 chains, with the exception of the roads on correction lines, which are subject to a widening or narrowing as explained under Table III.

TABLE VIII

CHORD AZIMUTHS, JOGS, ETC., FOR CORRECTION LINES, THIRD AND FOURTH SYSTEMS OF SURVEY

This table gives for the third and fourth systems the same quantities as are given in Table VII for the first and second systems.

The surplus or deficiency is in all cases divided equally among all the quarter sections.

TABLE IX

LATITUDES, AND WIDTHS IN CHAINS, OF NORTHERN BOUNDARIES OF SECTIONS IN FIRST AND SECOND SYSTEMS OF SURVEY

This table, with Table XI, gives the latitudes in degrees, minutes and seconds for the northern boundaries of all sections in the first and second systems.

The sections numbered in the second column are those adjacent to the eastern boundary of the township. The latitudes of the northern boundaries of interior sections lying west of these are approximately the same. Thus the northern boundaries of sections 14, 15, 16, 17 and 18 have very nearly the same latitude as the north boundary of 13, and so for the other east and west tiers of sections. The small corrections required to the latitudes of Tables IX and X to obtain the latitudes of the northeast corners of sections not on the bounding meridians of townships are given in Table XI.

These latitudes are computed by interpolating from the latitudes given in Table III.

The logarithmic secant and tangent of the latitude are given in the table for use in calculation of azimuth observations.

In the last column of the table are given the widths of the north boundaries of the quarter sections (in the second system of survey). These are calculated for the correction lines in the manner explained under Table VII, and for the intermediate lines by interpolation.

For quarter sections adjoining correction lines the usual width is given for the north boundary of the quarter section to the south of the correction line; bracketed with it is also given the width, measured along the south boundary, of the quarter section immediately to the north. That is, the two lengths bracketed are the lengths of quarter section sides measured along the south limit and the north limit, respectively, of the road on correction lines.

TABLE X

LATITUDES, AND WIDTHS IN CHAINS, OF NORTHERN BOUNDARIES OF SECTIONS IN THIRD AND FOURTH SYSTEMS OF SURVEY

This table gives for the third system the same quantities as are given in Table IX for the first and second.

The table may also be applied to the fourth system by correcting the latitudes of the alternate section lines, viz., the north boundaries of sections 1, 13 and 25 in each township, by subtracting therefrom 0."33, the equivalent in arc of 50 links. The change in the logarithmic secant and tangent is inappreciable, as these logarithms are given to only five places of decimals. The widths of quarter sections in the last column must be increased by 50 links.

TABLE XI

DIFFERENCE OF LATITUDE BETWEEN TOWNSHIP CORNERS AND SECTION AND QUARTER SECTION CORNERS

This table is used when it is required to find the latitude of any point on a township chord, or within a township, as when it is desired to find the error of the survey lines by connecting with an astronomically determined point.

Let l = length of chord, chains.

c = distance along chord from either end to point at which latitude difference is required, chains.

θ = convergence of meridians per chain, seconds of arc.

dL = approximate distance from the parallel to the chord, in links.

then $dL = .00024\,(l - c)c\theta$ (approximately).

The angular difference of latitude may be obtained by use of the conversion factors given in Table I.

Table XI can be used for all systems.

TABLE XII

FOR CONVERTING LOGARITHMIC TANGENTS OF SMALL ARCS INTO LOGARITHMS OF SECONDS OF ARC

This gives the logarithm of the ratio of a small arc expressed in seconds of arc, to its tangent; by adding it to the log tangent, the logarithm of the arc is obtained, and the arc itself is found with a table of logarithms of numbers, without having to compute proportional parts.

TABLE XIII

$\text{Log}\ \frac{1}{1 - m}$ tabulated with log m as argument.

These tables are useful in abridging the work of time-azimuth observations on Polaris; they give by inspection the value of

$$\log \frac{1}{1 - \tan P \tan L \cos t}$$

when log tan P tan L cos t is known. The quantity tan P tan L cos t has been represented by m, so that the azimuth formula may be written

$$\tan Z = -\frac{1}{1 - m} \tan P \sec L \sin t$$

It will be noted that $\log \frac{1}{1 - m}$ must be taken out with regard to the sign of m.

TABLE XIV

DEFLECTION OF A TRIAL LINE FOR DEVIATIONS FROM 1 TO 149 LINKS AT THE END OF EIGHTY-ONE CHAINS

This is useful in deflecting trial lines. It gives the angular deflection of a line for deviations of 1 to 149 links at the end of eighty-one chains

TABLE XV

CORRECTIONS IN LINKS TO SLOPE MEASUREMENTS

This table has been computed for the use of surveyors working in mountainous country where the slopes are measured with the transit; it is not well adapted to ordinary clinometer chaining.

The table has been compiled with the correction as argument, to give an accuracy of one-tenth of a link per chain. A greater degree of accuracy may, of course, be obtained by interpolation to the measured slope, but it is seldom necessary. The corrections are given for every chain length up to nine chains, the object being to simplify the surveyor's calculation in the field. A convenient method of using the tables is illustrated by the following example.

Required: the slope correction for 3.682 chains at 26°09'. This slope lies between the tabulated slopes 26°06' and 26°14'. Taking out the slope corrections for a slope of 26°06' and the differences of the corrections for 26°14' and 26°06':

Correc. for 3 chs. = 30.6 lks. with diff. for 8' of 0.3 lks.
" 0.6 " = 6.12 " " " 0.06 "
" 0.08 " = 0.82 " " " 0.01 "
" 3.68 " = 37.54 " " " 0.37 "

Difference for 3' is $^{3}/_{8}$ x 0.37 = 0.14 lks.
Correc. for 3.68 chs. at 26°09' = 37.54 + 0.14 = 37.68 lks.
= 0.377chs.

TABLE XVI

TABLE FOR LAYING OUT ROADS ONE CHAIN WIDE

Roads are normally posted at points of change of direction, at the intersections of the road limits, as explained in the Manual of Instructions for the Survey of Dominion Lands (Art. 157). Table XVI correlates the diagonal distance between the points of intersection of the limits of road to the angle of deflection, or change of direction. It applies to a road of constant perpendicular width of one chain but may be used for other widths by increasing or decreasing the tabulated distances in direct proportion to the width required.

TABLE XVII

TO CONVERT TIME INTO ARC

For convenience in converting time into arc the equivalents of hours, minutes and seconds are tabulated in degrees, minutes and seconds.

TABLE XVIII

TO CONVERT A MEAN TIME INTERVAL TO THE EQUIVALENT SIDEREAL TIME INTERVAL

The number of minutes and seconds to be added to a mean time interval to obtain the equivalent sidereal time interval are tabulated with days, hours and minutes as arguments.

Example: To convert a mean time interval of 2 days, 6 hours, 12 minutes and 20 seconds to the equivalent sidereal time interval.

	Days	Hours	Min's	Sec's
Mean Time Interval	2	6	12	20
Tabulated addition for				
2 days			7	53.1
6 hours				59.1
12 minutes				1.6 .3
20 seconds $1/3$ x 0.2				.1
Sidereal Time Interval	2	6	21	14

THE ASTRONOMICAL FIELD TABLES

The Field Tables are issued in two sets, one giving data for sun observations, and the other for star observations. Both sets should be in the hands of all surveyors engaged on Canada lands surveys.

FIELD TABLES FOR SOLAR OBSERVATIONS

The Field Tables for solar observations are issued each year. They give the sun's apparent declination at 0^h Greenwich Civil Time with its variation for one hour and the sun's apparent right ascension at Greenwich apparent noon with its variation for one hour. These data, which are taken direct from the American Ephemeris, are tabulated for every day of the year. There is also a table of mean refraction for different altitudes, with the corrections required thereto for temperature and barometric pressure.

The tables of the sun's declination and of the mean refraction are required for observations on the sun for azimuth; the table of the sun's right ascension is required for obtaining the sidereal time by observing the meridian transit of the sun. For both these purposes the approximate longitude is necessary; if not known from the survey it generally can be obtained with sufficient accuracy from a large-scale map of the area.

Full instructions for solar observing with specimen observations are given in Chapter 1.

FIELD TABLES FOR STAR OBSERVATIONS

The Field Tables for star observations are issued for short periods in different years as explained in a subsequent paragraph "Apparent Motion of Polaris". They contain a table for finding the Pole star and the astronomical meridian, a list of "time stars", the sidereal time at noon, eastern standard time (75° longitude) at ten day intervals, and a diagram showing the convergence of meridians per mile of longitude at latitudes from 44° to 60° inclusive.

Table for Finding the Pole Star and the Astronomical Meridian. - The table is entered with the sidereal time as argument. The first column gives the number of minutes to be added to or subtracted from the latitude to obtain the altitude of the star. In the second column is the argument, the local sidereal time for every ten minutes. In the other columns is the azimuth of the star for every even degree of latitude for 44° to 60°.* The table enables the Pole star to be readily found in day time and when it is found and observed, provides an easy means of determining its bearing. When the position of the astronomical meridian is known approximately, as is the case on most surveys, the transit can be set in the direction of the star and to the proper altitude by means of the table. When it is not known, however, the compass needle may be used, the magnetic declination being taken from the current "Magnetic Map of Canada" or from the magnetic diagram shown on many of the large-scale maps.

The method of observing and the use of the field tables are fully explained in Chapter 1.

Time Stars - The Star Field Tables give a list of time stars taken from the American Ephemeris which are suitable for Canada lands survey work. The method of observing the sidereal time of meridian transit of a star is described in Chapter 1.

Latitude and Convergence Per Mile of Longitude. - The diagram is convenient in determining the convergence for referring an observed azimuth to the meridian of the centre of the township or to any other reference meridian.

THE APPARENT MOTION OF POLARIS

The path described by the Pole star on the celestial sphere from 1949 to 1955 is shown on the diagram "Apparent Motion of the Pole Star". It is the combined effect of precession, nutation, aberration, and proper motion. This constant variation in the position of the star produces a slow change in the azimuth from any point, irrespective of the daily variation of azimuth caused by the earth's rotation. Hence, at the same sidereal time on two successive days the star will not have quite the same azimuth. If the azimuth of the star be considered at the same sidereal time each day for a month, there will be found a change which for latitude 60° may amount to 25", according to the month and the sidereal time chosen. Taken over a whole year this change may be anything up to 80" for latitude 49° or up to 110" for latitude 60° according to the sidereal time considered. Hence, if the Field Tables were made out taking a mean position of Polaris for a year, they would be subject to a maximum error of half this amount, that is, about 40" at latitude 49° and about 55" at latitude 60°. It will be observed from the diagram

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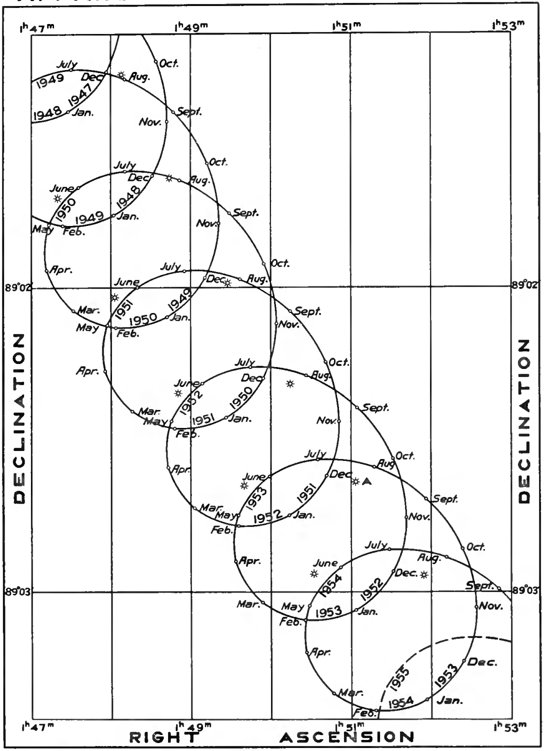
* Tables are available for latitudes 62°, 64°, and 66° for the months of April to October inclusive, for each year.

APPARENT MOTION OF THE POLE STAR



The mean position of the Pole Star adopted for each table is indicated by ✲

FIGURE 8

(Figure 8) that the star crosses its path again and again, occupying approximately the same positions during certain periods of consecutive years. Because of this peculiarity two star tables are issued each year, one for January, February and March of one year and April, May and June of the next, the other for November and December, September and October, and July and August of three successive years. With this arrangement the maximum error at latitude 49° is 24" and for latitude 60° is 32".

COMPUTATION OF THE AZIMUTH AND ALTITUDE OF POLARIS

Azimuth of the Pole Star. - The azimuth is computed by the formula:

$$\tan Z = -\frac{\tan P \sec L \sin t}{1 - \tan P \tan L \cos t}$$

Whence, $\cot Z = \sin L \cot t - \cot P \cos L \operatorname{cosec} t$ where Z, P, L, t denote the azimuth,polar distance, latitude and hour angle respectively.

The path of Polaris is plotted for each year by its right ascension and declination taken directly from the American Ephemeris. In order to determine a mean position of Polaris for the period specified on each table, the path of the star must be plotted for the three successive years being used. The American Ephemeris for the third year is not available at the time the tables are being prepared. The values for Polaris for this year are extrapolated for the first day of each month from the values tabulated for the foregoing years. The results are sufficiently accurate for plotting the diagram. From the points on the path representing the limiting dates of the table to be calculated, the mean position of Polaris for the table may be obtained graphically and its right ascension and declination read directly from the borders of the diagram.

On the diagram (Figure 8) the mean position, A, of the Pole star for the table comprising the following periods:

November, December	1951
September, October	1952
July, August	1953

has the values

$$RA = 1^h 51^m 03\overset{s}{.}5$$

$$P = 90° - 89° 02' 38\overset{"}{.}4 = 0° 57' 21\overset{"}{.}6$$

Since the argument in the Field Tables is the sidereal time and not the hour angle, the values of t to be used in the calculation for the azimuth should be the sidereal time minus the right ascension of the mean position.

Altitude of the Pole Star. - The correction to be applied to the latitude to obtain the altitude is given by

$$h - L = P \cos t - \tfrac{1}{2} P^2 \sin 1' \tan L \sin^2 t ,$$

terms involving higher powers of P being inappreciable.

Since the term containing L is small and since the altitude of Polaris is required only to find the star, a value for the mean latitude (Lm) may be used in the calculation. The values of P and t are the same as those used in the corresponding calculation for azimuth.

TABLES

TABLE I

Radii of Curvature of Meridians and Parallels, etc.

Latitude		log N sin 1"	log P sin 1"	log R sin 1"	Chains in 1"		Seconds in one Chain		English Miles in one Degree	
					Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
°	'						"	"		
42	00	0.1873775	0.0584510	0.1857461	1.5337	1.1441	0.6520	0.8741	69.02	51.48
	10	3818	73144	7589	38	1.1411	20	0.8764	.02	51.35
	20	3860	61711	7717	38	1.1381	20	0.8787	.02	51.21
	30	3903	50212	7845	39	1.1351	20	0.8810	.02	51.08
	40	3946	38645	7973	39	1.1320	19	0.8834	.03	50.94
	50	3989	27010	8101	39	1.1290	19	0.8857	.03	50.81
43	00	4031	15306	8230	40	1.1260	19	0.8881	.03	50.67
	10	4074	0.0503534	8358	40	1.1229	19	0.8905	.03	50.53
	20	4117	0.0491693	8487	41	1.1199	19	0.8930	.03	50.39
	30	4160	79782	8615	41	1.1168	18	0.8954	.04	50.26
	40	4203	67802	8744	42	1.1137	18	0.8979	.04	50.12
	50	4245	55750	8872	42	1.1106	18	0.9004	.04	49.98
44	00	4288	43629	9001	43	1.1075	18	0.9029	.04	49.84
	10	4331	31437	9129	43	1.1044	18	0.9054	.04	49.70
	20	4374	19173	9258	44	1.1013	17	0.9080	.05	49.56
	30	4417	0.0406838	9387	44	1.0982	17	0.9106	.05	49.42
	40	4460	0.0394430	9515	44	1.0951	17	0.9132	.05	49.28
	50	4503	81949	9644	45	1.0919	17	0.9158	.05	49.14

45	00	4546	69396	9773	45	1.0888	17	0.9185	.05	49.00
	10	4589	56769	0.1859901	46	1.0856	16	0.9211	.06	48.85
	20	4631	44067	0.1860030	46	1.0824	16	0.9238	.06	48.71
	30	4674	31292	0159	47	1.0793	16	0.9266	.06	48.57
	40	4717	18442	0288	47	1.0761	16	0.9293	.06	48.42
	50	4760	0.0305517	0416	48	1.0729	16	0.9321	.06	48.28
46	00	4803	0.0292516	0545	48	1.0697	15	0.9349	.07	48.14
	10	4846	79439	0673	49	1.0665	15	0.9377	.07	47.99
	20	4889	66285	0802	49	1.0632	15	0.9405	.07	47.85
	30	4932	53054	0931	49	1.0600	15	0.9434	.07	47.70
	40	4974	39745	1059	50	1.0568	15	0.9463	.07	47.55
	50	5017	26358	1188	50	1.0535	15	0.9492	.08	47.41
47	00	5060	0.0212893	1316	51	1.0502	14	0.9522	.08	47.26
	10	5103	0.0199349	1445	51	1.0470	14	0.9551	.08	47.11
	20	5146	85726	1573	52	1.0437	14	0.9581	.08	46.97
	30	5188	72021	1701	52	1.0404	14	0.9612	.08	46.82
	40	5231	58237	1829	53	1.0371	14	0.9642	.09	46.67
	50	5274	44372	1957	53	1.0338	13	0.9673	.09	46.52
48	00	5317	30425	2086	54	1.0305	13	0.9704	.09	46.37
	10	5359	16396	2214	54	1.0272	13	0.9736	.09	46.22
	20	5402	0.0102285	2341	54	1.0238	13	0.9767	.09	46.07
	30	5445	0.0088090	2469	55	1.0205	13	0.9799	.10	45.92
	40	5487	73812	2597	55	1.0171	12	0.9831	.10	45.77
	50	0.1875530	0.0059449	0.1862725	1.5356	1.0138	0.6512	0.9864	69.10	45.62

TABLE I - Continued.

Radii of Curvature of Meridians and Parallels, etc.

Latitude		log N sin 1"	log P sin 1"	log R sin 1"	Chains in 1"		Seconds in one Chain		English Miles in one Degree	
					Lati-tude	Longi-tude	Lati-tude	Longi-tude	Lati-tude	Longi-tude
49°	00'	0.1875572	0.0045001	0.1862852	1.5356	1.0104	0.6512"	0.9897"	69.10	45.47
	10	5615	30469	2980	57	1.0070	12	0.9930	.11	45.32
	20	5657	15849	3107	57	1.0037	12	0.9964	.11	45.16
	30	5699	0.0001143	3234	58	1.0003	11	0.9997	.11	45.01
	40	5742	9.9986351	3361	58	0.9969	11	1.0031	.11	44.86
	50	5784	71470	3488	58	0.9935	11	1.0066	.11	44.71
50	00	5826	56501	3615	59	0.9900	11	1.0101	.12	44.55
	10	5869	41444	3742	59	0.9866	11	1.0136	.12	44.40
	20	5911	26296	3869	60	0.9832	10	1.0171	.12	44.24
	30	5953	9.9911058	3995	60	0.9797	10	1.0207	.12	44.09
	40	5995	9.9895730	4122	61	0.9763	10	1.0243	.12	43.93
	50	6037	80309	4248	61	0.9728	10	1.0279	.13	43.78
51	00	6079	64797	4374	62	0.9693	10	1.0316	.13	43.62
	10	6121	49192	4500	62	0.9659	10	1.0353	.13	43.46
	20	6163	33493	4625	63	0.9624	09	1.0391	.13	43.31
	30	6205	17701	4751	63	0.9589	09	1.0429	.13	43.15
	40	6247	9.9801813	4876	63	0.9554	09	1.0467	.14	42.99
	50	6289	9.9785830	5002	64	0.9519	09	1.0506	.14	42.83

52	00	6330	69750	5127	64	0.9484	09	1.0544	.14	42.68
	10	6372	53574	5252	65	0.9448	08	1.0584	.14	42.52
	20	6413	37299	5376	65	0.9413	08	1.0624	.14	42.36
	30	6455	20926	5501	66	0.9378	08	1.0664	.15	42.20
	40	6496	9.9704454	5625	66	0.9342	08	1.0704	.15	42.04
	50	6538	9.9687882	5749	66	0.9307	08	1.0745	.15	41.88
53	00	6579	71209	5873	67	0.9271	07	1.0786	.15	41.72
	10	6620	54435	5997	67	0.9235	07	1.0828	.15	41.56
	20	6662	37559	6120	68	0.9199	07	1.0870	.16	41.40
	30	6703	20579	6244	68	0.9163	07	1.0913	.16	41.24
	40	6744	9.9603495	6367	69	0.9127	07	1.0956	.16	41.07
	50	6785	9.9586307	6490	69	0.9091	07	1.0999	.16	40.91
54	00	6826	69012	6612	70	0.9055	06	1.1043	.16	40.75
	10	6866	51612	6735	70	0.9019	06	1.1088	.16	40.59
	20	6907	34104	6857	70	0.8983	06	1.1132	.17	40.42
	30	6948	9.9516488	6979	71	0.8946	06	1.1178	.17	40.26
	40	6988	9.9498763	7101	71	0.8910	06	1.1223	.17	40.09
	50	7029	80928	7222	72	0.8873	05	1.1270	.17	39.93
55	00	7069	62982	7343	72	0.8837	05	1.1316	.17	39.77
	10	7109	44924	7464	73	0.8800	05	1.1363	.18	39.60
	20	7150	26754	7585	73	0.8763	05	1.1411	.18	39.44
	30	7190	9.9408470	7705	73	0.8727	05	1.1459	.18	39.27
	40	7230	9.9390072	7826	74	0.8690	05	1.1508	.18	39.10
	50	0.1877270	71557	0.1867945	1.5374	0.8653	0.6504	1.1557	69.18	38.94

TABLE I - Continued.

Radii of Curvature of Meridians and Parallels, etc.

Latitude		log N sin 1"	log P sin 1"	log R sin 1"	Chains in 1"		Seconds in one Chain		English Miles in one Degree	
					Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
°	'						"	"		
56	00	0.1877310	9.9352927	0.1868065	1.5375	0.8616	0.6504	1.1607	69.19	38.77
	10	7350	34177	8184	75	0.8579	04	1.1657	.19	38.60
	20	7389	9.9315310	8304	76	0.8541	04	1.1708	.19	38.44
	30	7429	9.9296324	8422	76	0.8504	04	1.1759	.19	38.27
	40	7468	77216	8541	76	0.8467	03	1.1811	.19	38.10
	50	7508	57987	8659	77	0.8429	03	1.1863	.20	37.93
57	00	7547	38635	8777	77	0.8392	03	1.1916	.20	37.76
	10	7586	9.9219158	8894	78	0.8354	03	1.1970	.20	37.59
	20	7625	9.9199557	9012	78	0.8317	03	1.2024	.20	37.43
	30	7664	79829	9129	78	0.8279	03	1.2079	.20	37.26
	40	7703	59974	9245	79	0.8241	02	1.2134	.20	37.09
	50	7742	39991	9361	79	0.8203	02	1.2190	.21	36.92
58	00	7781	9.9119877	9478	80	0.8166	02	1.2247	.21	36.75
	10	7819	9.9099633	9593	80	0.8128	02	1.2304	.21	36.57
	20	7858	79257	9709	81	0.8090	02	1.2362	.21	36.40
	30	7896	58747	9824	81	0.8051	02	1.2420	.21	36.23
	40	7934	38102	0.1869938	81	0.8013	01	1.2479	.22	36.06
	50	7972	9.9017321	0.1870053	82	0.7975	01	1.2539	.22	35.89

59	00	8010	9.8996403	0167	82	0.7937	01	1.2600	.22	35.72
	10	8048	75347	0280	83	0.7898	01	1 2661	.22	35.54
	20	8086	54150	0393	83	0.7860	01	1.2723	.22	35.37
	30	8124	32812	0506	83	0.7821	01	1.2786	.23	35.20
	40	8161	9.8911331	0619	84	0.7783	00	1.2849	.23	35.02
	50	8198	9.8889706	0731	84	0.7744	00	1.2913	.23	34.85
60	00	8236	67936	0843	85	0.7705	00	1.2978	.23	34.67
	10	8273	46018	0955	85	0.7667	00	1.3044	.23	34.50
	20	8310	23952	1066	85	0.7628	00	1.3110	.23	34.32
	30	8347	9.8801735	1176	86	0.7589	0.6500	1.3177	.24	34.15
	40	8384	9.8779367	1287	86	0.7550	0.6499	1.3245	.24	33.97
	50	8420	56845	1397	86	0.7511	99	1.3314	.24	33.80
61	00	8457	34169	1506	87	0.7472	99	1.3384	.24	33.62
	10	8493	9.8711336	1615	87	0.7432	99	1.3454	.24	33.45
	20	8529	9.8688345	1724	88	0.7393	99	1.3526	.24	33.27
	30	8565	65194	1832	88	0.7354	99	1.3598	.25	33.09
	40	8601	41882	1940	88	0.7315	98	1.3671	.25	32.92
	50	8637	9.8618406	2048	89	0.7275	98	1.3745	.25	32.74
62	00	8673	9.8594766	2155	89	0.7236	98	1.3820	.25	32.56
	10	8709	70959	2262	90	0.7196	98	1.3896	.25	32.38
	20	8744	46982	2368	90	0.7156	98	1.3973	.25	32.20
	30	8779	9.8522835	2474	90	0.7117	98	1.4051	.26	32.03
	40	8814	9.8498516	2579	91	0.7077	97	1.4130	.26	31.85
	50	0.1878849	74022	0.1872684	1.5391	0.7037	0.6497	1.4210	69.26	31.67

TABLE I - Concluded.

Radii of Curvature of Meridians and Parallels, etc.

Latitude		log N sin 1"	log P sin 1"	log R sin 1"	Chains in 1"		Seconds in one Chain		English Miles in one Degree	
					Lati-tude	Longi-tude	Lati-tude	Longi-tude	Lati-tude	Longi-tude
°	'						"	"		
63	00	0.1878884	9.8449352	0.1872789	1.5391	0.6997	0.6497	1.4291	69.26	31.49
	10	8919	9.8424503	2893	92	0.6957	97	1.4373	.26	31.31
	20	8954	9.8399475	2996	92	0.6917	97	1.4456	.26	31.13
	30	8988	74262	3100	93	0.6877	97	1.4540	.27	30.95
	40	9022	48866	3202	93	0.6837	97	1.4626	.27	30.77
	50	9056	9.8323282	3305	93	0.6797	96	1.4712	.27	30.59
64	00	9090	9.8297510	3407	94	0.6757	96	1.4800	.27	30.41
	10	9124	71546	3508	94	0.6717	96	1.4888	.27	30.23
	20	9158	45389	3609	94	0.6676	96	1.4978	.27	30.04
	30	9191	9.8219035	3709	95	0.6636	96	1.5069	.28	29.86
	40	9225	9.8192482	3809	95	0.6596	96	1.5162	.28	29.68
	50	9258	65730	3909	95	0.6555	95	1.5256	.28	29.50
65	00	9291	38774	4008	96	0.6514	95	1.5351	.28	29.32
	10	9324	9.8111610	4107	96	0.6474	95	1.5447	.28	29.13
	20	9356	9.8084240	4205	96	0.6433	95	1.5544	.28	28.95
	30	9389	56659	4302	97	0.6392	95	1.5644	.29	28.77
	40	9421	28862	4399	97	0.6352	95	1.5744	.29	28.58
	50	9453	9.8000850	4496	97	0.6311	95	1.5846	.29	28.40

66	00	9485	9.7972618	4592	98	0.6270	94	1.5949	.29	28.21
	10	9517	44164	4688	98	0.6229	94	1.6054	.29	28.03
	20	9549	9.7915485	4783	98	0.6188	94	1.6160	.29	27.85
	30	9580	9.7886577	4877	99	0.6147	94	1.6268	.29	27.66
	40	9612	57439	4971	99	0.6106	94	1.6378	.30	27.48
	50	9643	9.7828065	5065	1.5399	0.6065	94	1.6489	.30	27.29
67	00	9674	9.7798454	5158	1.5400	0.6023	94	1.6602	.30	27.11
	10	9705	68602	5251	00	0.5982	93	1.6716	.30	26.92
	20	9736	38506	5343	00	0.5941	93	1.6833	.30	26.73
	30	9766	9.7708163	5434	01	0.5900	93	1.6951	.30	26.55
	40	9796	9.7677568	5525	01	0.5858	93	1.7070	.31	26.36
	50	9827	46718	5615	01	0.5817	93	1.7192	.31	26.17
68	00	9857	9.7615610	5705	02	0.5775	93	1.7316	.31	25.99
	10	9886	9.7584241	5795	02	0.5734	93	1.7441	.31	25.80
	20	9916	52605	5883	02	0.5692	92	1.7569	.31	25.61
	30	9945	9.7520699	5972	03	0.5650	92	1.7698	.31	25.43
	40	0.1879975	9.7488520	6059	03	0.5609	92	1.7830	.31	25.24
	50	0.1880004	56064	6147	03	0.5567	92	1.7964	.31	25.05
69	00	0032	9.7423324	6233	04	0.5525	92	1.8100	.32	24.86
	10	0061	9.7390298	6319	04	0.5483	92	1.8238	.32	24.67
	20	0090	56983	6405	04	0.5441	92	1.8378	.32	24.49
	30	0118	9.7323371	6490	05	0.5399	92	1.8521	.32	24.30
	40	0146	9.7289460	6574	05	0.5357	91	1.8666	.32	24.11
	50	0174	55244	6658	05	0.5315	91	1.8814	.32	23.92
70	00	0.1880202	9.7220719	0.1876741	1.5405	0.5273	0.6491	1.8964	69.32	23.73

TABLE II

Corrections to be applied to the Logarithms of R sin 1'' and N sin 1'' in Table I, for Clarke's later values of the Dimensions of the Earth

Latitude	d(log R sin 1'')	d(log N sin 1'')	Latitude	d(log R sin 1'')	d(log N sin 1'')
°			°		
42.........	-0.0000021	+0.0000063	56.........	+0.0000034	+0.0000081
43.........	17	64	57.........	37	82
44.........	13	66	58.........	41	84
45.........	09	67	59.........	45	85
46.........	05	68	60.........	48	86
47.........	-0.0000001	70	61.........	51	87
48.........	+0.0000003	71	62.........	55	88
49.........	07	72	63.........	58	89
50.........	11	74	64.........	61	90
51.........	15	75	65.........	64	91
52.........	19	76	66.........	67	92
53.........	23	77	67.........	70	93
54.........	26	79	68.........	73	94
55.........	30	80	69.........	76	95
			70.........	78	96

TABLE III

Latitudes, etc., of Base and Correction Lines. First and Second Systems of Survey.

No. of Town-ship	Number of Line	Latitude			Log N sin 1''	Log P sin 1''	Log R sin 1''	Longitude covered by 489 chains of westing	
		°	'	''				'	''
0	1st Base	49	00	00.00	0.1875572	0.0045001	0.1862852	8	03.959
2	1st Correction		10	36.86	5618	0.0029573	2988		05.681
4	2nd Base		21	13.71	5662	0.0014047	3123		07.421
6	2nd Correction		31	50.53	5707	9.9998425	3258		09.177
8	3rd Base		42	27.34	5752	9.9982704	3393		10.951
10	3rd Correction		53	04.12	5797	9.9966886	3527		12.743
12	4th Base	50	03	40.89	5842	9.9950968	3662		14.552
14	4th Correction		14	17.63	5887	9.9934951	3797		16.379
16	5th Base		24	54.36	5932	9.9918832	3931		18.225
18	5th Correction		35	31.07	5976	9.9902611	4065		20.089
20	6th Base		46	07.75	6021	9.9886289	4199		21.972
22	6th Correction		56	44.42	6065	9.9869863	4333		23.875
24	7th Base	51	07	21.07	6110	9.9853334	4466		25.796
26	7th Correction		17	57.69	6154	9.9836701	4600		27.737
28	8th Base		28	34.30	6199	9.9819962	4733		29.698
30	8th Correction		39	10.89	6244	9.9803117	4866		31.678
32	9th Base		49	47.46	6288	9.9786165	4999		33.680
34	9th Correction	52	00	24.01	6332	9.9769105	5132		35.701
36	10th Base		11	00.54	6376	9.9751935	5264		37.744
38	10th Correction		21	37.05	6420	9.9734658	5396		39.808
40	11th Base		32	13.54	6464	9.9717268	5529		41.894
42	11th Correction		42	50.02	6508	9.9699768	5660		44.001
44	12th Base		53	26.47	6552	9.9682156	5792		46.130
46	12th Correction	53	04	02.90	6596	9.9664431	5923		48.282
48	13th Base		14	39.32	0.1876640	9.9646592	0.1866055	8	50.456

TABLE IV

Latitudes, etc., of Base and Correction Lines. Third System of Survey.

No. of Town-ship	Number of Line	Latitude			Log N sin 1"	Log P sin 1"	Log R sin 1"	Longitude covered by 486 chains of westing	
		°	′	″				′	″
0	1st Base..............	49	00	00.00	0.1875572	0.0045001	0.1862852	8	00.990
2	1st Correction.........		10	29.05	5617	0.0029763	2986		02.681
4	2nd Base..............		20	58.08	5661	0.0014430	3119		04.388
6	2nd Correction		31	27.09	5706	9.9999002	3253		06.112
8	3rd Base..............		41	56.08	5750	9.9983479	3386		07.852
10	3rd Correction		52	25.06	5795	9.9967860	3519		09.610
12	4th Base	50	02	54.01	5839	9.9952144	3652		11.385
14	4th Correction		13	22.95	5883	9.9936331	3785		13.178
16	5th Base		23	51.86	5927	9.9920419	3918		14.988
18	5th Correction.........		34	20.76	5971	9.9904408	4050		16.816
20	6th Base..............		44	49.63	6016	9.9888298	4182		18.662
22	6th Correction.........		55	18.49	6060	9.9872087	4315		20.527
24	7th Base	51	05	47.33	6104	9.9855775	4447		22.411
26	7th Correction.........		16	16.15	6148	9.9839362	4578		24.313
28	8th Base		26	44.95	6192	9.9822845	4710		26.235
30	8th Correction.........		37	13.73	6235	9.9806225	4842		28.176
32	9th Base		47	42.49	6279	9.9789501	4973		30.136
34	9th Correction.........		58	11.24	6323	9.9772672	5104		32.117
36	10th Base	52	08	39.96	6366	9.9755738	5235		34.118
38	10th Correction........		19	08.66	6410	9.9738696	5366		36.139

40	11th Base..........		29	37.35	6454	9.9721546	5496		38.181
42	11th Correction......		40	06.02	6497	9.9704288	5626		40.245
44	12th Base..........		50	34.67	6540	9.9686921	5756		42.329
46	12th Correction......	53	01	03.30	6584	9.9669444	5886		44.435
48	13th Base..........		11	31.91	6627	9.9651856	6016		46.563
50	13th Correction......		22	00.50	6670	9.9634157	6145		48.714
52	14th Base..........		32	29.07	6713	9.9616344	6274		50.887
54	14th Correction......		42	57.63	6756	9.9598417	6403		53.083
56	15th Base..........		53	26.17	6799	9.9580376	6532		55.302
58	15th Correction......	54	03	54.68	6842	9.9562219	6660		57.545
60	16th Base..........		14	23.18	6884	9.9543946	6788	8	59.811
62	16th Correction......		24	51.66	6927	9.9525555	6916	9	02.102
64	17th Base..........		35	20.12	6969	9.9507045	7044		04.417
66	17th Correction......		45	48.57	7012	9.9488415	7171		06.758
68	18th Base..........		56	16.99	7054	9.9469665	7298		09.123
70	18th Correction......	55	06	45.40	7097	9.9450793	7425		11.515
72	19th Base..........		17	13.79	7139	9.9431799	7552		13.932
74	19th Correction......		27	42.16	7181	9.9412681	7678		16.376
76	20th Base..........		38	10.51	7223	9.9393438	7804		18.847
78	20th Correction......		48	38.85	7265	9.9374068	7929		21.345
80	21st Base..........		59	07.16	7306	9.9354571	8055		23.870
82	21st Correction......	56	09	35.46	7348	9.9334947	8180		26.424
84	22nd Base..........		20	03.74	7389	9.9315193	8304		29.006
86	22nd Correction		30	32.00	7431	9.9295308	8429		31.618
88	23rd Base..........	56	41	00.24	0.1877472	9.9275292	0.1868553	9	34.258

TABLE IV - Continued

Latitudes, etc., of Base and Correction Lines. Third System of Survey.

No. of Township	Number of Line	Latitude			Log N sin 1″	Log P sin 1″	Log R sin 1″	Longitude covered by 486 chains of westing	
		°	′	″				′	″
90	23rd Correction......	56	51	28.47	0.1877514	9.9255142	0.1868676	9	36.929
92	24th Base...........	57	01	56.68	7555	9.9234857	8800		39.630
94	24th Correction......		12	24.87	7596	9.9214437	8923		42.362
96	25th Base...........		22	53.04	7637	9.9193880	9045		45.125
98	25th Correction......		33	21.19	7677	9.9173186	9168		47.919
100	26th Base...........		43	49.33	7718	9.9152352	9290		50.747
102	26th Correction......		54	17.45	7759	9.9131377	9411		53.607
104	27th Base...........	58	04	45.55	7799	9.9110260	9533		56.500
106	27th Correction......		15	13.63	7839	9.9088999	9654	9	59.427
108	28th Base...........		25	41.70	7879	9.9067593	9774	10	02.389
110	28th Correction......		36	09.75	7920	9.9046041	0.1869894		05.386
112	29th Base...........		46	37.78	7960	9.9024341	0.1870014		08.418
114	29th Correction......		57	05.80	7999	9.9002491	0134		11.487
116	30th Base...........	59	07	33.79	8039	9.8980491	0253		14.592
118	30th Correction......		18	01.77	8079	9.8958338	0371		17.735
120	31st Base...........		28	29.74	8118	9.8936032	0489		20.916
122	31st Correction.....		38	57.68	8157	9.8913570	0607		24.136
124	32nd Base...........		49	25.61	8196	9.8890950	0725		27.395
126	32nd Correction.....		59	53.52	8235	9.8868172	0842		30.695
128	33rd Base...........	60	10	21.42	8274	9.8845233	0959		34.035

130	33rd Correction		20	49.30	8313	9.8822132	1075		37.416
132	34th Base		31	17.16	8352	9.8798867	1191		40.840
134	34th Correction......		41	45.00	8390	9.8775437	1306		44.307
136	35th Base		52	12.83	8429	9.8751839	1421		47.817
138	35th Correction......	61	02	40.64	8467	9.8728072	1535		51.372
140	36th Base		13	08.44	8505	9.8704133	1649		54.973
142	36th Correction......		23	36.22	8542	9.8680021	1763	10	58.619
144	37th Base	61	34	03.98	0.1878580	9.8655735	0.1871876	11	02.312
146	37th Correction......		44	31.73	8617	9.8631271	1989		06.054
148	38th Base		54	59.46	8655	9.8606628	2101		09.844
150	38th Correction......	62	05	27.18	8693	9.8581804	2213		13.683
152	39th Base		15	54.88	8730	9.8556798	2325		17.574
154	39th Correction......		26	22.56	8766	9.8531606	2436		21.516
156	40th Base		36	50.22	8803	9.8506227	2546		25.510
158	40th Correction......		47	17.87	8840	9.8480658	2656		29.558
160	41st Base		57	45.50	8876	9.8454898	2765		33.660
162	41st Correction......	63	08	13.12	8913	9.8428944	2874		37.818
164	42nd Base...........		18	40.72	8949	9.8402793	2983		42.032
166	42nd Correction		29	08.31	8985	9.8376442	3091		46.305
168	43rd Base...........		39	35.88	9021	9.8349890	3198		50.636
170	43rd Correction		50	03.44	9056	9.8323135	3305		55.027
172	44th Base	64	00	30.98	9092	9.8296174	3412	11	59.480
174	44th Correction		10	58.50	9127	9.8269004	3518	12	03.996
176	45th Base		21	26.01	9163	9.8241623	3623		08.575
178	45th Correction......		31	53.50	9198	9.8214027	3728		13.219

TABLE IV - Concluded.

Latitudes, etc., of Base and Correction Lines. Third System of Survey.

No. of Town-ship	Number of Line	Latitude			Log N sin 1"	Log P sin 1"	Log R sin 1"	Longitude covered by 486 chains of westing	
		°	'	"					
180	46th Base...........	64	42	20.98	0.1879233	9.8186215	0.1873833	12	17.929
182	46th Correction......		52	48.45	9267	9.8158183	3937		22.708
184	47th Base...........	65	03	15.90	9302	9.8129928	4040		27.556
186	47th Correction......		13	43.33	9336	9.8101448	4143		32.474
188	48th Base...........		24	10.75	9370	9.8072739	4245		37.465
190	48th Correction......		34	38.16	9404	9.8043799	4347		42.529
192	49th Base...........		45	05.55	9437	9.8014625	4448		47.668
194	49th Correction......		55	32.92	9471	9.7985213	4549		52.885
196	50th Base...........	66	06	00.28	9504	9.7955559	4649	12	58.180
198	50th Correction......		16	27.63	9538	9.7925661	4749	13	03.556
200	51st Base...........		26	54.96	9571	9.7895516	4848		09.014
202	51st Correction......		37	22.28	9604	9.7865120	4947		14.556
204	52nd Base...........		47	49.58	9636	9.7834470	5045		20.183
206	52nd Correction		58	16.87	9669	9.7803561	5142		25.898
208	53rd Base...........	67	08	44.14	9701	9.7772390	5239		31.703
210	53rd Correction		19	11.40	9733	9.7740953	5335		37.600
212	54th Base...........		29	38.65	9765	9.7709246	5431		43.591
214	54th Correction......		40	05.89	9797	9.7677266	5526		49.678
216	55th Base...........		50	33.11	9329	9.7645009	5620	13	55.864
218	55th Correction......	68	01	00.31	9860	9.7612470	5714	14	02.150

220	56th Base		11	27.51	9890	9.7579644	5808		08.539
222	56th Correction		21	54.69	9921	9.7546527	5900		15.034
224	57th Base		32	21.85	9952	9.7513117	5992		21.638
226	57th Correction		42	49.00	0.1879983	9.7479407	6084		28.352
228	58th Base		53	16.14	0.1880013	9.7445392	6175		35.179
230	58th Correction	69	03	43.27	0043	9.7411068	6265		42.124
232	59th Base		14	10.38	0073	9.7376431	6355		49.187
234	59th Correction		24	37.48	0103	9.7341475	6444	14	56.373
236	60th Base		35	04.57	0132	9.7306195	6533	15	03.684
238	60th Correction		45	31.65	0161	9.7270585	6621		11.125
240	61st Base		55	58.71	0191	9.7234641	6708		18.697
242	61st Correction	70	06	25.76	0220	9.7198356	6794		26.405
244	62nd Base		16	52.80	0.1880249	9.7161725	0.1876880	15	34.251

TABLE V

Chord Azimuths, Deflections, Deflection Offsets, etc., for Base Lines.
First and Second Systems of Survey.

No. of Base Line	Chord Azimuth	Convergence for 100 Chains	Deflection	Deflection Offset For one Chain Distance	Longitude covered by one Range	No. of Township
	° ' ''	''	' ''	inches	s.	
1	89 56 57.4	74.69	6 05.2	1.402	32.3	0
2	55.1	75.63	09.8	1.420	32.5	4
3	52.8	76.58	14.5	1.438	32.7	8
4	50.4	77.54	19.2	1.456	33.0	12
5	48.0	78.52	24.0	1.474	33.2	16
6	45.6	79.51	28.8	1.493	33.5	20
7	43.1	80.52	33.8	1.512	33.7	24
8	40.6	81.55	38.8	1.531	34.0	28
9	38.1	82.58	43.8	1.551	34.2	32
10	35.5	83.64	49.0	1.570	34.5	36
11	32.9	84.71	54.3	1.591	34.8	40
12	30.2	85.80	59.6	1.611	35.1	44
13	27.5	86.91	7 05.0	1.632	35.4	48

TABLE VI

Chord Azimuths, Deflections, Deflection Offsets, etc.,
for Base Lines.
Third System of Survey.

No. of Base Line	Chord Azimuth	Convergence for 100 Chains	Deflection	Deflection Offset For one Chain Distance	Longitude covered by one Range	No. of Township
	° ' "	"	' "	inches	s.	
1	89 56 58.5	74.69	6 03.0	1.394	32.1	0
2	56.3	75.62	07.5	1.411	32.3	4
3	54.0	76.56	12.1	1.429	32.5	8
4	51.7	77.51	16.7	1.446	32.8	12
5	49.4	78.47	21.4	1.464	33.0	16
6	46.9	79.45	26.1	1.483	33.2	20
7	44.5	80.45	31.0	1.501	33.5	24
8	42.1	81.46	35.9	1.520	33.7	28
9	39.6	82.48	40.9	1.539	34.0	32
10	37.0	83.52	45.9	1.559	34.3	36
11	34.5	84.58	51.1	1.578	34.5	40
12	31.9	85.66	56.3	1.598	34.8	44
13	29.2	86.75	7 01.6	1.619	35.1	48
14	26.5	87.85	07.0	1.639	35.4	52
15	23.8	88.98	12.5	1.661	35.7	56
16	21.0	90.13	18.0	1.682	36.0	60
17	18.2	91.30	23.7	1.704	36.3	64
18	15.3	92.48	29.5	1.726	36.6	68
19	12.3	93.69	35.3	1.748	36.9	72
20	09.4	94.92	41.3	1.771	37.3	76
21	06.3	96.17	47.4	1.795	37.6	80
22	03.2	97.44	53.6	1.818	37.9	84
23	00.1	98.74	59.9	1.843	38.3	88
24	89 55 56.9	100.06	8 06.3	1.867	38.6	92
25	53.6	101.41	12.8	1.892	39.0	96
26	50.3	102.78	19.5	1.918	39.4	100
27	46.8	104.18	26.3	1.944	39.8	104
28	43.4	105.60	33.2	1.971	40.2	108
29	39.9	107.06	40.3	1.998	40.6	112
30	36.2	108.54	47.5	2.025	41.0	116
31	32.6	110.05	54.9	2.054	41.4	120
32	28.8	111.60	9 02.4	2.083	41.8	124
33	25.0	113.18	10.0	2.112	42.3	128
34	21.1	114.79	17.9	2.142	42.7	132
35	17.1	116.44	25.9	2.173	43.2	136

TABLE VI - Concluded

Chord Azimuths, Deflections, Deflection Offsets, etc., for Base Lines.
Third System of Survey.

No. of Base Line	Chord Azimuth	Conver-gence for 100 Chains	Deflec-tion	Deflection Offset For one Chain Distance	Longitude covered by one Range	No. of Town-ship
	° ' "	"	' "	inches	s.	
36	89 55 13.0	118.12	9 34.1	2.204	43.7	140
37	08.8	119.84	42.4	2.236	44.2	144
38	04.5	121.60	51.0	2.269	44.7	148
39	00.1	123.40	59.7	2.303	45.2	152
40	89 54 55.7	125.24	10 08.7	2.337	45.7	156
41	51.1	127.13	17.8	2.372	46.2	160
42	46.4	129.06	27.2	2.408	46.8	164
43	41.6	131.04	36.9	2.445	47.4	168
44	36.6	133.07	46.7	2.483	48.0	172
45	31.6	135.15	56.8	2.522	48.6	176
46	26.4	137.28	11 07.2	2.562	49.2	180
47	21.1	139.47	17.8	2.603	49.8	184
48	15.6	141.71	28.7	2.645	50.5	188
49	10.0	144.02	39.9	2.688	51.2	192
50	04.3	146.39	51.5	2.732	51.9	198
51	89 53 58.4	148.82	12 03.3	2.777	52.6	200
52	52.3	151.33	15.5	2.824	53.3	204
53	46.0	153.90	28.0	2.872	54.1	208
54	39.6	156.56	40.9	2.921	54.9	212
55	32.9	159.29	54.1	2.972	55.7	216
56	26.1	162.10	13 07.8	3.025	56.6	220
57	19.1	165.00	21.9	3.079	57.4	224
58	11.8	167.99	36.4	3.135	58.3	228
59	04.3	171.08	51.4	3.192	59.3	232
60	89 52 56.5	174.26	14 06.9	3.252	60.2	236
61	48.5	177.56	22.9	3.313	61.2	240
62	40.3	180.96	39.5	3.377	62.3	244

TABLE VII

Chord Azimuths, Deflections, Deflection Offsets, Jogs, etc., for Correction Lines.
First and Second Systems of Survey.

No. of Correction Line	Chord Azimuth	Convergence for 100 Chains on South side of Road	Deflection	Deflection Offset for one Chain Distance	Length of one Range on Correction Line		Jog for 1 Range	Convergence or Divergence on Half Section	No. of Township
					North side of Road	South side of Road			
	° ′ ″	″	′ ″	inches	chains	chains	chains	links	
1	89 56 56.9	75.16	6 06.2	1.406	490.751	487.266	3.485	14.5	2
2	54.6	76.10	10.8	1.424	.773	.244	.529	14.7	6
3	52.3	77.06	15.5	1.442	.796	.222	.574	14.9	10
4	49.9	78.03	20.2	1.460	.818	.200	.618	15.1	14
5	47.5	79.02	25.0	1.478	.841	.177	.664	15.3	18
6	45.1	80.02	29.8	1.497	.865	.154	.711	15.5	22
7	42.7	81.03	34.7	1.516	.888	.131	.758	15.7	26
8	40.2	82.06	39.7	1.535	.913	.107	.806	15.9	30
9	37.6	83.11	44.8	1.554	.937	.083	.854	16.1	34
10	35.0	84.17	50.0	1.574	.962	.058	.904	16.3	38
11	32.4	85.26	55.2	1.594	490.987	.034	3.953	16.5	42
12	29.7	86.36	7 00.6	1.615	491.012	487.008	4.004	16.7	46

TABLE VIII

Chord Azimuths, Deflections, Deflection Offsets, Jogs, etc., for Correction Lines.
Third System of Survey.

No. of Correction Line	Chord Azimuth	Convergence for 100 Chains on South side of Road	Deflection	Deflection Offset for one Chain Distance	Length of one Range on Correction Line		Jog for 1 Range	Convergence or Divergence on Half Section	No. of Township
					North side of Road	South side of Road			
	° ′ ″	″	′ ″	inches	chains	chains	chains	links	
1	89 56 58.0	75:15	6 04.0	1.398	487.719	484.298	3.421	14.3	2
2	55.7	76.08	08.5	1.415	.740	.277	.463	14.4	6
3	53.5	77.03	13.0	1.432	.762	.255	.507	14.6	10
4	51.2	77.99	17.6	1.450	.784	.234	.550	14.8	14
5	48.8	78.96	22.3	1.468	.806	.212	.594	15.0	18
6	46.4	79.95	27.1	1.486	.829	.189	.640	15.2	22
7	44.0	80.95	31.9	1.505	.852	.167	.685	15.4	26
8	41.6	81.97	36.8	1.524	.875	.144	.731	15.5	30
9	39.1	83.00	41.8	1.543	.899	.120	.779	15.7	34
10	36.5	84.05	46.9	1.562	.923	.097	.826	15.9	38
11	34.0	85.12	52.0	1.582	.947	.072	.875	16.1	42
12	31.4	86.20	57.2	1.602	.972	.048	.924	16.4	46
13	28.7	87.30	7 02.6	1.622	487.997	484.023	3.974	16.6	50
14	26.0	88.42	07.9	1.643	488.023	483.998	4.025	16.8	54
15	23.3	89.56	13.4	1.664	.049	.972	.077	17.0	58

16	20.5	90.71	19.0	1.686	.076	.946	.130	17.2	62
17	17.7	91.89	24.7	1.707	.103	.920	.183	17.4	66
18	14.8	93.08	30.4	1.729	.130	.893	.237	17.7	70
19	11.8	94.30	36.3	1.752	.158	.865	.293	17.9	74
20	89 56 08.9	95.54	7 42.3	1.775	488.187	483.837	4.350	18.1	78
21	89 56 05.8	96.80	7 48.3	1.798	488.216	483.809	4.407	18.4	82
22	02.7	98.09	54.5	1.822	.245	.780	.465	18.6	86
23	89 55 59.6	99.40	8 00.8	1.846	.275	.750	.525	18.9	90
24	56.4	100.73	07.3	1.871	.306	.720	.586	19.1	94
25	53.1	102.09	13.8	1.896	.337	.690	.647	19.4	98
26	49.8	103.47	20.5	1.922	.369	.658	.711	19.6	102
27	46.4	104.89	27.3	1.948	.401	.627	.775	19.9	106
28	42.9	106.32	34.2	1.974	.434	.594	.840	20.2	110
29	39.4	107.79	41.3	2.001	.468	.561	.907	20.4	114
30	35.8	109.29	48.5	2.029	.503	.527	4.976	20.7	118
31	32.1	110.82	55.8	2.057	.538	.493	5.045	21.0	122
32	28.3	112.39	9 03.3	2.086	.574	.458	.116	21.3	126
33	24.5	113.98	11.0	2.116	.610	.422	.188	21.6	130
34	20.6	115.61	18.8	2.146	.648	.385	.263	21.9	134
35	16.6	117.27	26.8	2.176	.686	.347	.339	22.2	138
36	12.5	118.97	35.0	2.208	.726	.309	.416	22.6	142
37	08.3	120.71	43.4	2.240	.765	.270	.495	22.9	146
38	04.0	122.50	51.9	2.273	.806	.230	.576	23.2	150
39	89 54 59.6	124.32	10 00.7	2.306	.848	.189	.659	23.6	154
40	55.2	126.18	09.6	2.341	488.891	483.147	.744	23.9	158

TABLE VIII - Concluded

Chord Azimuths, Deflections, Deflection Offsets, Jogs, etc., for Correction Lines.
Third System of Survey.

No. of Correction Line	Chord Azimuth	Convergence for 100 Chains on South side of Road	Deflection	Deflection Offset for one Chain Distance	Length of one Range on Correction Line		Jog for 1 Range	Convergence or Divergence on Half Section	No. of Township
					North side of Road	South side of Road			
	° ' "	"	' "	inches	chains	chains	chains	links	
41	89 54 50.6	128.09	10 18.8	2.376	488.935	483.104	5.831	24.3	162
42	45.9	130.04	28.2	2.412	488.980	.060	5.920	24.7	166
43	41.1	132.05	37.8	2.449	489.026	483.015	6.011	25.0	170
44	36.1	134.10	47.7	2.487	.074	482.969	.105	25.4	174
45	31.1	136.21	57.8	2.526	.122	.922	.201	25.8	178
46	25.9	138.37	11 08.1	2.565	.172	.873	.299	26.2	182
47	20.6	140.58	18.8	2.606	.223	.823	.400	26.7	186
48	15.1	142.86	29.7	2.648	.276	.772	.503	27.1	190
49	09.5	145.19	40.9	2.691	.330	.720	.610	27.5	194
50	03.8	147.60	52.4	2.735	.385	.666	.719	28.0	198
51	89 53 57.9	150.07	12 04.2	2.781	.442	.610	.832	28.5	202
52	51.8	152.61	16.4	2.828	.501	.553	6.947	28.9	206
53	45.5	155.22	28.9	2.876	.561	.495	7.066	29.4	210
54	39.1	157.91	41.8	2.925	.623	.434	.189	30.0	214
55	32.4	160.68	55.1	2.976	.687	.372	.315	30.5	218

56	25.6	163.54	13 08.8	3.029	.753	.308	.445	31.0	222
57	18.6	166.48	22.8	3.083	.821	.242	.579	31.6	226
58	11.3	169.52	37.4	3.138	.892	.174	.718	32.2	230
59	03.8	172.66	52.4	3.196	489.964	.104	7.860	32.7	234
60	89 52 56.0	175.90	14 07.9	3.256	490.039	482.031	8.008	33.4	238
61	48.0	179.24	23.9	3.317	490.117	481.956	8.160	34.0	242

TABLE IX

Latitude, with Logarithms of Secant and Tangent for the North Boundary of each Section, and the widths of Quarter Sections on such Boundaries.
First and Second Systems of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' ''			chains
	36	49 00 00.00	0.183 06	0.060 84	40.000
1	1	00 53.07	19	0.061 06	39.988
	12	01 46.14	31	29	.976
	13	02 39.22	44	51	.964
	24	03 32.29	57	74	.952
	25	04 25.36	70	97	.940
	36	05 18.43	83	0.062 19	.928
2	1	06 11.51	96	42	.916
	12	07 04.58	0.184 09	64	.904
	13	07 57.65	22	87	.892
	24	08 50.72	35	0.063 09	.880
	25	09 43.79	48	32	.868
	36	10 36.86	60	55	{39.856 {40.146
3	1	11 29.93	73	77	.134
	12	12 23.01	86	0.064 00	.122
	13	13 16.08	99	22	.109
	24	14 09.15	0.185 12	45	.097
	25	15 02.22	25	68	.085
	36	15 55.29	38	90	.073
4	1	16 48.36	51	0.065 13	.061
	12	17 41.43	64	35	.049
	13	18 34.50	77	58	.036
	24	19 27.57	90	81	.024
	25	20 20.64	0.186 03	0.066 03	.012
	36	21 13.71	16	26	40.000
5	1	22 06.78	29	48	39.988
	12	22 59.85	42	71	.976
	13	23 52.92	55	94	.963
	24	24 45.98	68	0.067 16	.951
	25	25 39.05	81	39	.939
	36	26 32.12	94	61	.927
6	1	27 25.19	0.187 07	84	39.915
	12	28 18.26	21	0.068 07	.902
	13	29 11.33	34	29	.890
	24	30 04.40	47	52	.878
	25	30 57.46	60	75	.866
	36	31 50.53	73	97	{39.854 {40.148

TABLE IX - Continued

Latitude, with Logarithms of Secant and Tangent, etc.
First and Second Systems of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
7	1	49 32 43.60	0.187 86	0.069 20	.135
	12	33 36.67	99	42	.123
	13	34 29.74	0.188 12	65	.111
	24	35 22.80	25	88	.099
	25	36 15.87	38	0.070 10	.086
	36	37 08.94	52	33	.074
8	1	38 02.00	65	56	.062
	12	38 55.07	78	78	.049
	13	39 48.14	91	0.071 01	.037
	24	40 41.20	0.189 04	24	.025
	25	41 34.27	17	46	.012
	36	42 27.34	30	69	40.000
9	1	43 20.40	44	92	39.988
	12	44 13.47	57	0.072 14	.975
	13	45 06.54	70	37	.963
	24	45 59.60	83	60	.951
	25	46 52.67	96	82	.938
	36	47 45.73	0.190 10	0.073 05	.926
10	1	48 38.80	23	28	.914
	12	49 31.86	36	50	.901
	13	50 24.93	49	73	.889
	24	51 17.99	63	96	.877
	25	52 11.06	76	0.074 18	.864
	36	53 04.12	89	41	39.852 40.150
11	1	53 57.19	0.191 02	64	.137
	12	54 50.25	16	86	.125
	13	55 43.32	29	0.075 09	.112
	24	56 36.38	42	32	.100
	25	57 29.44	55	54	.087
	36	58 22.51	69	77	.075
12	1	49 59 15.57	82	0.076 00	40.062
	12	50 00 08.63	95	22	.050
	13	01 01.70	0.192 09	45	.037
	24	01 54.76	22	68	.025
	25	02 47.82	35	90	.013
	36	03 40.89	49	0.077 13	40.000

TABLE IX - Continued

Latitude, with Logarithms of Secant and Tangent, etc.
First and Second Systems of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
13	1	50 04 33.95	0.192 62	0.077 36	39.988
	12	05 27.01	75	59	.975
	13	06 20.08	89	81	.963
	24	07 13.14	0.193 02	0.078 04	.950
	25	08 06.20	16	27	.938
	36	08 59.26	29	49	.925
14	1	09 52.32	42	72	.913
	12	10 45.39	56	95	.900
	13	11 38.45	69	0.079 17	.888
	24	12 31.51	83	40	.875
	25	13 24.57	96	63	.863
	36	14 17.63	0.194 09	86	39.850 40.152
15	1	15 10.69	23	0.080 08	.139
	12	16 03.76	36	31	.126
	13	16 56.82	50	54	.114
	24	17 49.88	63	77	.101
	25	18 42.94	77	99	.088
	36	19 36.00	90	0.081 22	.076
16	1	20 29.06	0.195 04	45	.063
	12	21 22.12	17	67	.050
	13	22 15.18	31	90	.038
	24	23 08.24	44	0.082 13	.025
	25	24 01.30	57	36	.013
	36	24 54.36	71	58	40.000
17	1	25 47.42	85	81	39.987
	12	26 40.48	98	0.083 04	.975
	13	27 33.54	0.196 12	27	.962
	24	28 26.60	25	49	.949
	25	29 19.66	39	72	.937
	36	30 12.71	52	95	.924
18	1	31 05.77	66	0.084 18	39.911
	12	31 58.83	79	41	.899
	13	32 51.89	93	63	.886
	24	33 44.95	0.197 06	86	.873
	25	34 38.01	20	0.085 09	.861
	36	35 31.07	34	32	39.848 40.153

TABLE IX - Continued

Latitude, with Logarithms of Secant and Tangent, etc.
First and Second Systems of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
19	1	50 36 24.12	0.197 47	0.085 54	.141
	12	37 17.18	61	77	.128
	13	38 10.24	75	0.086 00	.115
	24	39 03.30	88	23	.102
	25	39 56.35	0.198 02	46	.089
	36	40 49.41	15	68	.077
20	1	41 42.47	29	91	.064
	12	42 35.53	43	0.087 14	.051
	13	43 28.58	56	37	.038
	24	44 21.64	70	59	.026
	25	45 14.70	84	82	.013
	36	46 07.75	97	0.088 05	40.000
21	1	47 00.81	0.199 11	28	39.987
	12	47 53.86	25	51	.974
	13	48 46.92	38	74	.962
	24	49 39.98	52	96	.949
	25	50 33.03	66	0.089 19	.936
	36	51 26.09	80	42	.923
22	1	52 19.14	93	65	.910
	12	53 12.20	0.200 07	88	.897
	13	54 05.25	21	0.090 10	.885
	24	54 58.31	35	33	.872
	25	55 51.36	48	56	.859
	36	56 44.42	62	79	39.846 40.155
23	1	57 37.47	76	0.091 02	.142
	12	58 30.53	90	25	.130
	13	50 59 23.58	0.201 03	47	.117
	24	51 00 16.64	17	70	.104
	25	01 09.69	31	93	.091
	36	02 02.74	45	0.092 16	.078
24	1	02 55.80	59	0.092 39	40.065
	12	03 48.85	72	62	.052
	13	04 41.91	86	84	.039
	24	05 34.96	0.202 00	0.093 07	.026
	25	06 28.01	14	30	.013
	36	07 21.07	28	53	40.000

TABLE IX - Continued

Latitude, with Logarithms of Secant and Tangent, etc.
First and Second Systems of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
25	1	51 08 14.12	0.202 42	0.093 76	39.987
	12	09 07.17	56	99	.974
	13	10 00.22	69	0.094 22	.961
	24	10 53.28	83	45	.948
	25	11 46.33	97	67	.935
	36	12 39.38	0.203 11	90	.922
26	1	13 32.43	25	0.095 13	.909
	12	14 25.49	39	36	.896
	13	15 18.54	53	59	.883
	24	16 11.59	67	82	.870
	25	17 04.64	81	0.096 05	.857
	36	17 57.70	95	28	39.844 40.157
27	1	18 50.75	0.204 08	50	.144
	12	19 43.80	22	73	.131
	13	20 36.85	36	96	.118
	24	21 29.90	50	0.097 19	.105
	25	22 22.95	64	42	.092
	36	23 16.00	78	65	.079
28	1	24 09.05	92	88	.066
	12	25 02.10	0.205 06	0.098 11	.052
	13	25 55.15	20	34	.039
	24	26 48.20	34	57	.026
	25	27 41.25	48	80	.013
	36	28 34.30	62	0.099 02	40.000
29	1	29 27.35	76	25	39.987
	12	30 20.40	90	48	.974
	13	31 13.45	0.206 04	71	.961
	24	32 06.50	19	94	.947
	25	32 59.55	33	0.100 17	.934
	36	33 52.60	47	40	.921
30	1	34 45.65	61	63	39.908
	12	35 38.70	75	86	.895
	13	36 31.75	89	0.101 09	.882
	24	37 24.79	0.207 03	32	.868
	25	38 17.84	17	55	.855
	36	51 39 10.89	0.207 31	0.101 78	39.842
41	36	52 37 31.78	0.216 80	0.116 99	39.918

TABLE IX - Continued

Latitude, with Logarithms of Secant and Tangent, etc.
First and Second Systems of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
42	1	52 38 24.82	0.216 94	0.117 22	.904
	12	39 17.86	0.217 09	45	.891
	13	40 10.90	23	69	.877
	24	41 03.94	38	92	.863
	25	41 56.98	53	0.118 15	.850
	36	42 50.02	67	38	39.836 40.166
43	1	43 43.05	82	61	.152
	12	44 36.09	97	84	.138
	13	45 29.13	0.218 11	0.119 08	.124
	24	46 22.17	26	31	.110
	25	47 15.21	41	54	.097
	36	48 08.24	56	77	.083
44	1	49 01.28	70	0.120 00	.069
	12	49 54.32	85	23	.055
	13	50 47.36	0.219 00	47	.041
	24	51 40.39	14	70	.028
	25	52 33.43	29	93	.014
	36	53 26.47	44	0.121 16	40.000
45	1	54 19.50	59	39	39.986
	12	55 12.54	73	63	.972
	13	56 05.58	88	86	.959
	24	56 58.61	0.220 03	0.122 09	.945
	25	57 51.65	18	32	.931
	36	58 44.69	33	56	.917
46	1	52 59 37.72	47	79	39.903
	12	53 00 30.76	62	0.123 02	.889
	13	01 23.79	77	25	.876
	24	02 16.83	92	49	.862
	25	03 09.87	0.221 07	72	.848
	36	04 02.90	22	95	39.834 40.168
47	1	04 55.94	37	0.124 18	.154
	12	05 48.97	51	42	.140
	13	06 42.01	66	65	.126
	24	07 35.04	81	88	.112
	25	08 28.08	96	0.125 11	.098
	36	09 21.11	0.222 11	35	.084

TABLE IX - Concluded

Latitude, with Logarithms of Secant and Tangent, etc.
First and Second Systems of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
48	1	53 10 14.15	0. 222 26	0. 125 58	.070
	12	11 07.18	41	81	.056
	13	12 00.21	56	0.126 04	.042
	24	12 53.25	71	28	.028
	25	13 46.28	86	51	.014
	36	14 39.32	0.223 00	74	40.000

TABLE X

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ′ ″			chains
	36	49 00 00.00	0.183 06	0.060 84	40.000
1	1	00 52.75	19	0.061 06	39.988
	12	01 44.84	31	28	.976
	13	02 37.59	44	51	.965
	24	03 29.69	57	73	.953
	25	04 22.43	69	95	.941
	36	05 14.53	82	0.062 17	.929
2	1	06 07.27	95	40	.917
	12	06 59.37	0.184 08	62	.905
	13	07 52.11	20	85	.894
	24	08 44.21	33	0.063 07	.882
	25	09 36.96	46	29	.870
	36	10 29.05	59	51	39.858 40.143
3	1	11 21.80	71	74	.131
	12	12 13.89	84	96	.119
	13	13 06.63	97	0.064 18	.107
	24	13 58.73	0.185 10	41	.095
	25	14 51.47	23	63	.084
	36	15 43.57	35	85	.072
4	1	16 36.31	48	0.065 08	.060
	12	17 28.41	61	30	.048
	13	18 21.15	74	52	.036
	24	19 13.24	87	74	.024
	25	20 05.99	0.186 00	97	.012
	36	20 58.08	12	0.066 19	40.000
5	1	21 50.82	25	42	39.988
	12	22 42.92	38	64	.976
	13	23 35.66	51	86	.964
	24	24 27.75	64	0.067 08	.952
	25	25 20.50	77	31	.940
	36	26 12.59	90	53	.928
6	1	27 05.33	0.187 03	76	.916
	12	27 57.42	15	98	.904
	13	28 50.17	28	0.068 20	.892
	24	29 42.26	41	43	.880
	25	30 35.00	54	65	.868
	36	31 27.09	67	87	39.856 40.145

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
7	1	49 32 19.83	0.187 80	0.069 10	40.133
	12	33 11.92	93	32	.121
	13	34 04.67	0.188 06	54	.109
	24	34 56.76	19	77	.097
	25	35 49.50	32	99	.085
	36	36 41.59	45	0.070 21	.073
8	1	37 34.33	58	44	.060
	12	38 26.42	71	66	.048
	13	39 19.16	84	89	.036
	24	40 11.25	97	0.071 11	.024
	25	41 03.99	0.189 10	33	.012
	36	41 56.08	23	56	40.000
9	1	42 48.82	36	78	39.988
	12	43 40.91	49	0.072 00	.976
	13	44 33.65	62	23	.964
	24	45 25.74	75	45	.951
	25	46 18.48	88	68	.939
	36	47 10.57	0.190 01	90	.927
10	1	48 03.31	14	0.073 12	.915
	12	48 55.40	27	35	.903
	13	49 48.14	40	57	.891
	24	50 40.23	53	79	.879
	25	51 32.97	66	0.074 02	.867
	36	52 25.06	79	24	39.855 40.147
11	1	53 17.80	93	47	.135
	12	54 09.88	0.191 06	69	.122
	13	55 02.62	19	92	.110
	24	55 54.71	32	0.075 14	.098
	25	56 47.45	45	36	.086
	36	57 39.54	58	59	.073
12	1	58 32.27	71	81	.061
	12	59 24.36	84	0.076 03	.049
	13	50 00 17.10	98	26	.037
	24	01 09.19	0.192 11	48	.024
	25	02 01.92	24	71	.012
	36	02 54.01	37	93	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
13	1	50 03 46.75	0.192 50	0.077 16	39.988
	12	04 38.83	63	38	.975
	13	05 31.57	77	60	.963
	24	06 23.66	90	83	.951
	25	07 16.39	0.193 03	0.078 05	.939
	36	08 08.48	16	28	.926
14	1	09 01.22	29	50	.914
	12	09 53.30	43	72	.902
	13	10 46.04	56	95	.890
	24	11 38.12	69	0.079 17	.877
	25	12 30.86	82	40	.865
	36	13 22.95	96	62	39.853 40.149
15	1	14 15.68	0.194 09	85	.136
	12	15 07.77	22	0.080 07	.124
	13	16 00.50	35	30	.112
	24	16 52.59	49	52	.099
	25	17 45.32	62	75	.087
	36	18 37.41	75	97	.074
16	1	19 30.14	89	0.081 20	.062
	12	20 22.22	0.195 02	42	.050
	13	21 14.96	15	64	.037
	24	22 07.04	28	87	.025
	25	22 59.78	42	0.082 09	.012
	36	23 51.86	55	32	40.000
17	1	24 44.59	69	54	39.988
	12	25 36.68	82	77	.975
	13	26 29.41	95	99	.963
	24	27 21.49	0.196 09	0.083 22	.950
	25	28 14.23	22	44	.938
	36	29 06.31	35	67	.925
18	1	29 59.04	49	89	.913
	12	30 51.13	62	0.084 11	.901
	13	31 43.86	76	34	.888
	24	32 35.94	89	56	.876
	25	33 28.67	0.197 02	79	.863
	36	34 20.76	16	0.085 01	39.851 40.150

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			**chains**
19	1	50 35 13.49	0.197 29	0.085 24	40.138
	12	36 05.57	43	46	.125
	13	36 58.30	56	69	.113
	24	37 50.38	69	91	.100
	25	38 43.12	83	0.086 14	.088
	36	39 35.20	96	36	.075
20	1	40 27.93	0.198 10	59	.063
	12	41 20.01	23	81	.050
	13	42 12.74	37	0.087 04	.038
	24	43 04.82	50	26	.025
	25	43 57.55	64	49	.013
	36	44 49.63	77	72	40.000
21	1	45 42.36	91	94	39.987
	12	46 34.44	0.199 04	0.088 17	.975
	13	47 27.18	18	39	.962
	24	48 19.26	31	62	.950
	25	49 11.99	45	84	.937
	36	50 04.07	58	0.089 07	.925
22	1	50 56.80	72	29	.912
	12	51 48.87	85	52	.899
	13	52 41.60	99	74	.887
	24	53 33.68	0.200 13	97	.874
	25	54 26.41	26	0.090 20	.862
	36	55 18.49	40	42	39.849 40.152
23	1	56 11.22	53	65	.140
	12	57 03.30	67	87	.127
	13	57 56.03	81	0.091 10	.114
	24	58 48.11	94	32	.102
	25	59 40.83	0.201 08	55	.089
	36	51 00 32.91	21	77	.076
24	1	01 25.64	35	0.092 00	.064
	12	02 17.72	49	22	.051
	13	03 10.45	62	45	.038
	24	04 02.52	76	68	.025
	25	04 55.25	90	90	.013
	36	05 47.33	0.202 03	0.093 13	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
25	1	51 06 40.06	0.202 17	0.093 35	39.987
	12	07 32.13	31	58	.975
	13	08 24.86	44	81	.962
	24	09 16.94	58	0.094 03	.949
	25	10 09.67	72	26	.936
	36	11 01.74	85	48	.924
26	1	11 54.47	99	71	.911
	12	12 46.54	0.203 13	93	.898
	13	13 39.27	27	0.095 16	.885
	24	14 31.35	40	39	.873
	25	15 24.07	54	61	.860
	36	16 16.15	68	84	39.847 40.154
27	1	17 08.87	82	0.096 07	.141
	12	18 00.95	95	29	.129
	13	18 53.68	0.204 09	52	.116
	24	19 45.75	23	74	.103
	25	20 38.48	37	97	.090
	36	21 30.55	51	0.097 19	.077
28	1	22 23.28	64	42	.064
	12	23 15.35	78	65	.051
	13	24 08.08	92	87	.039
	24	25 00.15	0.205 06	0.098 10	.026
	25	25 52.87	20	33	.013
	36	26 44.95	33	55	40.000
29	1	27 37.67	47	78	39.987
	12	28 29.75	61	0.099 00	.974
	13	29 22.47	75	23	.961
	24	30 14.54	89	46	.948
	25	31 07.27	0.206 03	69	.936
	36	31 59.34	17	91	.923
30	1	32 52.07	31	0.100 14	.910
	12	33 44.14	44	36	.897
	13	34 36.86	58	59	.884
	24	35 28.93	72	82	.871
	25	36 21.66	86	0.101 05	.858
	36	37 13.73	0.207 00	27	39.845 40.156

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			**chains**
31	1	51 38 06.45	0.207 14	0.101 50	40.143
	12	38 58.52	28	72	.130
	13	39 51.25	42	95	.117
	24	40 43.32	56	0.102 18	.104
	25	41 36.04	70	41	.091
	36	42 28.11	84	63	.078
32	1	43 20.83	98	86	.065
	12	44 12.91	0.208 12	0.103 08	.052
	13	45 05.63	26	31	.039
	24	45 57.70	40	54	.026
	25	46 50.42	54	77	.013
	36	47 42.49	68	99	40.000
33	1	48 35.21	82	0.104 22	39.987
	12	49 27.28	96	45	.974
	13	50 20.00	0.209 10	67	.961
	24	51 12.07	24	90	.948
	25	52 04.80	38	0.105 13	.935
	36	52 56.87	52	35	.922
34	1	53 49.59	66	58	.909
	12	54 41.66	80	81	.896
	13	55 34.38	94	0.106 04	.883
	24	56 26.45	0.210 08	26	.869
	25	57 19.17	22	49	.856
	36	58 11.24	36	72	39.843 40.158
35	1	59 03.95	51	95	.145
	12	59 56.02	65	0.107 17	.132
	13	52 00 48.74	79	40	.119
	24	01 40.81	93	63	.106
	25	02 33.53	0.211 07	86	.092
	36	03 25.60	21	0.108 08	.079
36	1	04 18.32	36	31	.066
	12	05 10.39	50	54	.053
	13	06 03.10	64	77	.040
	24	06 55.17	78	99	.026
	25	07 47.89	92	0.109 22	.013
	36	08 39.96	0.212 06	45	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ′ ″			chains
37	1	52 09 32.68	0.212 21	0.109 68	39.987
	12	10 24.74	35	90	.974
	13	11 17.46	49	0.110 13	.960
	24	12 09.53	63	36	.947
	25	13 02.25	77	59	.934
	36	13 54.31	92	81	.921
38	1	14 47.03	0.213 06	0.111 04	.907
	12	15 39.10	20	27	.894
	13	16 31.81	34	50	.881
	24	17 23.88	49	73	.868
	25	18 16.60	63	96	.855
	36	19 08.66	77	0.112 18	39.841 40.160
39	1	20 01.38	92	41	.147
	12	20 53.45	0.214 06	64	.134
	13	21 46.16	20	87	.120
	24	22 38.23	34	0.113 09	.107
	25	23 30.94	49	32	.093
	36	24 23.01	63	55	.080
40	1	25 15.72	77	78	.067
	12	26 07.79	92	0.114 01	.053
	13	27 00.51	0.215 06	24	.040
	24	27 52.57	20	46	.027
	25	28 45.29	35	69	.013
	36	29 37.35	49	92	40.000
41	1	30 30.06	64	0.115 15	39.987
	12	31 22.13	78	38	.973
	13	32 14.84	92	61	.960
	24	33 06.91	0.216 07	83	.946
	25	33 59.62	21	0.116 06	.933
	36	34 51.69	35	29	.920
42	1	35 44.40	50	52	.906
	12	36 36.46	64	75	.893
	13	37 29.18	79	98	.879
	24	38 21.24	93	0.117 21	.866
	25	39 13.95	0.217 08	44	.853
	36	40 06.02	22	66	39.839 40.162

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
43	1	52 40 58.73	0.217 37	0.117 89	40.149
	12	41 50.79	51	0.118 12	.135
	13	42 43.51	66	35	.122
	24	43 35.57	80	58	.108
	25	44 28.28	95	81	.095
	36	45 20.35	0.218 09	0.119 04	.081
44	1	46 13.06	24	27	.068
	12	47 05.12	38	49	.054
	13	47 57.83	53	73	.041
	24	48 49.89	67	95	.027
	25	49 42.61	82	0.120 18	.014
	36	50 34.67	96	41	40.000
45	1	51 27.38	0.219 11	64	39.986
	12	52 19.44	25	87	.973
	13	53 12.15	40	0.121 10	.959
	24	54 04.21	54	33	.946
	25	54 56.92	69	56	.932
	36	55 48.98	84	79	.919
46	1	56 41.69	98	0.122 02	.905
	12	57 33.76	0.220 13	25	.891
	13	58 26.47	28	48	.878
	24	59 18.53	42	70	.864
	25	53 00 11.24	57	93	.851
	36	01 03.30	71	0.123 16	39.837 40.164
47	1	01 56.01	86	39	.151
	12	02 48.07	0.221 01	62	.137
	13	03 40.78	15	85	.123
	24	04 32.84	30	0.124 08	.110
	25	05 25.55	45	31	.096
	36	06 17.61	59	54	.082
48	1	07 10.31	74	77	.068
	12	08 02.37	89	0.125 00	.055
	13	08 55.08	0.222 04	23	.041
	24	09 47.14	18	46	.027
	25	10 39,85	33	69	.014
	36	11 31.91	48	92	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			**chains**
49	1	53 12 24.62	0.222 63	0.126 15	39.986
	12	13 16.67	77	38	.973
	13	14 09.38	92	61	.959
	24	15 01.44	0.223 07	84	.945
	25	15 54.15	22	0.127 07	.931
	36	16 46.21	36	30	.918
50	1	17 38.91	51	53	.904
	12	18 30.97	66	76	.890
	13	19 23.68	81	99	.876
	24	20 15.74	96	0.128 22	.863
	25	21 08.44	0.224 10	45	.849
	36	22 00.50	25	68	39.835 40.166
51	1	22 53.21	40	91	.153
	12	23 45.26	55	0.129 14	.139
	13	24 37.97	70	37	.125
	24	25 30.03	85	60	.111
	25	26 22.73	0.225 00	83	.097
	36	27 14.79	14	0.130 06	.083
52	1	28 07.50	29	30	.069
	12	28 59.55	44	53	.055
	13	29 52.26	59	76	.042
	24	30 44.31	74	99	.028
	25	31 37.02	89	0.131 22	.014
	36	32 29.07	0.226 04	45	40.000
53	1	33 21.78	19	68	39.986
	12	34 13.83	34	91	.972
	13	35 06.54	49	0.132 14	.958
	24	35 58.59	63	37	.944
	25	36 51.30	79	60	.930
	36	37 43.35	93	83	.917
54	1	38 36.06	0.227 08	0.133 07	.903
	12	39 28.11	23	30	.889
	13	40 20.82	38	53	.875
	24	41 12.87	53	76	.861
	25	42 05.58	68	99	.847
	36	42 57.63	83	0.134 22	39.833 40.169

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
55	1	53 43 50.33	0.227 99	0.134 45	40.155
	12	44 42.39	0.228 13	68	.140
	13	45 35.09	29	91	.126
	24	46 27.14	44	0.135 14	.112
	25	47 19.85	59	38	.098
	36	48 11.90	74	61	.084
56	1	49 04.60	89	84	.070
	12	49 56.65	0.229 04	0.136 07	.056
	13	50 49.36	19	30	.042
	24	51 41.41	34	53	.028
	25	52 34.11	49	77	.014
	36	53 26.17	64	0.137 00	40.000
57	1	54 18.87	79	23	39.986
	12	55 10.92	95	46	.972
	13	56 03.62	0.230 10	69	.958
	24	56 55.67	25	92	.944
	25	57 48.37	40	0.138 16	.930
	36	58 40.43	55	39	.915
58	1	59 33.13	70	62	.901
	12	54 00 25.18	85	85	.887
	13	01 17.88	0.231 01	0.139 08	.873
	24	02 09.93	16	31	.859
	25	03 02.63	31	55	.845
	36	03 54.68	46	78	{39.831 {40.171
59	1	04 47.38	62	0.140 01	.157
	12	05 39.43	77	24	.142
	13	06 32.13	92	48	.128
	24	07 24.18	0.232 07	71	.114
	25	08 16.88	23	94	.100
	36	09 08.93	38	0.141 17	.085
60	1	10 01.63	53	41	.071
	12	10 53.68	68	64	.057
	13	11 46.38	84	87	.043
	24	12 38.43	99	0.142 10	.028
	25	13 31.13	0.233 14	34	.014
	36	14 23.18	29	57	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
61	1	54 15 15.88	0.233 45	0.142 80	39.986
	12	16 07.93	60	0.143 03	.971
	13	17 00.63	75	27	.957
	24	17 52.68	91	50	.943
	25	18 45.38	0.234 06	73	.929
	36	19 37.42	21	96	.914
62	1	20 30.12	37	0.144 20	.900
	12	21 22.17	52	43	.886
	13	22 14.87	68	66	.872
	24	23 06.92	83	89	.857
	25	23 59.62	98	0.145 13	.843
	36	24 51.66	0.235 14	36	39.829 40.173
63	1	25 44.36	29	59	.159
	12	26 36.41	45	83	.144
	13	27 29.10	60	0.146 06	.130
	24	28 21.15	75	29	.115
	25	29 13.85	91	53	.101
	36	30 05.90	0.236 06	76	.086
64	1	30 58.59	22	99	.072
	12	31 50.64	37	0.147 22	.058
	13	32 43.34	53	46	.043
	24	33 35.38	68	69	.029
	25	34 28.08	84	93	.014
	36	35 20.12	99	0.148 16	40.000
65	1	36 12.82	0.237 15	39	39.986
	12	37 04.87	30	63	.971
	13	37 57.56	46	86	.957
	24	38 49.61	61	0.149 09	.942
	25	39 42.30	77	33	.928
	36	40 34.35	92	56	.913
66	1	41 27.04	0.238 08	80	.899
	12	42 19.09	24	0.150 03	.884
	13	43 11.78	39	26	.870
	24	44 03.83	55	50	.856
	25	44 56.52	70	73	.841
	36	45 48.57	86	96	39.827 40.175

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ′ ″			chains
67	1	54 46 41.26	0.239 02	0.151 20	40.161
	12	47 33.31	17	43	.146
	13	48 26.00	33	67	.131
	24	49 18.04	49	90	.117
	25	50 10.74	64	0.152 14	.102
	36	51 02.78	80	37	.088
68	1	51 55.48	96	60	.073
	12	52 47.52	0.240 11	84	.058
	13	53 40.21	27	0.153 07	.044
	24	54 32.26	43	31	.029
	25	55 24.95	58	54	.015
	36	56 16.99	74	77	40.000
69	1	57 09.69	90	0.154 01	39.985
	12	58 01.73	0.241 05	24	.971
	13	58 54.42	21	48	.956
	24	59 46.46	37	71	.941
	25	55 00 39.16	53	95	.927
	36	01 31.20	68	0.155 18	.912
70	1	02 23.89	84	42	.898
	12	03 15.93	0.242 00	65	.883
	13	04 08.62	16	89	.868
	24	05 00.67	31	0.156 12	.854
	25	05 53.36	47	36	.839
	36	06 45.40	63	59	39.824 40.177
71	1	07 38.09	79	83	.163
	12	08 30.13	95	0.157 06	.148
	13	09 22.82	0.243 11	30	.133
	24	10 14.86	26	53	.118
	25	11 07.56	42	77	.104
	36	11 59.60	58	0.158 00	.089
72	1	12 52.29	74	24	.074
	12	13 44.33	90	47	.059
	13	14 37.02	0.244 06	71	.044
	24	15 29.06	22	94	.030
	25	16 21.75	38	0.159 18	.015
	36	17 13.79	53	41	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
73	1	55 18 06.48	0.244 69	0.159 65	39.985
	12	18 58.52	85	89	.970
	13	19 51.21	0.245 01	0.160 12	.956
	24	20 43.25	17	36	.941
	25	21 35.94	33	59	.926
	36	22 27.98	49	83	.911
74	1	23 20.67	65	0.161 07	.896
	12	24 12.70	81	30	.881
	13	25 05.39	97	54	.867
	24	25 57.43	0.246 13	77	.852
	25	26 50.12	29	0.162 01	.837
	36	27 42.16	45	24	39.822 40.180
75	1	28 34.85	61	48	.165
	12	29 26.89	77	72	.150
	13	30 19.57	93	95	.135
	24	31 11.61	0.247 09	0.163 19	.120
	25	32 04.30	25	43	.105
	36	32 56.34	41	66	.090
76	1	33 49.02	57	90	.075
	12	34 41.06	73	0.164 13	.060
	13	35 33.75	90	37	.045
	24	36 25.79	0.248 06	61	.030
	25	37 18.47	22	85	.015
	36	38 10.51	38	0.165 08	40.000
77	1	39 03.20	54	32	39.985
	12	39 55.23	70	55	.970
	13	40 47.92	86	79	.955
	24	41 39.96	0.249 02	0.166 03	.940
	25	42 32.64	19	27	.925
	36	43 24.68	35	50	.910
78	1	44 17.37	51	74	.895
	12	45 09.40	67	97	.880
	13	46 02.09	83	0.167 21	.865
	24	46 54.12	0.250 00	45	.850
	25	47 46.81	16	69	.835
	36	48 38.85	32	92	39.820 40.182

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
					chains
79	1	55 49 31.53	0.250 48	0.168 16	40.167
	12	50 23.57	64	40	.152
	13	51 16.25	81	64	.137
	24	52 08.29	97	87	.122
	25	53 00.97	0.251 13	0.169 11	.106
	36	53 53.01	30	35	.091
80	1	54 45.69	46	59	.076
	12	55 37.72	62	82	.061
	13	56 30.41	79	0.170 06	.046
	24	57 22.44	95	30	.030
	25	58 15.13	0.252 11	54	.015
	36	59 07.16	27	77	40.000
81	1	59 59.84	44	0.171 01	39.985
	12	56 00 51.88	60	25	.970
	13	01 44.56	77	49	.954
	24	02 36.60	93	72	.939
	25	03 29.28	0.253 09	96	.924
	36	04 21.31	26	0.172 20	.909
82	1	05 14.00	42	44	.893
	12	06 06.03	58	68	.878
	13	06 58.71	75	92	.863
	24	07 50.74	91	0.173 15	.848
	25	08 43.43	0.254 08	39	.833
	36	09 35.46	24	63	39.817 40.185
83	1	10 28.14	41	87	.169
	12	11 20.17	57	0.174 11	.154
	13	12 12.86	74	35	.138
	24	13 04.89	90	58	.123
	25	13 57.57	0.255 06	82	.108
	36	14 49.60	23	0.175 06	.092
84	1	15 42.28	39	30	.077
	12	16 34.31	56	54	.062
	13	17 27.00	72	78	.046
	24	18 19.03	89	0.176 01	.031
	25	19 11.71	0.256 06	26	.015
	36	20 03.74	22	49	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ′ ″			chains
85	1	56 20 56.42	0.256 39	0.176 73	39.985
	12	21 48.45	55	97	.969
	13	22 41.13	72	0.177 21	.954
	24	23 33.16	88	45	.938
	25	24 25.84	0.257 05	69	.923
	36	25 17.87	21	93	.908
86	1	26 10.55	38	0.178 17	.892
	12	27 02.58	55	41	.877
	13	27 55.26	71	65	.861
	24	28 47.29	88	88	.846
	25	29 39.97	0.258 05	0.179 13	.830
	36	30 32.00	21	36	{39.815 {40.187
87	1	31 24.68	38	60	.171
	12	32 16.71	55	84	.156
	13	33 09.39	71	0.180 08	.140
	24	34 01.42	88	32	.125
	25	34 54.10	0.259 05	56	.109
	36	35 46.12	21	80	.093
88	1	36 38.80	38	0.181 04	.078
	12	37 30.83	55	28	.062
	13	38 23.51	72	52	.047
	24	39 15.54	88	76	.031
	25	40 08.21	0.260 05	0.182 00	.015
	36	41 00.24	22	24	40.000
89	1	41 52.92	39	48	39.984
	12	42 44.95	55	72	.969
	13	43 37.63	72	96	.953
	24	44 29.65	89	0.183 20	.937
	25	45 22.33	0.261 06	44	.922
	36	46 14.36	23	68	.906
90	1	47 07.03	40	93	.891
	12	47 59.06	56	0.184 16	.875
	13	48 51.74	73	41	.859
	24	49 43.76	90	65	.844
	25	50 36.44	0.262 07	89	.828
	36	51 28.47	24	0.185 13	{39.813 {40.190

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ′ ″			chains
91	1	56 52 21.14	0.262 41	0.185 37	40.174
	12	53 13.17	58	61	.158
	13	54 05.85	75	85	.142
	24	54 57.87	91	0.186 09	.126
	25	55 50.55	0.263 08	33	.111
	36	56 42.57	25	57	.095
92	1	57 35.25	42	82	.079
	12	58 27.27	59	0.187 06	.063
	13	59 19.95	76	30	.047
	24	57 00 11.98	93	54	.032
	25	01 04.65	0.264 10	78	.016
	36	01 56.68	27	0.188 02	40.000
93	1	02 49.35	44	26	39.984
	12	03 41.38	61	50	.968
	13	04 34.05	78	75	.953
	24	05 26.07	95	99	.937
	25	06 18.75	0.265 12	0.189 23	.921
	36	07 10.77	29	47	.905
94	1	08 03.45	46	71	.889
	12	08 55.47	63	95	.873
	13	09 48.14	80	0.190 20	.858
	24	10 40.17	97	44	.842
	25	11 32.84	0.266 15	68	.826
	36	12 24.87	32	92	39.810 40.192
95	1	13 17.54	49	0.191 17	.176
	12	14 09.56	66	41	.160
	13	15 02.24	83	65	.144
	24	15 54.26	0.267 00	89	.128
	25	16 46.93	17	0.192 13	.112
	36	17 38.95	34	38	.096
96	1	18 31.63	52	62	.080
	12	19 23.65	69	86	.064
	13	20 16.32	86	0.193 10	.048
	24	21 08.34	0.268 03	35	.032
	25	22 01.02	20	59	.016
	36	22 53.04	38	83	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
97	1	57 23 45.71	0.268 55	0.194 07	39.984
	12	24 37.73	72	32	.968
	13	25 30.40	89	56	.952
	24	26 22.42	0.269 07	80	.936
	25	27 15.10	24	0.195 05	.920
	36	28 07.12	41	29	.904
98	1	28 59.79	58	53	.888
	12	29 51.81	76	77	.872
	13	30 44.48	93	0.196 02	.856
	24	31 36.50	0.270 10	26	.840
	25	32 29.17	28	51	.824
	36	33 21.19	45	75	39.808 40.195
99	1	34 13.86	62	99	.178
	12	35 05.88	80	0.197 24	.162
	13	35 58.55	97	48	.146
	24	36 50.57	0.271 14	72	.130
	25	37 43.24	32	97	.114
	36	38 35.26	49	0.198 21	.097
100	1	39 27.93	67	45	.081
	12	40 19.95	84	70	.065
	13	41 12.62	0.272 01	94	.049
	24	42 04.64	19	0.199 19	.032
	25	42 57.31	36	43	.016
	36	43 49.33	54	67	40.000
101	1	44 42.00	71	92	39.984
	12	45 34.02	89	0.200 16	.968
	13	46 26.69	0.273 06	41	.951
	24	47 18.70	24	65	.935
	25	48 11.37	41	90	.919
	36	49 03.39	59	0.201 14	.902
102	1	49 56.06	76	39	.886
	12	50 48.08	94	63	.870
	13	51 40.74	0.274 11	87	.854
	24	52 32.76	29	0.202 12	.837
	25	53 25.43	46	36	.821
	36	54 17.45	64	61	39.805 40.197

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
103	1	57 55 10.12	0.274 82	0.202 85	40.181
	12	56 02.13	99	0.203 10	.165
	13	56 54.80	0.275 17	34	.148
	24	57 46.82	34	59	.132
	25	58 39.48	52	83	.115
	36	59 31.50	69	0.204 08	.099
104	1	58 00 24.17	87	32	.082
	12	01 16.18	0.276 05	57	.066
	13	02 08.85	23	81	.049
	24	03 00.87	40	0.205 06	.033
	25	03 53.53	58	31	.017
	36	04 45.55	75	55	40.000
105	1	05 38.22	93	80	39.984
	12	06 30.23	0.277 11	0.206 04	.967
	13	07 22.90	29	29	.951
	24	08 14.91	46	53	.934
	25	09 07.58	64	78	.918
	36	09 59.59	82	0.207 02	.901
106	1	10 52.26	0.278 00	27	.885
	12	11 44.27	17	52	.868
	13	12 36.94	35	76	.852
	24	13 28.95	53	0.208 01	.835
	25	14 21.62	71	26	.819
	36	15 13.63	88	50	39.802 40.200
107	1	16 06.30	0.279 06	75	.183
	12	16 58.31	24	99	.167
	13	17 50.98	42	0.209 24	.150
	24	18 42.99	60	49	.133
	25	19 35.66	78	73	.117
	36	20 27.67	95	98	.100
108	1	21 20.33	0.280 13	0.210 23	.083
	12	22 12.35	31	47	.067
	13	23 05.01	49	72	.050
	24	23 57.02	67	97	.033
	25	24 49.69	85	0.211 22	.017
	36	25 41.70	0.281 03	46	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
109	1	58 26 34.36	0.281 21	0.211 71	39.983
	12	27 26.38	39	95	.967
	13	28 19.04	57	0.212 20	.950
	24	29 11.05	75	45	.933
	25	30 03.72	93	70	.916
	36	30 55.73	0.282 11	94	.900
110	1	31 48.39	29	0.213 19	.883
	12	32 40.40	47	44	.866
	13	33 33.06	65	69	.850
	24	34 25.08	83	93	.833
	25	35 17.74	0.283 01	0.214 18	.816
	36	36 09.75	19	43	(39.800 (40.203
111	1	37 02.41	37	68	.186
	12	37 54.42	55	93	.169
	13	38 47.08	73	[illegible]	.152
	24	39 39.10	21	42	.135
	25	40 31.76	0.28[illegible] 40	67	[illegible]
	36	41 23.77	59	92	.101
112	1	42 16.43	[illegible]	0.216 17	.085
	12	43 08.44	[illegible] 64	41	.068
	13	46 [illegible]	[illegible] 82	66	.051
	24	44 53.1[illegible]	0.285 00	91	.034
	25	45 45.77	18	0.217 16	.017
	36	46 37.78	36	41	40.000
113	1	47 30.44	55	66	39.983
	12	48 22.45	73	91	.966
	13	49 15.11	91	0.218 16	.949
	24	50 07.12	0.286 09	40	.932
	25	50 59.78	27	65	.915
	36	51 51.79	45	90	.898
114	1	52 44.45	64	0.219 15	.881
	12	53 36.46	82	40	.865
	13	54 29.12	0.287 00	65	.848
	24	55 21.13	18	90	.831
	25	56 13.79	37	0.220 15	.814
	36	57 05.80	55	40	(39 797 (40.206

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
115	1	58 57 58.45	0.287 73	0.220 65	40.189
	12	58 50.46	92	89	.171
	13	59 43.12	0.288 10	0.221 15	.154
	24	59 00 35.13	28	39	.137
	25	01 27.79	47	65	.120
	36	02 19.80	65	89	.103
116	1	03 12.45	84	0.222 14	.086
	12	04 04.46	0.289 02	39	.069
	13	04 57.12	20	64	.051
	24	05 49.13	39	89	.034
	25	06 41.79	57	0.223 14	.017
	36	07 33.79	75	39	40.000
117	1	08 26.45	94	64	39.983
	12	09 18.46	0.290 12	89	.966
	13	10 11.11	31	0.224 15	.948
	[illegible]	11 03.12	49	39	.931
	[illegible]	09 05.78	68	65	.914
	36	09 57.78	86	90	.897
118	1	10 50.44	0.291 05	0.225 15	.880
	12	14 42.45	23	40	.863
	13	15 36.10	42	65	.845
	24	16 18.11	63	90	.828
	25	17 09.77	79	0.226 44	.811
	36	18 01.77	97	40	{39.794 {40.209
119	1	18 54.43	0.292 16	65	.191
	12	19 46.43	35	90	.174
	13	20 39.09	53	0.227 15	.156
	24	21 31.10	72	40	.139
	25	22 23.75	90	66	.122
	36	23 15.76	0.293 09	91	.104
120	1	24 08.41	28	0.228 16	.087
	12	25 00.42	46	41	.070
	13	25 53.07	65	66	.052
	24	26 45.08	84	91	.035
	25	27 37.73	0.294 02	0.229 17	.017
	36	28 29.74	21	42	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
121	1	59 29 22.39	0.294 40	0.229 67	39.983
	12	30 14.39	58	92	.965
	13	31 07.05	77	0.230 17	.948
	24	31 59.05	96	43	.930
	25	32 51.71	0.295 15	68	.913
	36	33 43.71	33	93	.896
122	1	34 36.36	52	0.231 18	.878
	12	35 28.37	71	43	.861
	13	36 21.02	90	69	.843
	24	37 13.02	0.296 08	94	.826
	25	38 05.68	27	0.232 19	.808
	36	38 57.68	46	44	39.791 40.212
123	1	39 50.33	65	70	.194
	12	40 42.34	84	95	.176
	13	41 34.99	0.297 02	0.233 20	.159
	24	42 26.99	21	46	.141
	25	43 19.65	40	71	.123
	36	44 11.65	59	96	.106
124	1	45 04.30	78	0.234 22	.088
	12	45 56.30	97	47	.071
	13	46 48.96	0.298 16	72	.053
	24	47 40.96	35	97	.035
	25	48 33.61	54	0.235 23	.018
	36	49 25.61	72	48	40.000
125	1	50 18.26	92	74	39.982
	12	51 10.26	0.299 10	99	.965
	13	52 02.91	29	0.236 24	.947
	24	52 54.92	48	50	.929
	25	53 47.57	67	75	.912
	36	54 39.57	86	0.237 00	.894
126	1	55 32.22	0.300 05	26	.876
	12	56 24.22	24	51	.859
	13	57 16.87	44	77	.841
	24	58 08.87	63	0.238 02	.824
	25	59 01.52	82	28	.806
	36	59 53.52	0.301 01	53	39.787 40.214

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
127	1	60 00 46.17	0.301 20	0.238 79	40.197
	12	01 38.17	39	0.239 04	.179
	13	02 30.82	58	29	.161
	24	03 22.82	77	55	.143
	25	04 15.47	96	80	.125
	36	05 07.47	0.302 15	0.240 06	.107
128	1	06 00.12	35	31	.089
	12	06 52.12	54	57	.072
	13	07 44.77	73	82	.054
	24	08 36.77	92	0.241 08	.036
	25	09 29.42	0.303 11	33	.018
	36	10 21.42	30	59	40.000
129	1	11 14.07	50	84	39.982
	12	12 06.06	69	0.242 10	.964
	13	12 58.71	88	36	.946
	24	13 50.71	0.304 07	61	.928
	25	14 43.36	27	87	.910
	36	15 35.36	46	0.243 12	.893
130	1	16 28.01	65	38	.875
	12	17 20.00	84	63	.857
	13	18 12.65	0.305 04	89	.839
	24	19 04.65	23	0.244 14	.821
	25	19 57.30	43	40	.803
	36	20 49.30	62	66	39.785 40.218
131	1	21 41.94	81	91	.199
	12	22 33.94	0.306 01	0.245 17	.181
	13	23 26.59	20	43	.163
	24	24 18.58	39	68	.145
	25	25 11.23	59	94	.127
	36	26 03.23	78	0.246 20	.109
132	1	26 55.88	98	45	.091
	12	27 47.87	0.307 17	71	.073
	13	28 40.52	37	97	.054
	24	29 32.51	56	0.247 22	.036
	25	30 25.16	75	48	.018
	36	31 17.16	95	74	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
					chains
133	1	60 32 09.80	0.308 14	0.248 00	39.982
	12	33 01.80	34	25	.964
	13	33 54.44	53	51	.946
	24	34 46.44	73	77	.927
	25	35 39.09	93	0.249 03	.909
	36	36 31.08	0.309 12	28	.891
134	1	37 23.73	32	54	.873
	12	38 15.72	51	80	.855
	13	39 08.37	71	0.250 06	.837
	24	40 00.36	90	31	.818
	25	40 53.01	0.310 10	57	.800
	36	41 45.00	30	83	39.782 40.221
135	1	42 37.65	49	0.251 09	.202
	12	43 29.64	69	34	.184
	13	44 22.29	89	60	.165
	24	45 14.28	0.311 08	86	.147
	25	46 06.92	28	0.252 12	.129
	36	46 58.92	48	38	.110
136	1	47 51.56	67	64	.092
	12	48 43.56	87	90	.074
	13	49 36.20	0.312 07	0.253 16	.055
	24	50 28.19	26	41	037
	25	51 20.84	46	67	.018
	36	52 12.83	66	93	40.000
137	1	53 05.47	86	0.254 19	39.981
	12	53 57.47	0.313 05	45	.963
	13	54 50.11	25	71	.945
	24	55 42.10	45	97	.926
	25	56 34.75	65	0.255 23	.908
	36	57 26.74	85	49	889
138	1	58 19.38	0.314 05	75	.871
	12	59 11.37	24	0.256 01	.853
	13	61 00 04 02	44	27	.834
	24	00 56.01	64	53	.816
	25	01 48.65	84	79	.797
	36	02 40.64	0.315 04	0.257 05	39.779 40.224

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
139	1	61 03 33.28	0.315 24	0.257 31	40.205
	12	04 25.28	44	57	.187
	13	05 17.92	64	83	.168
	24	06 09.91	84	0.258 09	.149
	25	07 02 55	0.316 04	35	.131
	36	07 54.54	24	61	.112
140	1	08 47.18	44	87	.093
	12	09 39.17	64	0.259 13	.075
	13	10 31.81	84	39	.056
	24	11 23.81	0.317 04	65	.037
	25	12 16.45	24	91	.019
	36	13 08.44	44	0.260 17	40.000
141	1	14 01.08	64	44	39.981
	12	14 53.07	84	69	.963
	13	15 45.71	0.318 04	96	.944
	24	16 37.70	24	0.261 22	.925
	25	17 30.34	44	48	.906
	36	18 22.33	64	74	.888
142	1	19 14.97	85	0.262 00	.869
	12	20 06.96	0.319 05	26	.851
	13	20 59.60	25	53	.832
	24	21 51.59	45	79	.813
	25	22 44.23	65	0.263 05	.794
	36	23 36.22	85	31	39.776 40.227
143	1	24 28.85	0.320 06	57	.208
	12	25 20.84	26	84	.189
	13	26 13.48	46	0.264 10	.170
	24	27 05.47	66	36	.151
	25	27 58.11	86	62	.133
	36	28 50.10	0.321 07	88	.114
144	1	29 42.74	27	0.265 15	.095
	12	30 34.73	47	41	.076
	13	31 27.36	68	67	.057
	24	32 19.35	88	94	.038
	25	33 11.99	0.322 08	0.266 20	.019
	36	34 03.98	28	46	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
145	1	61 34 56.63	0.322 49	0.266 73	39.981
	12	35 48.61	69	99	.962
	13	36 41.25	90	0.267 25	.943
	24	37 33.24	0.323 10	51	.924
	25	38 25.88	30	78	.905
	36	39 17.86	51	0.268 04	.886
146	1	40 10.50	71	31	.867
	12	41 02.49	92	57	.848
	13	41 55.12	0.324 12	83	.829
	24	42 47.11	33	0.269 10	.810
	25	43 39.75	53	36	.791
	36	44 31.73	73	62	39.772 40.230
147	1	45 24.37	94	89	.211
	12	46 16.36	0.325 14	0.270 15	.192
	13	47 08.99	35	42	.173
	24	48 00.98	56	68	.154
	25	48 53.62	76	95	.134
	36	49 45.60	97	0.271 21	.115
148	1	50 38.24	0.326 17	48	.096
	12	51 30.22	38	74	.077
	13	52 22.86	59	0.272 01	.058
	24	53 14.84	79	27	.038
	25	54 07.48	0.327 00	54	.019
	36	54 59.46	20	80	40.000
149	1	55 52.10	41	0.273 07	39.981
	12	56 44.08	62	33	.962
	13	57 36.72	82	60	.942
	24	58 28.70	0.328 03	86	.923
	25	59 21.34	24	0.274 13	.904
	36	62 00 13.32	44	39	.885
150	1	01 05.96	65	66	.865
	12	01 57.94	86	92	.846
	13	02 50.58	0.329 07	0.275 19	.827
	24	03 42.56	27	46	.808
	25	04 35.19	48	72	.788
	36	05 27.18	69	99	39.769 40.234

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
151	1	62 06 19.81	0.329 90	0.276 26	40.214
	12	07 11.79	0.330 10	52	.195
	13	08 04.43	31	79	.175
	24	08 56.41	52	0.277 05	.156
	25	09 49.05	73	32	.136
	36	10 41.03	94	59	.117
152	1	11 33.66	0.331 15	86	.097
	12	12 25.64	36	0.278 12	.078
	13	13 18.28	57	39	.058
	24	14 10.26	77	66	.039
	25	15 02.89	99	93	.019
	36	15 54.88	0.332 19	0.279 19	40.000
153	1	16 47.51	40	46	39.980
	12	17 39.49	61	73	.961
	13	18 32.12	82	0.280 00	.941
	24	19 24.10	0.333 03	26	.922
	25	20 16.74	24	53	.902
	36	21 08.72	45	80	.883
154	1	22 01.35	66	0.281 07	.863
	12	22 53.33	87	33	.844
	13	23 45.96	0.334 08	60	.824
	24	24 37.94	29	87	.805
	25	25 30.58	51	0.282 14	.785
	36	26 22.56	72	41	39.766 40.237
155	1	27 15.19	93	68	.218
	12	28 07.17	0.335 14	94	.198
	13	28 59.80	35	0.283 21	.178
	24	29 51.78	56	48	.158
	25	30 44.41	77	75	.138
	36	31 36.39	98	0.284 02	.119
156	1	32 29.02	0.336 20	29	.099
	12	33 21.00	41	56	.079
	13	34 13.63	62	83	.059
	24	35 05.61	83	0.285 10	.040
	25	35 58.24	0.337 05	37	.020
	36	36 50.22	26	64	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
157	1	62 37 42.85	0.337 47	0.285 91	39.980
	12	38 34.83	68	0.286 17	.960
	13	39 27.46	90	45	.941
	24	40 19.44	0.338 11	71	.921
	25	41 12.07	32	99	.901
	36	42 04.05	54	0.287 25	.881
158	1	42 56.68	75	53	.861
	12	43 48.66	96	80	.842
	13	44 41.28	0.339 18	0.288 07	.822
	24	45 33.26	39	34	.802
	25	46 25.89	61	61	.782
	36	47 17.87	82	88	39.762 40.241
159	1	48 10.50	0.340 03	0.289 15	.221
	12	49 02.48	25	42	.201
	13	49 55.11	46	69	.181
	24	50 47.08	68	96	.161
	25	51 39.71	89	0.290 23	.141
	36	52 31.69	0.341 11	50	.120
160	1	53 24.32	32	78	.100
	12	54 16.29	54	0.291 05	.080
	13	55 08.92	75	32	.060
	24	56 00.90	97	59	.040
	25	56 53.53	0.342 18	86	.020
	36	57 45.50	40	0.292 13	40.000
161	1	58 38.13	62	41	39.980
	12	59 30.11	83	68	.960
	13	63 00 22.74	0.343 05	95	.940
	24	01 14.71	26	0.293 22	.920
	25	02 07.34	48	50	.899
	36	02 59.32	70	77	.879
162	1	03 51.94	91	0.294 04	.859
	12	04 43.92	0.344 13	31	.839
	13	05 36.54	35	59	.819
	24	06 28.52	56	86	.799
	25	07 21.15	78	0.295 13	.779
	36	08 13.12	0.345 00	41	39.759 40.245

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			**chains**
163	1	63 09 05.75	0.345 22	0.295 68	40.224
	12	09 57.72	43	95	.204
	13	10 50.35	65	0.296 23	.183
	24	11 42.32	87	50	.163
	25	12 34.95	0.346 09	77	.143
	36	13 26.93	30	0.297 05	.122
164	1	14 19.55	52	32	.102
	12	15 11.53	74	59	.082
	13	16 04.15	96	87	.061
	24	16 56.13	0.347 18	0.298 14	.041
	25	17 48.75	40	42	.020
	36	18 40.72	62	69	40.000
165	1	19 33.35	84	97	39.980
	12	20 25.32	0.348 05	0.299 24	.959
	13	21 17.95	27	52	.939
	24	22 09.92	49	79	.918
	25	23 02.55	71	0.300 07	.898
	36	23 54.52	93	34	.878
166	1	24 47.14	0.349 15	62	.857
	12	25 39.12	37	89	.837
	13	26 31.74	59	0.301 17	.816
	24	27 23.71	81	44	.796
	25	28 16.34	0.350 03	72	.775
	36	29 08.31	25	99	{39.755 {40.248
167	1	30 00.93	48	0.302 27	.228
	12	30 52.91	70	54	.207
	13	31 45.53	92	82	.186
	24	32 37.50	0.351 14	0.303 09	.166
	25	33 30.13	36	37	.145
	36	34 22.10	58	65	.124
168	1	35 14.72	80	93	.103
	12	36 06.69	0.352 02	0.304 20	.083
	13	36 59.31	25	48	.062
	24	37 51.29	47	75	.041
	25	38 43.91	69	0.305 03	.021
	36	39 35.88	91	31	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
169	1	63 40 28.50	0.353 14	0.305 59	39.979
	12	41 20.48	36	86	.959
	13	42 13.10	58	0.306 14	.938
	24	43 05.07	80	42	.917
	25	43 57.69	0.354 03	69	.896
	36	44 49.66	25	97	.876
170	1	45 42.28	47	0.307 25	.855
	12	46 34.25	70	53	.834
	13	47 26.87	92	80	.813
	24	48 18.85	0.355 14	0.308 08	.793
	25	49 11.47	37	36	.772
	36	50 03.44	59	64	39.751 40.252
171	1	50 56.06	82	92	.231
	12	51 48.03	0.356 04	0.309 19	.210
	13	52 40.65	27	47	.189
	24	53 32.62	49	75	.168
	25	54 25.24	72	0.310 03	.147
	36	55 17.21	94	31	.126
172	1	56 09.83	0.357 17	59	.105
	12	57 01.80	39	87	.084
	13	57 54.42	62	0.311 15	.063
	24	58 46.39	84	42	.042
	25	59 39.01	0.358 07	71	.021
	36	64 00 30.98	29	98	40.000
173	1	01 23.60	52	0.312 27	39.979
	12	02 15.57	74	54	.958
	13	03 08.18	97	82	.937
	24	04 00.15	0.359 20	0.313 10	.916
	25	04 52.77	42	38	.895
	36	05 44.74	65	66	.874
174	1	06 37.36	88	94	.853
	12	07 29.33	0.360 10	0.314 22	.832
	13	08 21.95	33	51	.811
	24	09 13.92	56	78	.790
	25	10 06.53	79	0.315 07	.768
	36	10 58.50	0.361 01	35	39.747 40.256

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ′ ″			**chains**
175	1	64 11 51.12	0.361 24	0.315 63	40.235
	12	12 43.09	47	91	.213
	13	13 35.70	70	0.316 19	.192
	24	14 27.67	92	47	.171
	25	15 20.29	0.362 15	75	.149
	36	16 12.26	38	0.317 03	.128
176	1	17 04.87	61	32	.107
	12	17 56.84	84	60	.085
	13	18 49.46	0.363 07	88	.064
	24	19 41.43	30	0.318 16	.043
	25	20 34.04	53	44	.021
	36	21 26.01	75	72	40.000
177	1	22 18.63	98	0.319 01	39.979
	12	23 10.59	0.364 21	29	.957
	13	24 03.21	44	57	.936
	24	24 55.18	67	85	.914
	25	25 47.79	90	0.320 14	.893
	36	26 39.76	0.365 13	42	.872
178	1	27 32.38	36	70	.850
	12	28 24.34	59	99	.829
	13	29 16.96	83	0.321 27	.808
	24	30 08.92	0.366 06	55	.786
	25	31 01.54	29	84	.765
	36	31 53.50	52	0.322 12	{39.743 {40.260
179	1	32 46.12	75	40	.238
	12	33 38.09	98	69	.217
	13	34 30.70	0.367 21	97	.195
	24	35 22.67	44	0.323 25	.173
	25	36 15.28	68	54	.152
	36	37 07.25	91	82	.130
180	1	37 59.86	0.368 14	0.324 11	.108
	12	38 51.83	37	39	.087
	13	39 44.44	60	68	.065
	24	40 36.41	84	96	.043
	25	41 29.02	0.369 07	0.325 25	.022
	36	42 20.98	30	53	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ′ ″			chains
181	1	64 43 13.60	0.369 54	0.325 82	39.978
	12	44 05.56	77	0.326 10	.957
	13	44 58.18	0.370 00	39	.935
	24	45 50.14	23	67	.913
	25	46 42.75	47	96	.891
	36	47 34.72	70	0.327 24	.870
182	1	48 27.33	94	53	.848
	12	49 19.30	0.371 17	81	.826
	13	50 11.91	41	0.328 10	.805
	24	51 03.87	64	39	.783
	25	51 56.49	88	67	.761
	36	52 48.45	0.372 11	96	(39.739 (40.264
183	1	53 41.06	34	0.329 25	.242
	12	54 33.02	58	53	.220
	13	55 25.64	82	82	.198
	24	56 17.60	0.373 05	0.330 11	.176
	25	57 10.21	29	39	.154
	36	58 02.17	52	68	.132
184	1	58 54.79	76	97	.110
	12	59 46.75	99	0.331 25	.088
	13	65 00 39.36	0.374 23	54	.066
	24	01 31.32	46	83	.044
	25	02 23.94	70	0.332 12	.022
	36	03 15.90	94	41	40.000
185	1	04 08.51	0.375 18	69	39.978
	12	05 00.47	41	98	.956
	13	05 53.08	65	0.333 27	.934
	24	06 45.04	89	56	.912
	25	07 37.66	0.376 12	85	.890
	36	08 29.62	36	0.334 13	.868
186	1	09 22.23	60	43	.846
	12	10 14.19	84	71	.824
	13	11 06.80	0.377 08	0.335 00	.801
	24	11 58.76	31	29	.779
	25	12 51.37	55	58	.757
	36	13 43.33	79	87	(39.735 (40.269

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			**chains**
187	1	65 14 35.94	0.378 03	0.336 16	40.246
	12	15 27.90	27	45	.224
	13	16 20.51	51	74	.201
	24	17 12.47	74	0.337 03	.179
	25	18 05.08	99	32	.157
	36	18 57.04	0.379 22	61	.134
188	1	19 49.65	46	90	.112
	12	20 41.61	70	0.338 19	.090
	13	21 34.22	94	48	.067
	24	22 26.18	0.380 18	77	.045
	25	23 18.79	42	0.339 06	.022
	36	24 10.75	66	35	40.000
189	1	25 03.36	91	64	39.978
	12	25 55.32	0.381 14	93	.955
	13	26 47.93	39	0.340 23	.933
	24	27 39.89	63	51	.910
	25	28 32.50	87	81	.888
	36	29 24.45	0.382 11	0.341 10	.865
190	1	30 17.06	35	39	.843
	12	31 09.02	59	68	.821
	13	32 01.63	84	97	.798
	24	32 53.59	0.383 08	0.342 27	.776
	25	33 46.20	32	56	.753
	36	34 38.16	56	85	39.731 40.273
191	1	35 30.76	80	0.343 14	.250
	12	36 22.72	0.384 05	43	.227
	13	37 15.33	29	73	.205
	24	38 07.29	53	0.344 02	.182
	25	38 59.89	78	32	.159
	36	39 51.85	0.385 02	61	.136
192	1	40 44.46	26	90	.114
	12	41 36.42	51	0.345 19	.091
	13	42 29.02	75	49	.068
	24	43 20.98	99	78	.045
	25	44 13.59	0.386 24	0.346 08	.023
	36	45 05.55	48	37	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
					chains
193	1	65 45 58.15	0.386 73	0.346 66	39.977
	12	46 50.11	97	96	.954
	13	47 42.71	0.387 22	0.347 25	.932
	24	48 34.67	46	54	.909
	25	49 27.28	71	84	.886
	36	50 19.23	95	0.348 13	.863
194	1	51 11.84	0.388 20	43	.841
	12	52 03.80	44	72	.818
	13	52 56.40	69	0.349 02	.795
	24	53 48.36	93	31	.772
	25	54 40.96	0.389 18	61	.749
	36	55 32.92	43	91	39.727 40.277
195	1	56 25.53	67	0.350 20	.254
	12	57 17.48	92	50	.231
	13	58 10.09	0.390 17	79	.208
	24	59 02.04	41	0.351 09	.185
	25	59 54.65	66	39	.162
	36	66 00 46.60	91	68	.139
196	1	01 39.21	0.391 16	98	.116
	12	02 31.16	40	0.352 27	.092
	13	03 23.77	65	57	.069
	24	04 15.72	90	87	.046
	25	05 08.33	0.392 15	0.353 17	.023
	36	06 00.28	39	46	40.000
197	1	06 52.88	64	76	39.977
	12	07 44.84	89	0.354 06	.954
	13	08 37.44	0.393 14	36	.931
	24	09 29.40	39	65	.907
	25	10 22.00	64	95	.884
	36	11 13.96	89	0.355 25	.861
198	1	12 06.56	0.394 14	55	.838
	12	12 58.51	39	84	.815
	13	13 51.12	64	0.356 14	.792
	24	14 43.07	89	44	.768
	25	15 35.67	0.395 14	74	.745
	36	16 27.63	39	0.357 04	39.722 40.282

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
199	1	66 17 20.23	0.395 64	0.357 34	40.259
	12	18 12.18	89	64	.235
	13	19 04.79	0.396 14	94	.212
	24	19 56.74	39	0.358 23	.188
	25	20 49.34	64	54	,165
	36	21 41.30	89	83	.141
200	1	22 33.90	0.397 15	0.359 13	.118
	12	23 25.85	40	43	.094
	13	24 18.45	65	73	.070
	24	25 10.40	90	0.360 03	.047
	25	26 03.01	0.398 15	33	.023
	36	26 54.96	41	63	40.000
201	1	27 47.56	66	94	39.976
	12	28 39.51	91	0.361 23	.953
	13	29 32.11	0.399 17	54	.929
	24	30 24.07	42	84	.906
	25	31 16.67	67	0.362 14	.882
	36	32 08.62	92	44	.859
202	1	33 01.22	0.400 18	74	.835
	12	33 53.17	43	0.363 04	.812
	13	34 45.77	69	35	.788
	24	35 37.72	94	65	.765
	25	36 30.33	0.401 20	95	.741
	36	37 22.28	45	0.364 25	{39.717 {40.287
203	1	38 14.88	70	55	.263
	12	39 06.83	96	85	.239
	13	39 59.43	0.402 21	0.365 16	.215
	24	40 51.38	47	46	.191
	25	41 43.98	73	76	.167
	36	42 35.93	98	0.366 07	.143
204	1	43 28.53	0.403 24	37	.120
	12	44 20.48	49	67	.096
	13	45 13.08	75	98	.072
	24	46 05.03	0.404 00	0.367 28	.048
	25	46 57.63	26	58	.024
	36	47 49.58	52	89	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
205	1	66 48 42.18	0.404 78	0.368 19	40.976
	12	49 34.13	0.405 03	49	.952
	13	50 26.73	29	80	.928
	24	51 18.68	55	0.369 10	.904
	25	52 11.28	80	41	.880
	36	53 03.23	0.406 06	71	.856
206	1	53 55.82	32	0.370 02	.832
	12	54 47.77	58	32	.808
	13	55 40.37	84	63	.785
	24	56 32.32	0.407 09	93	.761
	25	57 24.92	35	0.371 24	.737
	36	58 16.87	61	54	39.713 40.292
207	1	59 09.47	87	85	.267
	12	67 00 01.42	0.408 13	0.372 16	.243
	13	00 54.01	39	46	.219
	24	01 45.96	65	77	.195
	25	02 38.56	91	0.373 08	.170
	36	03 30.51	0.409 17	38	.146
208	1	04 23.11	43	69	.122
	12	05 15.05	69	0.374 00	.097
	13	06 07.65	95	30	.073
	24	06 59.60	0.410 21	61	.049
	25	07 52.20	47	92	.024
	36	08 44.14	73	0.375 22	40.000
209	1	09 36.74	99	53	39.976
	12	10 28.69	0.411 25	84	.951
	13	11 21.28	52	0.376 15	.927
	24	12 13.23	78	46	.903
	25	13 05.83	0.412 04	77	.878
	36	13 57.78	30	0.377 07	.854
210	1	14 50.37	57	38	.830
	12	15 42.32	83	69	.805
	13	16 34.92	0.413 09	0.378 00	.781
	24	17 26.86	35	31	.757
	25	18 19.46	62	62	.732
	36	19 11.40	88	93	39.708 40.297

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
211	1	67 20 04.00	0.414 14	0.379 24	40.272
	12	20 55.95	41	54	.247
	13	21 48.54	67	86	.223
	24	22 40.49	93	0.380 16	.198
	25	23 33.08	0.415 20	48	.173
	36	24 25.03	46	78	.148
212	1	25 17.62	73	0.381 10	.124
	12	26 09.57	99	40	.099
	13	27 02.17	0.416 26	72	.074
	24	27 54.11	52	0.382 03	.049
	25	28 46.71	79	34	.025
	36	29 38.65	0.417 05	65	40.000
213	1	30 31.25	32	96	39.975
	12	31 23.19	58	0.383 27	.950
	13	32 15.79	85	58	.926
	24	33 07.73	0.418 12	89	.901
	25	34 00.33	38	0.384 21	.876
	36	34 52.27	65	52	.851
214	1	35 44.86	92	83	.827
	12	36 36.81	0.419 18	0.385 14	.802
	13	37 29.40	45	46	.777
	24	38 21.35	72	77	.752
	25	39 13.94	99	0.386 08	.728
	36	40 05.89	0.420 25	39	39.703 40.302
215	1	40 58.48	52	71	.277
	12	41 50.42	79	0.387 02	.252
	13	42 43.02	0.421 06	34	.226
	24	43 34.96	33	65	.201
	25	44 27.55	60	96	.176
	36	45 19.50	86	0.388 28	.151
216	1	46 12.09	0.422 13	59	.126
	12	47 04.03	40	90	.101
	13	47 56.63	67	0.389 22	.075
	24	48 48.57	94	53	.050
	25	49 41.16	0.423 21	85	.025
	36	50 33.11	48	0.390 16	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			**chains**
217	1	67 51 25.70	0.423 75	0.390 48	39.975
	12	52 17.64	0.424 02	79	.950
	13	53 10.23	30	0.391 11	.924
	24	54 02.18	56	43	.899
	25	54 54.77	84	74	.874
	36	55 46.71	0.425 11	0.392 06	.849
218	1	56 39.30	38	37	.824
	12	57 31.25	65	69	.798
	13	58 23.84	92	0.393 01	.773
	24	59 15.78	0.426 19	32	.748
	25	68 00 08.37	47	64	.723
	36	01 00.31	74	96	39.698 40.307
219	1	01 52.90	0.427 01	0.394 28	.282
	12	02 44.85	28	59	.256
	13	03 37.44	56	91	.230
	24	04 29.38	83	0.395 23	.205
	25	05 21.97	0.428 11	55	.179
	36	06 13.91	38	86	.154
220	1	07 06.50	65	0.396 18	.128
	12	07 58.44	93	50	.102
	13	08 51.03	0.429 20	82	.077
	24	09 42.97	48	0.397 13	.051
	25	10 35.56	75	46	.026
	36	11 27.51	0.430 02	77	40.000
221	1	12 20.10	30	0.398 09	39.974
	12	13 12.04	58	41	.949
	13	14 04.63	85	73	.923
	24	14 56.57	0.431 13	0.399 05	.897
	25	15 49.16	40	37	.872
	36	16 41.10	68	69	.846
222	1	17 33.69	96	0.400 01	.821
	12	18 25.63	0.432 23	33	.795
	13	19 18.22	51	65	.769
	24	20 10.16	78	97	.744
	25	21 02.74	0.433 06	0.401 29	.718
	36	21 54.69	34	61	39.692 40.313

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ′ ″			chains
223	1	68 22 47.27	0.433 62	0.401 94	40.287
	12	23 39.21	89	0.402 26	.261
	13	24 31.80	0.434 17	58	.235
	24	25 23.74	45	90	.209
	25	26 16.33	73	0.403 22	.182
	36	27 08.27	0.435 01	54	.156
224	1	28 00.86	29	87	.130
	12	28 52.80	57	0.404 19	.104
	13	29 45.39	85	51	.078
	24	30 37.32	0.436 12	83	.052
	25	31 29.91	41	0.405 16	.026
	36	32 21.85	68	48	40.000
225	1	33 14.44	97	80	39.974
	12	34 06.38	0.437 24	0.406 13	.948
	13	34 58.97	53	45	.922
	24	35 50.90	80	77	.896
	25	36 43.49	0.438 09	0.407 10	.869
	36	37 35.43	37	42	.843
226	1	38 28.02	65	75	.817
	12	39 19.95	93	0.408 07	.791
	13	40 12.54	0.439 21	40	.765
	24	41 04.48	49	72	.739
	25	41 57.07	78	0.409 05	.713
	36	42 49.00	0.440 06	37	39.687 40.318
227	1	43 41.59	34	70	.292
	12	44 33.53	62	0.410 02	.265
	13	45 26.11	91	35	.239
	24	46 18.05	0.441 19	67	.212
	25	47 10.64	47	0.411 00	.186
	36	48 02.58	76	32	.159
228	1	48 55.16	0.442 04	65	.133
	12	49 47.10	32	98	.106
	13	50 39.68	61	0.412 31	.080
	24	51 31.62	89	63	.053
	25	52 24.21	0.443 18	96	.026
	36	53 16.14	46	0.413 29	40.000

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ′ ″			chains
229	1	68 54 08.73	0.443 75	0.413 62	39.973
	12	55 00.67	0.444 03	94	.947
	13	55 53.25	32	0.414 27	.920
	24	56 45.19	60	60	.894
	25	57 37.77	89	93	.867
	36	58 29.71	0.445 18	0.415 25	.841
230	1	59 22.29	46	59	.814
	12	69 00 14.23	75	91	.787
	13	01 06.81	0.446 04	0.416 24	.761
	24	01 58.75	32	57	.734
	25	02 51.33	61	90	.708
	36	03 43.27	90	0.417 23	39.681 40.324
231	1	04 35.85	0.447 19	56	.297
	12	05 27.79	47	89	.270
	13	06 20.37	76	0.418 22	.243
	24	07 12.31	0.448 05	55	.216
	25	08 04.89	34	88	.189
	36	08 56.83	63	0.419 21	.162
232	1	09 49.41	92	54	.135
	12	10 41.35	0.449 21	87	.108
	13	11 33.93	50	0.420 21	.081
	24	12 25.86	78	54	.054
	25	13 18.45	0.450 08	87	.027
	36	14 10.38	36	0.421 20	40.000
233	1	15 02.97	66	53	39.973
	12	15 54.90	95	86	.946
	13	16 47.48	0.451 24	0.422 20	.919
	24	17 39.42	53	53	.892
	25	18 32.00	82	86	.865
	36	19 23.93	0.452 11	0.423 19	.838
234	1	20 16.52	40	53	.811
	12	21 08.45	69	86	.784
	13	22 01.03	99	0.424 20	.756
	24	22 52.97	0.453 28	53	.729
	25	23 45.55	57	86	.702
	36	24 37.48	86	0.425 20	39.675 40.330

TABLE X - Continued

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
235	1	69 25 30.07	0.454 16	0.425 53	40.303
	12	26 22.00	45	86	.275
	13	27 14.58	74	0.426 20	.248
	24	28 06.51	0.455 04	53	.220
	25	28 59.10	33	87	.193
	36	29 51.03	62	0.427 20	.165
236	1	30 43.61	92	54	.138
	12	31 35.54	0.456 21	88	.110
	13	32 28.13	51	0.428 21	.083
	24	33 20.06	80	55	.055
	25	34 12.64	0.457 10	89	.027
	36	35 04.57	39	0.429 22	40.000
237	1	35 57.15	69	56	39.972
	12	36 49.08	99	89	.945
	13	37 41.67	0.458 28	0.430 23	.917
	24	38 33.60	58	57	.890
	25	39 26.18	88	91	.862
	36	40 18.11	0.459 17	0.431 24	.835
238	1	41 10.69	47	58	.807
	12	42 02.62	77	92	.780
	13	42 55.20	0.460 07	0.432 26	.752
	24	43 47.13	36	60	.724
	25	44 39.72	66	94	.697
	36	45 31.65	96	0.433 27	39.669 40.337
239	1	46 24.23	0.461 26	61	.309
	12	47 16.16	55	95	.280
	13	48 08.74	86	0.434 29	.252
	24	49 00.67	0.462 15	63	.224
	25	49 53.25	45	97	.196
	36	50 45.18	75	0.435 31	.168
240	1	51 37.76	0.463 05	65	.140
	12	52 29.69	35	99	.112
	13	53 22.27	65	0.436 33	.084
	24	54 14.20	95	67	.056
	25	55 06.78	0.464 26	0.437 02	.028
	36	55 58.71	55	36	40.000

TABLE X - Concluded

Latitude, etc., for the North Boundary of each Section.
Third System of Survey.

Township	Section	Latitude L.	Log Sec L.	Log Tan L.	Quarter Section
		° ' "			chains
241	1	69 56 51.29	0.464 86	0.437 70	39.972
	12	57 43.22	0.465 16	0.438 04	.944
	13	58 35.80	46	38	.916
	24	59 27.73	76	72	.888
	25	70 00 20.31	0.466 07	0.439 07	.860
	36	01 12.24	37	41	.832
242	1	02 04.81	67	75	.803
	12	02 56.74	97	0.440 09	.775
	13	03 49.32	0.467 28	44	.747
	24	04 41.25	58	78	.719
	25	05 33.83	88	0.441 13	.691
	36	06 25.76	0.468 19	47	(39.663 (40.343
243	1	07 18.34	49	81	.314
	12	08 10.27	80	0.442 16	.286
	13	09 02.84	0.469 10	50	.257
	24	09 54.77	40	84	.229
	25	10 47.35	71	0.443 19	.200
	36	11 39.28	0.470 02	53	.172
244	1	12 31.86	32	88	.143
	12	13 23.78	63	0.444 22	.114
	13	14 16.36	93	57	.086
	24	15 08.29	0.471 24	92	.057
	25	16 00.87	55	0.445 26	.029
	36	16 52.80	85	61	40.000

TABLE XI

Showing the difference of Latitude between Township Corners and Section and Quarter Section Posts on a Township Chord.

Number of Line	dL for 1/2 Sec. from Corner	dL for 1 Sec. from Corner	dL for 1 1/2 Secs. from Corner	dL for 2 Secs. from Corner	dL for 2 1/2 Secs. from Corner	dL for 3 Secs. from Corner
1st Base	0".02	0".04	0".05	0".06	0".07	0".07
	lks.	lks.	lks.	lks.	lks.	lks.
do	3.2	5.9	7.9	9.4	10.3	10.6
11th Base	0".02	0".04	0".06	0".07	0".08	0".08
	lks.	lks.	lks.	lks.	lks.	lks.
do	3.7	6.7	9.0	10.6	11.6	12.0
21st Base	0".03	0".05	0".07	0".08	0".09	0".09
	lks.	lks.	lks.	lks.	lks.	lks.
do	4.2	7.6	10.2	12.1	13.2	13.6
31st Base	0".03	0".06	0".08	0".09	0".10	0".10
	lks.	lks.	lks.	lks.	lks.	lks.
do	4.8	8.7	11.7	13.9	15.2	15.6
41st Base	0".04	0".06	0".09	0".10	0".11	0".12
	lks.	lks.	lks.	lks.	lks.	lks.
do	5.5	10.0	13.5	16.0	17.5	18.0
51st Base	0".04	0".08	0".10	0".12	0".13	0".14
	lks.	lks.	lks.	lks.	lks.	lks.
do	6.4	11.7	15.8	18.7	20.5	21.1
61st Base	0".05	0".09	0".12	0".14	0".16	0".16
	lks.	lks.	lks.	lks.	lks.	lks.
do	7.7	14.0	18.9	22.4	24.5	25.2

TABLE XII

For Converting Logarithmic Tangents of Small Arcs into Logarithms of Seconds of Arc

Log Tan	Log T	Log Tan	Log T	Log Tan	Log T
		8.49305		8.64361	
	5.31442		5.31428		5.31414
7.92263		.50802		.65116	
	41		27		13
8.07156		.52200		.65849	
	40		26		12
.15924		.53516		.66562	
	39		25		11
.22142		.54753		.67253	
	38		24		10
.26973		.55938		.67921	
	37		23		09
.30930		.57046		.68570	
	36		22		08
.34270		.58099		.69201	
	35		21		07
.37167		.59105		.69814	
	34		20		06
.39713		.60073		.70410	
	33		19		05
.41999		.61009		.70991	
	32		18		04
.44072		.61872		.71555	
	31		17		03
.45955		.62745		.72104	
	30		16		02
.47697		.63567		.72639	
	29		15		01

TABLE XIII

$$\text{Log}\ \frac{1}{1-m}$$

m positive
that is, when t lies between 0^h and 6^h, or 18^h and 24^h.

Log m	0	1	2	3	4	5	6	7	8	9
5.	0.00 000	001	001	001	001	001	002	002	003	003
6.0	004	004	005	005	005	005	005	005	005	005
1	006	006	006	006	006	006	006	006	007	007
2	007	007	007	007	008	008	008	008	008	009
3	009	009	009	009	010	010	010	010	010	011
4	011	011	011	012	012	012	013	013	013	013
5	014	014	014	015	015	015	016	016	017	017
6	017	018	018	019	019	019	020	020	021	021
7	022	022	023	023	024	024	025	026	026	027
8	027	028	029	029	030	031	032	032	033	034
9	035	035	036	037	038	039	040	041	042	043
7.0	044	045	046	047	048	049	050	051	052	054
1	055	056	057	059	060	061	063	064	066	067
2	069	071	072	074	076	077	079	081	083	085
3	087	089	091	093	095	097	100	102	104	107
4	109	112	114	117	120	123	125	128	131	134
5	138	141	144	147	151	154	158	162	165	169
6	173	177	181	186	190	194	199	204	208	213
7	218	223	229	234	239	245	251	257	263	269
8	275	281	288	295	302	309	316	323	331	338
9	346	355	363	371	380	389	398	407	417	427
8.00	437	438	439	440	441	442	443	444	445	446
01	447	448	449	450	451	452	453	454	455	456
02	457	458	459	460	461	463	464	465	466	467
03	468	469	470	471	472	473	474	476	477	478
04	479	480	481	482	483	484	486	487	488	489
05	490	491	492	494	495	496	497	498	499	500
06	502	503	504	505	506	507	509	510	511	512
07	513	515	516	517	518	519	521	522	523	524
08	525	527	528	529	530	531	533	534	535	536
09	538	539	540	541	543	544	545	546	548	549
8.10	0.00 550	552	553	554	555	557	558	559	561	562

TABLE XIII. --Continued.

$$\text{Log}\ \frac{1}{1-m}$$

m negative
that is, when t lies between 6^h and 18^h.

Log m	0	1	2	3	4	5	6	7	8	9
5. n	10.00 000 9.99	999	999	999	999	999	998	998	997	997
6.0 n	9.99 996	996	996	995	995	995	995	995	995	995
1 n	995	994	994	994	994	994	994	994	993	993
2 n	993	993	993	993	993	992	992	992	992	992
3 n	991	991	991	991	991	990	990	990	990	989
4 n	989	989	989	988	988	988	988	987	987	987
5 n	986	986	986	985	985	985	984	984	984	983
6 n	983	982	982	982	981	981	980	980	979	979
7 n	978	978	977	977	976	976	975	974	974	973
8 n	973	972	971	971	970	969	969	968	967	966
9 n	966	965	964	963	962	961	960	960	959	958
7.0 n	957	956	955	954	952	951	950	949	948	947
1 n	945	944	943	942	940	939	937	936	934	933
2 n	931	930	928	926	925	923	921	919	917	915
3 n	913	911	909	907	905	903	901	898	896	894
4 n	891	889	886	883	881	878	875	872	869	866
5 n	863	860	856	853	850	846	843	839	835	831
6 n	827	823	819	815	811	806	802	797	793	788
7 n	783	778	773	767	762	757	751	745	739	733
8 n	727	721	714	707	701	694	687	679	672	664
9 n	656	648	640	632	623	615	606	597	587	578
8.00n	568	567	566	565	564	563	562	561	560	559
01n	558	557	556	555	554	553	552	551	550	549
02n	548	547	546	545	543	542	541	540	539	538
03n	537	536	535	534	533	532	531	530	529	528
04n	526	525	524	523	522	521	520	519	518	517
05n	515	514	513	512	511	510	509	508	507	505
06n	504	503	502	501	500	499	497	496	495	494
07n	493	492	490	489	488	487	486	485	483	482
08n	481	480	479	477	476	475	474	473	471	470
09n	469	468	467	465	464	463	462	460	459	458
8.10n	9.99 457	455	454	453	452	450	449	448	447	445

TABLE XIII.--Continued.

$$\text{Log } \frac{1}{1-m}$$

m positive
that is, when t lies between 0^h and 6^h, or 18^h and 24^h.

Log m	0	1	2	3	4	5	6	7	8	9
8.10	0.00 550	552	553	554	555	557	558	559	561	562
11	563	564	566	567	568	570	571	572	574	575
12	576	578	579	580	582	583	584	586	587	589
13	590	591	593	594	595	597	598	600	601	602
14	604	605	607	608	609	611	612	614	615	616
15	618	619	621	622	624	625	627	628	629	631
16	632	634	635	637	638	640	641	643	644	646
17	647	649	650	652	653	655	656	658	659	661
18	662	664	665	667	669	670	672	673	675	676
19	678	680	681	683	684	686	687	689	691	692
8.20	694	695	697	699	700	702	704	705	707	709
21	710	712	713	715	717	718	720	722	723	725
22	727	729	730	732	734	735	737	739	740	742
23	744	746	747	749	751	753	754	756	758	760
24	761	763	765	767	769	770	772	774	776	777
25	779	781	783	785	787	788	790	792	794	796
26	798	799	801	803	805	807	809	811	813	814
27	816	818	820	822	824	826	828	830	832	834
28	836	838	839	841	843	845	847	849	851	853
29	855	857	859	861	863	865	867	869	871	873
8.30	875	877	879	881	884	886	888	890	892	894
31	896	898	900	902	904	906	909	911	913	915
32	917	919	921	923	926	928	930	932	934	936
33	939	941	943	945	947	950	952	954	956	958
34	961	963	965	967	970	972	974	977	979	981
35	983	986	988	990	993	995	997	000	002	004
36	0.01 007	009	011	014	016	018	021	023	025	028
37	030	033	035	037	040	042	045	047	050	052
38	055	057	059	062	064	067	069	072	074	077
39	079	082	084	087	090	092	095	097	100	102
8.40	0.01 105	107	110	113	115	118	120	123	126	128

TABLE XIII. --Continued.

$$\text{Log}\ \frac{1}{1-m}$$

m negative
that is, when t lies between 6^h and 18^h.

Log m	0	1	2	3	4	5	6	7	8	9
8.10n	9.99 457	455	454	453	452	450	449	448	447	445
11n	444	443	442	440	439	438	436	435	434	433
12n	431	430	429	427	426	425	423	422	421	419
13n	418	417	415	414	413	411	410	409	407	406
14n	405	403	402	401	399	398	396	395	394	392
15n	391	389	388	387	385	384	382	381	380	378
16n	377	375	374	373	371	370	368	367	365	364
17n	362	361	359	358	357	355	354	352	351	349
18n	348	346	345	343	342	340	339	337	336	334
19n	333	331	330	328	326	325	323	322	320	319
8.20n	317	316	314	312	311	309	308	306	305	303
21n	301	300	298	297	295	293	292	290	288	287
22n	285	284	282	280	279	277	275	274	272	270
23n	269	267	265	264	262	260	259	257	255	254
24n	252	250	248	247	245	243	241	240	238	236
25n	235	233	231	229	228	226	224	222	220	219
26n	217	215	213	211	210	208	206	204	202	201
27n	199	197	195	193	191	190	188	186	184	182
28n	180	178	177	175	173	171	169	167	165	163
29n	161	159	158	156	154	152	150	148	146	144
8.30n	142	140	138	136	134	132	130	128	126	124
31n	122	120	118	116	114	112	110	108	106	104
32n	102	100	098	096	094	092	090	088	086	083
33n	081	079	077	075	073	071	069	066	064	062
34n	060	058	056	054	052	049	047	045	043	041
35n	039	036	034	032	030	027	025	023	021	019
36n	016	014	012	010	007	005	003	001	998	996
37n	9.98 994	991	989	987	985	982	980	978	975	973
38n	971	968	966	963	961	959	956	954	952	949
39n	947	944	942	940	937	935	932	930	928	925
8.40n	9.98 923	920	918	915	913	910	908	905	903	900

TABLE XIII. --Continued.

$$\text{Log } \frac{1}{1-m}$$

m positive
that is, when t lies between 0^h and 6^h, or 18^h and 24^h.

Log m	0	1	2	3	4	5	6	7	8	9
8.40	0.01 105	107	110	113	115	118	120	123	126	128
41	131	134	136	139	142	144	147	150	152	155
42	158	160	163	166	169	171	174	177	179	182
43	185	188	191	193	196	199	202	205	207	210
44	213	216	219	222	224	227	230	233	236	239
45	242	245	247	250	253	256	259	262	265	268
46	271	274	277	280	283	286	289	292	295	298
47	301	304	307	310	313	316	319	323	326	329
48	332	335	338	341	344	347	351	354	357	360
49	363	367	370	373	376	379	383	386	389	392
8.50	396	399	402	405	409	412	415	419	422	425
51	429	432	435	439	442	445	449	452	456	459
52	462	466	469	473	476	480	483	487	490	494
53	497	501	504	508	511	515	518	522	525	529
54	533	536	540	543	547	551	554	558	562	565
55	569	573	576	580	584	587	591	595	599	602
56	606	610	614	618	621	625	629	633	637	640
57	644	648	652	656	660	664	668	672	676	679
58	683	687	691	695	699	703	707	711	715	719
59	723	727	732	736	740	744	748	752	756	760
8.60	764	768	773	777	781	785	789	794	798	802
61	806	811	815	819	823	828	832	836	841	845
62	849	854	858	862	867	871	876	880	884	889
63	893	898	902	907	911	916	920	925	929	934
64	938	943	948	952	957	961	966	971	975	980
65	985	989	994	999	003	008	013	018	022	027
66	0.02 032	037	042	046	051	056	061	066	071	075
67	080	085	090	095	100	105	110	115	120	125
68	130	135	140	145	150	155	160	166	171	176
69	181	186	191	196	202	207	212	217	223	228
8.70	0.02 233	238	244	249	254	260	265	270	276	281

TABLE XIII. --Concluded.

$$\text{Log}\ \frac{1}{1-m}$$

m negative
that is, when t lies between 6^h and 18^h.

Log m	0	1	2	3	4	5	6	7	8	9
8.40n	9.98 923	920	918	915	913	910	908	905	903	900
41n	898	895	893	890	888	885	883	880	878	875
42n	873	870	867	865	862	860	857	854	852	849
43n	847	844	841	839	836	833	831	828	825	823
44n	820	817	815	812	809	807	804	801	798	796
45n	793	790	787	785	782	779	776	774	771	768
46n	765	762	760	757	754	751	748	745	743	740
47n	737	734	731	728	725	722	720	717	714	711
48n	708	705	702	699	696	693	690	687	684	681
49n	678	675	672	669	666	663	660	657	654	651
8.50n	648	645	642	639	636	633	629	626	623	620
51n	617	614	611	608	604	601	598	595	592	588
52n	585	582	579	576	572	569	566	563	559	556
53n	553	550	546	543	540	536	533	530	526	523
54n	520	516	513	510	506	503	499	496	493	489
55n	486	482	479	476	472	469	465	462	458	455
56n	451	448	444	441	437	434	430	426	423	419
57n	416	412	409	405	401	398	394	390	387	383
58n	380	376	372	368	365	361	357	354	350	346
59n	342	339	335	331	327	324	320	316	312	308
8.60n	305	301	297	293	289	285	281	278	274	270
61n	266	262	258	254	250	246	242	238	234	230
62n	226	222	218	214	210	206	202	198	194	190
63n	186	182	178	173	169	165	161	157	153	149
64n	144	140	136	132	128	123	119	115	111	106
65n	102	098	094	089	085	081	076	072	068	063
66n	059	055	050	046	041	037	033	028	024	019
67n	015	010	006	001	997	992	988	983	979	974
68n	9.97 970	965	960	956	951	947	942	937	933	928
69n	923	919	914	909	905	900	895	890	886	881
8.70n	9.97 876	871	867	862	857	852	847	842	838	833

TABLE XIV

Deflection of a Trial Line for Deviations from 1 to 149 Links at the end of Eighty-one Chains.

Deflection in Minutes and Seconds of Arc.

Links	0		1		2		3		4		5		6		7		8		9	
	'	''	'	''	'	''	'	''	'	''	'	''	'	''	'	''	'	''	'	''
0	0	00	0	25	0	51	1	16	1	42	2	07	2	33	2	58	3	24	3	49
10	4	15	4	40	5	06	5	31	5	57	6	22	6	47	7	13	7	38	8	04
20	8	29	8	55	9	20	9	46	10	11	10	37	11	02	11	28	11	53	12	18
30	12	44	13	09	13	35	14	00	14	26	14	51	15	17	15	42	16	08	16	33
40	16	59	17	24	17	50	18	15	18	40	19	06	19	31	19	57	20	22	20	48
50	21	13	21	39	22	04	22	30	22	55	23	21	23	46	24	11	24	37	25	02
60	25	28	25	53	26	19	26	44	27	10	27	35	28	01	28	26	28	52	29	17
70	29	43	30	08	30	33	30	59	31	24	31	50	32	15	32	41	33	06	33	32
80	33	57	34	23	34	48	35	13	35	39	36	04	36	30	36	55	37	21	37	46
90	38	12	38	37	39	03	39	28	39	54	40	19	40	44	41	10	41	35	42	01
100	42	26	42	52	43	17	43	43	44	08	44	34	44	59	45	25	45	50	46	15
110	46	41	47	06	47	32	47	57	48	23	48	48	49	14	49	39	50	05	50	30
120	50	56	51	21	51	46	52	12	52	37	53	03	53	28	53	54	54	19	54	45
130	55	10	55	36	56	01	56	26	56	52	57	17	57	43	58	08	58	34	58	59
140	59	25	59	50	60	16	60	41	61	07	61	32	61	57	62	23	62	48	63	14

TABLE XV

Corrections in Links to Slope Measurements.

Slope		1 ch.	2 chs.	3 chs.	4 chs.	5 chs.	6 chs.	7 chs.	8 chs.	9 chs.
°	'									
1	30	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3
2	34	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3	37	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8
4	26	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7
5	08	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6
	44	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
6	17	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4
	47	0.7	1.4	2.1	2.8	3.5	4.2	4.9	5.6	6.3
7	15	0.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2
	42	0.9	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.1
8	07	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
	30	1.1	2.2	3.3	4.4	5.5	6.6	7.7	8.8	9.9
	53	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8
9	15	1.3	2.6	3.9	5.2	6.5	7.8	9.1	10.4	11.7
	36	1.4	2.8	4.2	5.6	7.0	8.4	9.8	11.2	12.6
	56	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5
10	16	1.6	3.2	4.8	6.4	8.0	9.6	11.2	12.8	14.4
	35	1.7	3.4	5.1	6.8	8.5	10.2	11.9	13.6	15.3
	53	1.8	3.6	5.4	7.2	9.0	10.8	12.6	14.4	16.2
11	11	1.9	3.8	5.7	7.6	9.5	11.4	13.3	15.2	17.1
	29	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0
	46	2.1	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9
12	02	2.2	4.4	6.6	8.8	11.0	13.2	15.4	17.6	19.8
	19	2.3	4.6	6.9	9.2	11.5	13.8	16.1	18.4	20.7
	35	2.4	4.8	7.2	9.6	12.0	14.4	16.8	19.2	21.6
	50	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5
13	06	2.6	5.2	7.8	10.4	13.0	15.6	18.2	20.8	23.4
	21	2.7	5.4	8.1	10.8	13.5	16.2	18.9	21.6	24.3
	35	2.8	5.6	8.4	11.2	14.0	16.8	19.6	22.4	25.2
	50	2.9	5.8	8.7	11.6	14.5	17.4	20.3	23.2	26.1
14	04	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0
	18	3.1	6.2	9.3	12.4	15.5	18.6	21.7	24.8	27.9
	32	3.2	6.4	9.6	12.8	16.0	19.2	22.4	25.6	28.8
	46	3.3	6.6	9.9	13.2	16.5	19.8	23.1	26.4	29.7
	59	3.4	6.8	10.2	13.6	17.0	20.4	23.8	27.2	30.6
15	12	3.5	7.0	10.5	14.0	17.5	21.0	24.5	28.0	31.5
	25	3.6	7.2	10.8	14.4	18.0	21.6	25.2	28.8	32.4
	38	3.7	7.4	11.1	14.8	18.5	22.2	25.9	29.6	33.3
	51	3.8	7.6	11.4	15.2	19.0	22.8	26.6	30.4	34.2
16	03	3.9	7.8	11.7	15.6	19.5	23.4	27.3	31.2	35.1

TABLE XV - Continued
Corrections in Links to Slope Measurements.

Slope		1 ch.	2 chs.	3 chs.	4 chs.	5 chs.	6 chs.	7 chs.	8 chs.	9 chs.
°	'									
16	16	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0
	28	4.1	8.2	12.3	16.4	20.5	24.6	28.7	32.8	36.9
	40	4.2	8.4	12.6	16.8	21.0	25.2	29.4	33.6	37.8
	52	4.3	8.6	12.9	17.2	21.5	25.8	30.1	34.4	38.7
17	04	4.4	8.8	13.2	17.6	22.0	26.4	30.8	35.2	39.6
	15	4.5	9.0	13.5	18.0	22.5	27.0	31.5	36.0	40.5
	27	4.6	9.2	13.8	18.4	23.0	27.6	32.2	36.8	41.4
	38	4.7	9.4	14.1	18.8	23.5	28.2	32.9	37.6	42.3
	49	4.8	9.6	14.4	19.2	24.0	28.8	33.6	38.4	43.2
18	01	4.9	9.8	14.7	19.6	24.5	29.4	34.3	39.2	44.1
	12	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0
	23	5.1	10.2	15.3	20.4	25.5	30.6	35.7	40.8	45.9
	34	5.2	10.4	15.6	20.8	26.0	31.2	36.4	41.6	46.8
	44	5.3	10.6	15.9	21.2	26.5	31.8	37.1	42.4	47.7
	55	5.4	10.8	16.2	21.6	27.0	32.4	37.8	43.2	48.6
19	05	5.5	11.0	16.5	22.0	27.5	33.0	38.5	44.0	49.5
	16	5.6	11.2	16.8	22.4	28.0	33.6	39.2	44.8	50.4
	26	5.7	11.4	17.1	22.8	28.5	34.2	39.9	45.6	51.3
	37	5.8	11.6	17.4	23.2	29.0	34.8	40.6	46.4	52.2
	47	5.9	11.8	17.7	23.6	29.5	35.4	41.3	47.2	53.1
	57	6.0	12.0	18.0	24.0	30.0	36.0	42.0	48.0	54.0
20	07	6.1	12.2	18.3	24.4	30.5	36.6	42.7	48.8	54.9
	17	6.2	12.4	18.6	24.8	31.0	37.2	43.4	49.6	55.8
	27	6.3	12.6	18.9	25.2	31.5	37.8	44.1	50.4	56.7
	37	6.4	12.8	19.2	25.6	32.0	38.4	44.8	51.2	57.6
	46	6.5	13.0	19.5	26.0	32.5	39.0	45.5	52.0	58.5
	56	6.6	13.2	19.8	26.4	33.0	39.6	46.2	52.8	59.4
21	06	6.7	13.4	20.1	26.8	33.5	40.2	46.9	53.6	60.3
	15	6.8	13.6	20.4	27.2	34.0	40.8	47.6	54.4	61.2
	25	6.9	13.8	20.7	27.6	34.5	41.4	48.3	55.2	62.1
	34	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	63.0
	43	7.1	14.2	21.3	28.4	35.5	42.6	49.7	56.8	63.9
	52	7.2	14.4	21.6	28.8	36.0	43.2	50.4	57.6	64.8
22	02	7.3	14.6	21.9	29.2	36.5	43.8	51.1	58.4	65.7
	11	7.4	14.8	22.2	29.6	37.0	44.4	51.8	59.2	66.6
	20	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5
	29	7.6	15.2	22.8	30.4	38.0	45.6	53.2	60.8	68.4
	38	7.7	15.4	23.1	30.8	38.5	46.2	53.9	61.6	69.3
	47	7.8	15.6	23.4	31.2	39.0	46.8	54.6	62.4	70.2
	56	7.9	15.8	23.7	31.6	39.5	47.4	55.3	63.2	71.1

TABLE XV - Continued
Corrections in Links to Slope Measurements.

Slope		1 ch.	2 chs.	3 chs.	4 chs.	5 chs.	6 chs.	7 chs.	8 chs.	9 chs.
°	'									
23	04	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0
	13	8.1	16.2	24.3	32.4	40.5	48.6	56.7	64.8	72.9
	22	8.2	16.4	24.6	32.8	41.0	49.2	57.4	65.6	73.8
	31	8.3	16.6	24.9	33.2	41.5	49.8	58.1	66.4	74.7
	39	8.4	16.8	25.2	33.6	42.0	50.4	58.8	67.2	75.6
	48	8.5	17.0	25.5	34.0	42.5	51.0	59.5	68.0	76.5
	56	8.6	17.2	25.8	34.4	43.0	51.6	60.2	68.8	77.4
24	05	8.7	17.4	26.1	34.8	43.5	52.2	60.9	69.6	78.3
	13	8.8	17.6	26.4	35.2	44.0	52.8	61.6	70.4	79.2
	21	8.9	17.8	26.7	35.6	44.5	53.4	62.3	71.2	80.1
	30	9.0	18.0	27.0	36.0	45.0	54.0	63.0	72.0	81.0
	38	9.1	18.2	27.3	36.4	45.5	54.6	63.7	72.8	81.9
	46	9.2	18.4	27.6	36.8	46.0	55.2	64.4	73.6	82.8
	54	9.3	18.6	27.9	37.2	46.5	55.8	65.1	74.4	83.7
25	03	9.4	18.8	28.2	37.6	47.0	56.4	65.8	75.2	84.6
	11	9.5	19.0	28.5	38.0	47.5	57.0	66.5	76.0	85.5
	19	9.6	19.2	28.8	38.4	48.0	57.6	67.2	76.8	86.4
	27	9.7	19.4	29.1	38.8	48.5	58.2	67.9	77.6	87.3
	35	9.8	19.6	29.4	39.2	49.0	58.8	68.6	78.4	88.2
	43	9.9	19.8	29.7	39.6	49.5	59.4	69.3	79.2	89.1
	51	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0
	58	10.1	20.2	30.3	40.4	50.5	60.6	70.7	80.8	90.9
26	06	10.2	20.4	30.6	40.8	51.0	61.2	71.4	81.6	91.8
	14	10.3	20.6	30.9	41.2	51.5	61.8	72.1	82.4	92.7
	22	10.4	20.8	31.2	41.6	52.0	62.4	72.8	83.2	93.6
	29	10.5	21.0	31.5	42.0	52.5	63.0	73.5	84.0	94.5
	37	10.6	21.2	31.8	42.4	53.0	63.6	74.2	84.8	95.4
	45	10.7	21.4	32.1	42.8	53.5	64.2	74.9	85.6	96.3
	52	10.8	21.6	32.4	43.2	54.0	64.8	75.6	86.4	97.2
27	00	10.9	21.8	32.7	43.6	54.5	65.4	76.3	87.2	98.1
	08	11.0	22.0	33.0	44.0	55.0	66.0	77.0	88.0	99.0
	15	11.1	22.2	33.3	44.4	55.5	66.6	77.7	88.8	99.9
	23	11.2	22.4	33.6	44.8	56.0	67.2	78.4	89.6	100.8
	30	11.3	22.6	33.9	45.2	56.5	67.8	79.1	90.4	101.7
	38	11.4	22.8	34.2	45.6	57.0	68.4	79.8	91.2	102.6
	45	11.5	23.0	34.5	46.0	57.5	69.0	80.5	92.0	103.5
	52	11.6	23.2	34.8	46.4	58.0	69.6	81.2	92.8	104.4
28	00	11.7	23.4	35.1	46.8	58.5	70.2	81.9	93.6	105.3
	07	11.8	23.6	35.4	47.2	59.0	70.8	82.6	94.4	106.2
	14	11.9	23.8	35.7	47.6	59.5	71.4	83.3	95.2	107.1

TABLE XV - Continued.
Corrections in Links to Slope Measurements.

Slope		1 ch.	2 chs.	3 chs.	4 chs.	5 chs.	6 chs.	7 chs.	8 chs.	9 chs.
°	'									
28	21	12.0	24.0	36.0	48.0	60.0	72.0	84.0	96.0	108.0
	29	12.1	24.2	36.3	48.4	60.5	72.6	84.7	96.8	108.9
	36	12.2	24.4	36.6	48.8	61.0	73.2	85.4	97.6	109.8
	43	12.3	24.6	36.9	49.2	61.5	73.8	86.1	98.4	110.7
	50	12.4	24.8	37.2	49.6	62.0	74.4	86.8	99.2	111.6
	57	12.5	25.0	37.5	50.0	62.5	75.0	87.5	100.0	112.5
29	04	12.6	25.2	37.8	50.4	63.0	75.6	88.2	100.8	113.4
	11	12.7	25.4	38.1	50.8	63.5	76.2	88.9	101.6	114.3
	18	12.8	25.6	38.4	51.2	64.0	76.8	89.6	102.4	115.2
	25	12.9	25.8	38.7	51.6	64.5	77.4	90.3	103.2	116.1
	32	13.0	26.0	39.0	52.0	65.0	78.0	91.0	104.0	117.0
	39	13.1	26.2	39.3	52.4	65.5	78.6	91.7	104.8	117.9
	46	13.2	26.4	39.6	52.8	66.0	79.2	92.4	105.6	118.8
	53	13.3	26.6	39.9	53.2	66.5	79.8	93.1	106.4	119.7
30	00	13.4	26.8	40.2	53.6	67.0	80.4	93.8	107.2	120.6
	07	13.5	27.0	40.5	54.0	67.5	81.0	94.5	108.0	121.5
	14	13.6	27.2	40.8	54.4	68.0	81.6	95.2	108.8	122.4
	21	13.7	27.4	41.1	54.8	68.5	82.2	95.9	109.6	123.3
	27	13.8	27.6	41.4	55.2	69.0	82.8	96.6	110.4	124.2
	34	13.9	27.8	41.7	55.6	69.5	83.4	97.3	111.2	125.1
	41	14.0	28.0	42.0	56.0	70.0	84.0	98.0	112.0	126.0
	48	14.1	28.2	42.3	56.4	70.5	84.6	98.7	112.8	126.9
	54	14.2	28.4	42.6	56.8	71.0	85.2	99.4	113.6	127.8
31	01	14.3	28.6	42.9	57.2	71.5	85.8	100.1	114.4	128.7
	08	14.4	28.8	43.2	57.6	72.0	86.4	100.8	115.2	129.6
	14	14.5	29.0	43.5	58.0	72.5	87.0	101.5	116.0	130.5
	21	14.6	29.2	43.8	58.4	73.0	87.6	102.2	116.8	131.4
	28	14.7	29.4	44.1	58.8	73.5	88.2	102.9	117.6	132.3
	34	14.8	29.6	44.4	59.2	74.0	88.8	103.6	118.4	133.2
	41	14.9	29.8	44.7	59.6	74.5	89.4	104.3	119.2	134.1
	47	15.0	30.0	45.0	60.0	75.0	90.0	105.0	120.0	135.0
	54	15.1	30.2	45.3	60.4	75.5	90.6	105.7	120.8	135.9
32	00	15.2	30.4	45.6	60.8	76.0	91.2	106.4	121.6	136.8
	07	15.3	30.6	45.9	61.2	76.5	91.8	107.1	122.4	137.7
	13	15.4	30.8	46.2	61.6	77.0	92.4	107.8	123.2	138.6
	20	15.5	31.0	46.5	62.0	77.5	93.0	108.5	124.0	139.5
	26	15.6	31.2	46.8	62.4	78.0	93.6	109.2	124.8	140.4
	33	15.7	31.4	47.1	62.8	78.5	94.2	109.9	125.6	141.3
	39	15.8	31.6	47.4	63.2	79.0	94.8	110.6	126.4	142.2
	45	15.9	31.8	47.7	63.6	79.5	95.4	111.3	127.2	143.1

TABLE XV - Concluded.
Corrections in Links to Slope Measurements.

Slope		1 ch.	2 chs.	3 chs.	4 chs.	5 chs.	6 chs.	7 chs.	8 chs.	9 chs.
°	'									
32	52	16.0	32.0	48.0	64.0	80.0	96.0	112.0	128.0	144.0
	58	16.1	32.2	48.3	64.4	80.5	96.6	112.7	128.8	144.9
33	04	16.2	32.4	48.6	64.8	81.0	97.2	113.4	129.6	145.8
	11	16.3	32.6	48.9	65.2	81.5	97.8	114.1	130.4	146.7
	17	16.4	32.8	49.2	65.6	82.0	98.4	114.8	131.2	147.6
	23	16.5	33.0	49.5	66.0	82.5	99.0	115.5	132.0	148.5
	29	16.6	33.2	49.8	66.4	83.0	99.6	116.2	132.8	149.4
	36	16.7	33.4	50.1	66.8	83.5	100.2	116.9	133.6	150.3
	42	16.8	33.6	50.4	67.2	84.0	100.8	117.6	134.4	151.2
	48	16.9	33.8	50.7	67.6	84.5	101.4	118.3	135.2	152.1
	54	17.0	34.0	51.0	68.0	85.0	102.0	119.0	136.0	153.0
34	00	17.1	34.2	51.3	68.4	85.5	102.6	119.7	136.8	153.9
	06	17.2	34.4	51.6	68.8	86.0	103.2	120.4	137.6	154.8
	12	17.3	34.6	51.9	69.2	86.5	103.8	121.1	138.4	155.7
	19	17.4	34.8	52.2	69.6	87.0	104.4	121.8	139.2	156.6
	25	17.5	35.0	52.5	70.0	87.5	105.0	122.5	140.0	157.5
	31	17.6	35.2	52.8	70.4	88.0	105.6	123.2	140.8	158.4
	37	17.7	35.4	53.1	70.8	88.5	106.2	123.9	141.6	159.3
	43	17.8	35.6	53.4	71.2	89.0	106.8	124.6	142.4	160.2
	49	17.9	35.8	53.7	71.6	89.5	107.4	125.3	143.2	161.1
	55	18.0	36.0	54.0	72.0	90.0	108.0	126.0	144.0	162.0
35	01	18.1	36.2	54.3	72.4	90.5	108.6	126.7	144.8	162.9
	07	18.2	36.4	54.6	72.8	91.0	109.2	127.4	145.6	163.8
	13	18.3	36.6	54.9	73.2	91.5	109.8	128.1	146.4	164.7
	19	18.4	36.8	55.2	73.6	92.0	110.4	128.8	147.2	165.6
	25	18.5	37.0	55.5	74.0	92.5	111.0	129.5	148.0	166.5
	31	18.6	37.2	55.8	74.4	93.0	111.6	130.2	148.8	167.4
	37	18.7	37.4	56.1	74.8	93.5	112.2	130.9	149.6	168.3
	42	18.8	37.6	56.4	75.2	94.0	112.8	131.6	150.4	169.2
	48	18.9	37.8	56.7	75.6	94.5	113.4	132.3	151.2	170.1
	54	19.0	38.0	57.0	76.0	95.0	114.0	133.0	152.0	171.0
36	00	19.1	38.2	57.3	76.4	95.5	114.6	133.7	152.8	171.9
	06	19.2	38.4	57.6	76.8	96.0	115.2	134.4	153.6	172.8
	12	19.3	38.6	57.9	77.2	96.5	115.8	135.1	154.4	173.7
	18	19.4	38.8	58.2	77.6	97.0	116.4	135.8	155.2	174.6
	23	19.5	39.0	58.5	78.0	97.5	117.0	136.5	156.0	175.5
	29	19.6	39.2	58.8	78.4	98.0	117.6	137.2	156.8	176.4
	35	19.7	39.4	59.1	78.8	98.5	118.2	137.9	157.6	177.3
	41	19.8	39.6	59.4	79.2	99.0	118.8	138.6	158.4	178.2
	46	19.9	39.8	59.7	79.6	99.5	119.4	139.3	159.2	179.1
	52	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0

TABLE XVI

Table for Laying Out Roads One Chain Wide.

Difference of Bearing				Links	Difference of Bearing				Links	Difference of Bearing				Links
°	'	°	'		°	'	°	'		°	'	°	'	
360	00	0	00	100	275	35	84	25	135	252	04	107	56	170
343	52	16	08	101	274	40	85	20	136	251	35	108	25	171
337	16	22	44	102	273	46	86	14	137	251	06	108	54	172
332	16	27	44	103	272	53	87	07	138	250	38	109	22	173
328	07	31	53	104	272	01	87	59	139	250	10	109	50	174
324	30	35	30	105	271	10	88	50	140	249	42	110	18	175
321	16	38	44	106	270	21	89	39	141	249	15	110	45	176
318	19	41	41	107	269	32	90	28	142	248	48	111	12	177
315	37	44	23	108	268	44	91	16	143	248	22	111	38	178
313	06	46	54	109	267	58	92	02	144	247	56	112	04	179
310	46	49	14	110	267	12	92	48	145	247	30	112	30	180
308	33	51	27	111	266	28	93	32	146	247	05	112	55	181
306	28	53	32	112	265	44	94	16	147	246	40	113	20	182
304	30	55	30	113	265	01	94	59	148	246	15	113	45	183
302	37	57	23	114	264	19	95	41	149	245	50	114	10	184
300	49	59	11	115	263	37	96	23	150	245	26	114	34	185
299	06	60	54	116	262	57	97	03	151	245	03	114	57	186
297	27	62	33	117	262	17	97	43	152	244	39	115	21	187
295	52	64	08	118	261	38	98	22	153	244	16	115	44	188
294	21	65	39	119	260	59	99	01	154	243	53	116	07	189
292	53	67	07	120	260	21	99	39	155	243	31	116	29	190
291	28	68	32	121	259	44	100	16	156	243	09	116	51	191
290	06	69	54	122	259	08	100	52	157	242	47	117	13	192
288	47	71	13	123	258	32	101	28	158	242	25	117	35	193
287	30	72	30	124	257	57	102	03	159	242	03	117	57	194
286	16	73	44	125	257	22	102	38	160	241	42	118	18	195
285	03	74	57	126	256	48	103	12	161	241	21	118	39	196
283	53	76	07	127	256	14	103	46	162	241	01	118	59	197
282	45	77	15	128	255	41	104	19	163	240	40	119	20	198
281	39	78	21	129	255	09	104	51	164	240	20	119	40	199
280	34	79	26	130	254	37	105	23	165	240	00	120	00	200
279	31	80	29	131	254	05	105	55	166					
278	30	81	30	132	253	34	106	26	167					
277	30	82	30	133	253	04	106	56	168					
276	32	83	28	134	252	34	107	26	169					

TABLE XVII

To Convert Time Into Arc

Hours of Time into Arc

Time	Arc	Time	Arc	Time	Arc	Time	Arc	Time	Arc	Time	Arc
hrs.	°	hrs.	°	hrs.	°	hrs.	°	hrs.	°	hrs.	°
1	15	5	75	9	135	13	195	17	255	21	315
2	30	6	90	10	150	14	210	18	270	22	330
3	45	7	105	11	165	15	225	19	285	23	345
4	60	8	120	12	180	16	240	20	300	24	360

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

TABLE XVIII

Conversion of Mean Time Interval To The Equivalent Siderial Time Interval

(Add listed correction to Mean Time Interval)

Days	Add		Hours	Add		Minutes	Add
	m.	s.		m.	s.		s.
1	3	56.6	1		9.9	1	0.2
2	7	53.1	2		19.7	2	0.3
3	11	49.7	3		29.6	3	0.5
4	15	46.2	4		39.4	4	0.7
5	19	42.8	5		49.3	5	0.8
6	23	39.4	6		59.1	6	1.0
7	27	35.9	7	1	09.0	7	1.2
8	31	32.5	8	1	18.8	8	1.3
9	35	29.0	9	1	28.7	9	1.5
			10	1	38.6	10	1.6
			20	3	17.1	20	3.3
						30	4.9
						40	6.6
						50	8.2

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