MANUAL OF SURVEY

2

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MANUAL

SHEWING THE

SYSTEM OF SURVEY

OF THE

DOMINION LANDS,

WITH

INSTRUCTIONS TO SURVEYORS.

PUBLISHED BY AUTHORITY OF THE
HONOURABLE THE MINISTER OF THE INTERIOR FOR CANADA

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Prefatory Note to Second Edition.

This Manual was originally prepared by Lieut.-Col. J. S. Dennis, Deputy Minister of the Interior, at the time Surveyor General of Dominion Lands. A second edition became necessary for the reasons: first, that it was out of print; next, that owing to changes made in the number and width of Township Road Allowances, and to other modifications of the processes of survey found desirable, corresponding alterations in the Manual became necessary. These have been made under my direction by Capt. E. Deville, D. T. S., F. R. A. S. Several useful tables, calculated for the purpose by him and by Mr. W. F. King, M.A., D.T.S., have also been added in this edition.

Lindsay Russell,
Surveyor General.

Dominion Lands Office,
Ottawa, 17th March, 1881.

ERRATA.

PAGE.	LINE.	INSTEAD OF.	READ.
11	49	Townships and section corner	Section corner.
14	1	xxx	xxv.
16	33	7	– 7.
22	45	$270+\frac{c}{6}$, $270-\frac{c}{6}$	$270+\frac{c}{6}$, 270, $270-\frac{c}{6}$.
32	11	forty chains	forty-one chains.
32	12	forty-one chains	forty chains.
32	15	forty chains	forty-one chains.
32	19	forty chains	forty-one chains.
32	20	distance	distance from corner post
32	23	70 chains	71 chains.
32	26	40 chains	forty-one chains.
32	26	14 chains	15 chains.
32	56	*g* or *G*	*b* or *B*.
33	6	Fig. 2	Fig. 3.
34	5	the the	the.
35	8	232 39 30	322 39 30.
39	41	broken	irregular.
40	12	page 5	page 51.
40	15	Oak	Brulé.
41	29	fifth correction	sixth correction.
41	43	In this	In the.
47	1	a	at.
47	7	therever	wherever.
60	14	$\phi - d$	$\phi - \delta$.
60	21	Nat tan ϕ	Nat tan δ.
60	22	tan ϕ — tan ϕ	tan ϕ — tan δ.
60	22	log (tan ϕ — tan ϕ)	log (tan ϕ — tan δ).
60	22	log sin ($\phi - \phi$)	log sin ($\phi - \delta$)
60	24	log sec ϕ	log sec δ.
60	26	ϕ	α.
60	32	386	486.
60	37	north	south.
60	38	south	north.

Diagram No. 4.—Rope skeleton for building mounds: 3ft. 6½in. is the distance from the corner to the centre, the total length of diagonal being 7ft. 1in.

Fig. 4, page 34, was inverted in printing.

Specimen timber plan and timber report.—*Delete* numbers of township, range and meridian, as the township is purely imaginary.

Table VI gives degrees and decimals.

Table IX gives links and decimals.

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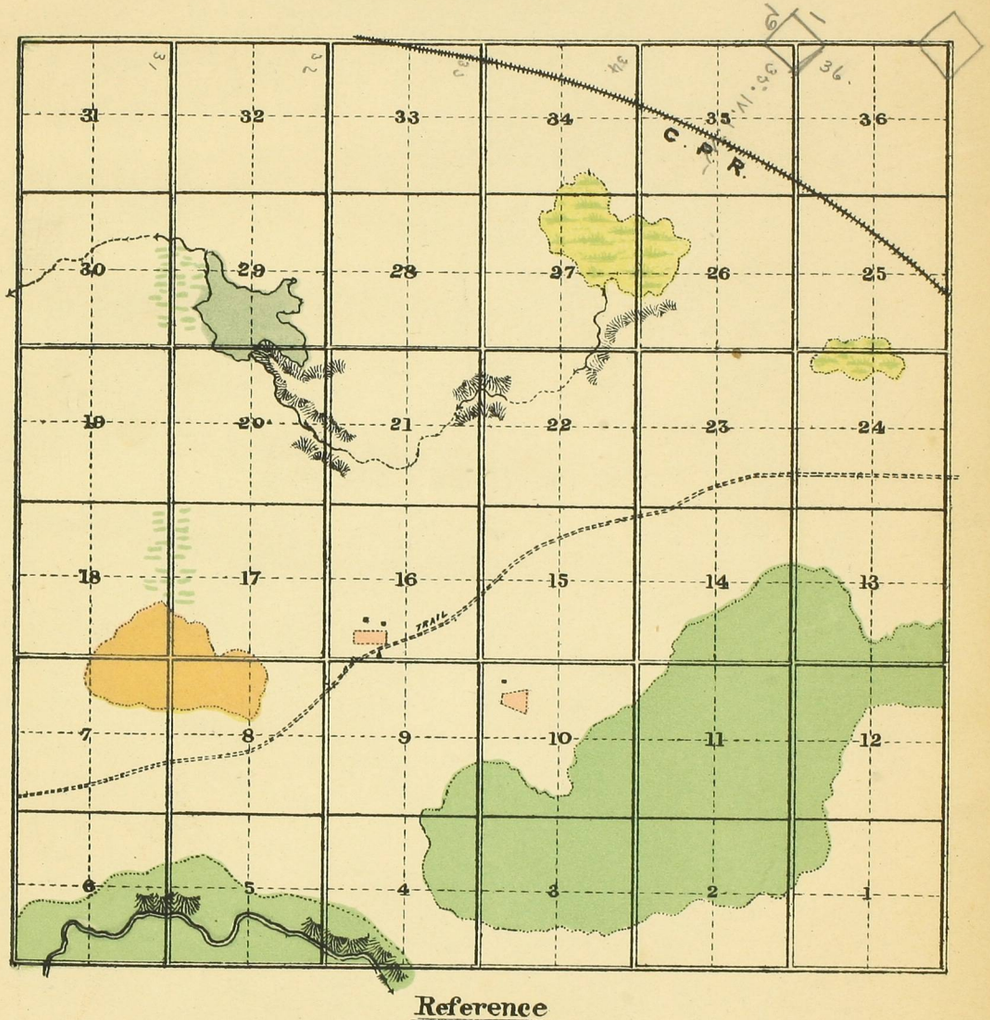
DIAGRAMS.

DIAGRAM Nº 1.

Illustrating method of shewing Topography

NORTH



Reference

Bush

Scrub or Brush

Brulé

Ploughed or cultivated land

Swamp

SYSTEM OF SURVEY.

Townships contain thirty-six square miles, more or less, exclusive of road allowances.

1. The Dominion lands are laid off in quadrilateral townships containing thirty six sections of six hundred and forty acres or one square mile in each, subject to the deficiency or surplus from the convergence or divergence of meridians, as hereinafter mentioned, together with road allowances of one chain on every section line running north and south and on every alternate section line running east and west.

Sections.

2. The sections are bounded and numbered as shewn by Diagram No. 1.

Townships measure 483 chains on east and west sides and 486 on north and south sides.

3. The township, therefore, measures on the east and west sides, from centre to centre of the road allowances bounding the same, four hundred and eighty-three chains, and on the north and south sides four hundred and eighty-six chains, subject to the deficiency or surplus from converging or diverging meridians, as the case may be.

Lines bounding townships.

4. The lines bounding townships on the east and west sides are true meridians, and those on the north and south sides are chords of the circles of latitude passing through the angles of the townships.

Lines bounding sections.

5. The lines bounding sections on the east and west sides are true meridians, and those on the north and south sides are lines parallel to the north and south boundaries of the township.

How townships are numbered.

6. The townships number in regular order, northerly from the International Boundary or forty-ninth parallel of latitude, and lie in ranges and are numbered west of certain meridian lines styled "First, Second, Third,.....Principal Meridian." There are also ranges lying and numbered east of the First Principal Meridian and townships lying and numbered south of the forty-ninth parallel. The latter are east of the Lake of the Woods.

Sections are 80 chains on base line.

7. The sections are laid out of the precise width, eighty chains, as aforesaid, or eighty-one chains with the road allowance, on certain lines called "base lines," and the meridians between the sections are drawn from such bases, north or south, to the depth of two townships, that is to say, to the correction line hereinafter mentioned. The sections south of the base measure therefore more than eighty chains, while they measure less north of the same line. The interval between a base line and the next one is equal to the depth of four townships. (See Diagram No. 2.)

"Jog" allowed on correction lines.

8. The correction lines are those upon which the "jog," resulting from the want of parallelism of meridians, is allowed, or, in other words, they are those township lines running east and west which are equidistant from the bases at the depth of two townships. The interval between the correction lines is equal to the depth of four townships. (See Diagram No. 2.)

Base lines in the system.

9. The first base line is the forty-ninth parallel of latitude or International Boundary; the second base is between townships four and five, the third between townships eight and nine, the fourth between townships twelve and thirteen, the fifth between townships sixteen and seventeen and so on, northerly, in regular succession.

Correction lines in the system.

10. The first correction line is between townships two and three, the second between townships six and seven, the third between townships ten and eleven, and so on, northerly, in regular succession.

Division of sections.

11. Each section is divided into quarter sections of one hundred and sixty acres, or one half mile square, more or less.

Country laid out into blocks of sixteen townships each, in the first instance and how.

12. Preliminary to the subdivision into townships and sections of any given portion of country proposed to be laid out for settlement, the same is laid out into blocks of sixteen townships each, by projecting the base lines and the east and west meridian boundaries of each block.

Blocks subdivided into townships and how.

13. Such blocks are subdivided into townships by projecting the meridians from the base lines to the correction line, and connecting by straight lines the township corners on the meridians.

Allowance for the discrepancies of the survey.

14. In the survey of any block or its subdivision, the closing errors on the correction line are allowed for in the ranges of quarter sections north and south of and adjoining the correction line.

Corners.

15. On the block and township outlines, at the time of the survey, all township, section and quarter section corners are marked, which corners govern respectively in the subsequent subdivision of the block or township.

Posts and monuments.

16. Only a single row of posts or monuments to indicate the corners of the townships or sections (except as hereinafter provided) is placed on any survey line. These posts and monuments, as an invariable rule (with the exception above referred to) are placed in the west limit of the road allowances on north and south lines, and in the south limit of road allowances or on the line between the sections, on east and west lines; and in all cases fix and govern the position of the boundary corner between the two adjoining townships, sections or quarter sections on the opposite side of the road allowance, or either side of the line.

Posts and monuments on correction lines.

17. The township, section or quarter section corners on correction lines are in all cases indicated by posts or monuments planted and marked independently for the townships on either side; those for the townships north of the line, in the north limit of the road allowance, and those for the townships south, in the south limit.

INSTRUCTIONS TO SURVEYORS.

FIELD WORK.

Surveys to be astronomical.

1. The surveys of the Dominion lands are to be astronomical, that is to say, the directions of their lines must be referred to the astronomical meridian.

Chain to be used.

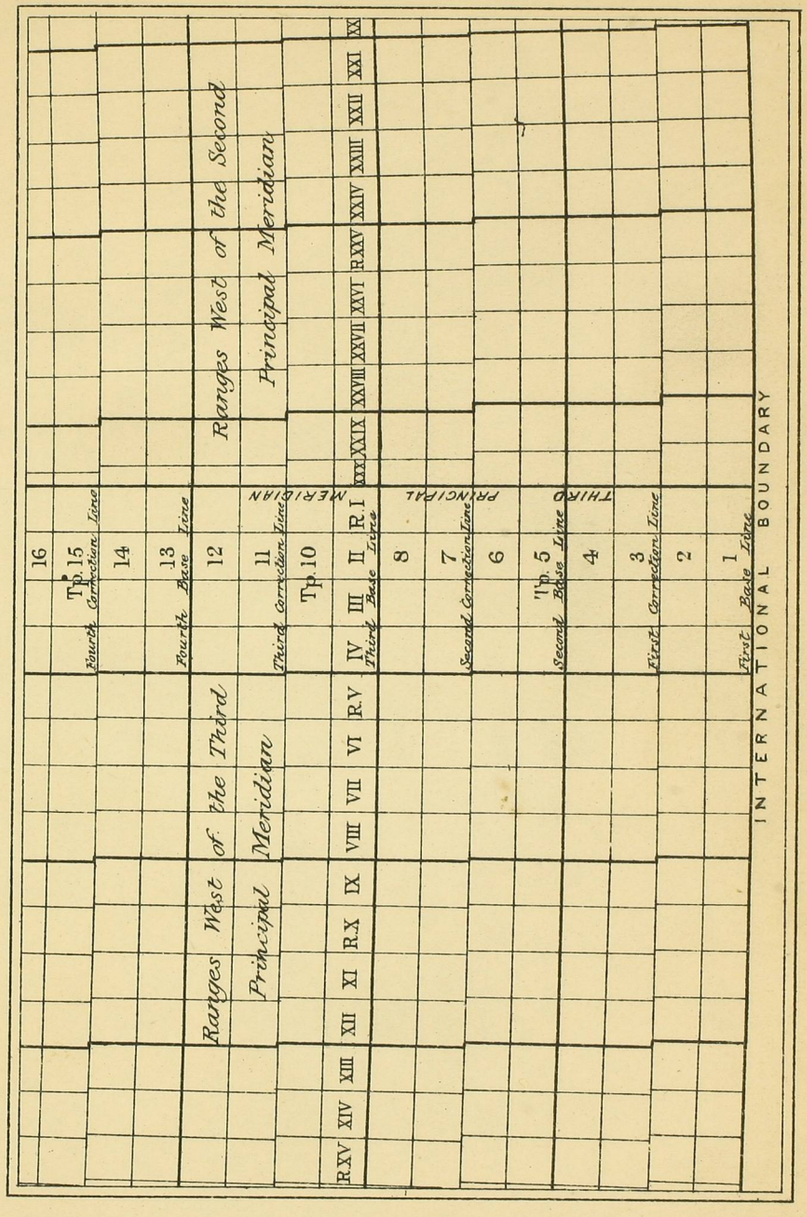
2. All measurements shall be made with the ordinary four pole or Gunter's chain. It is to be tested and corrected, during use, by a standard measure which shall have been previously compared with the standard at the Dominion Lands Office. If going through Winnipeg, or any other point where a standard section may have been established the surveyor will train his chainmen there until they can chain correctly. Eleven pins should be used, so as to leave one in the ground when exchanging tallies. The number of chains at any point is then equal to the number of pins, minus one.

Chainmen to be sworn.

3. Previous to entering on their duties, the chainmen shall be sworn according to the form below, and such oath filed with the returns of the survey.

DIAGRAM No. 2

Illustrating the subdivision of the country into blocks and townships.



(FORM OF OATH.)

I, A. B., do solemnly swear that I will faithfully discharge the duties of a chainman to the best of my ability and knowledge. So help me God.

Signed, A. B.

Sworn before me at
this day of 188 } .....D. L. S.

Precautions in chaining over broken ground.

4. In chaining over uneven ground, should the same be so broken as not to permit of the full chain being levelled, the measurement should be made with such portion thereof as may be easily levelled, and particular care should be taken at such times, in plumbing and dropping the pins, in order to obtain the accurate horizontal measurement.

Obstacles on the line.

5. In case the survey line be obstructed by a lake, pond, deep marsh or other obstacle, the Surveyor will pass it by right angled offsets, or, if more convenient, by a trigonometrical operation. In all triangles, the angle opposite to the base shall be called B, the angle opposite to the side to be calculated C and the third one A. The calculation is to be made according to the form given with the specimen of field notes (see page 16). The distance to the near side of the obstruction being entered at the proper place, it is only necessary to fill the form to have the distance to the far side. From this last point the chainmen start with the number of tallies and pins and the fraction of chain found by the calculation. The angle B should be, whenever practicable, at least thirty degrees. It shall never be less than fifteen degrees.

Blazing.

6. Surveyors will understand that all lines through wood land are to be well opened out, those established as boundaries are to be marked by blazing the adjacent trees on each of the sides in the direction which the line is being run, as well as the side on which the line passes. In running trial lines, no trees are to be blazed or other permanent marks left, but the true line is to be well opened out and blazed.

BOUNDARY CORNERS.

Township, section and quarter section corners.

Having ascertained by exact running and measurement, the proper point for establishing the township, section or quarter section corner, as the case may be, the Surveyor in marking the same, is to be governed by the following directions:

How to be marked in wooded country.

1. In a timbered country, a post is to be firmly planted at the proper point ascertained, and the position of such post is to be defined by ascertaining the astronomical bearing and distance therefrom of one or more adjacent trees, which tree or trees are to be marked B. T., with a knife or scribing iron, on the side next the post, the distance and bearing being marked with red chalk. The size and description of the tree as well as the bearing and distance are to be duly entered in the field notes.

Dimensions of posts.

2. Such posts should be, at least, of the following dimensions, that is to say:—~~Township and~~ section corner posts, three inches square, two feet above and twelve inches below the surface of the ground; quarter section posts, three inches wide (flattened on two sides only) eighteen inches above and twelve inches below the surface of the

ground. These posts should be marked with the fraction $\frac{1}{4}$ (fraction-wise) to identify them as quarter section posts, and should stand with the planes of their flatted sides at right angles to the direction the line is being run. All posts to be bevelled on top to turn rain. (See Diagram No. 3.)

Under certain circumstances, stone to be used.

3. In a wooded region, where stone abounds, corners may be defined by simple stones planted and marked, said stones to measure not less than eight by three inches, face measurement, and not less than two feet long, so as to allow them to stand one foot in the ground and show a like distance above. The position of such stone corners will also be defined by reference to bearing trees, when the same may be conveniently near. (See Diagram No. 3.)

Mound to be used in prairie country.

4. In prairie country, it will often prove very difficult to get timber. Posts must be had, however, although their carriage for many miles may be involved. After planting, the post will be surrounded by a mound of pyramidal form.

Size and height of the mounds.

5. These mounds will be in form rectangular pyramids. The mound thrown up at the corner of a township will be three feet high with sides of base six feet; at section and quarter-section corners, the sides of the base will be five feet, and the height two and a-half feet. (See Diagram No. 4.)

Earth to be taken from pits.

6. In the formation of mounds, the earth will be taken from four several "pits" three feet square and eighteen inches deep, the centres of which pits should be, whenever practicable, four feet six inches outside and opposite the centre of the respective bases.

To be formed of solid earth.

7. Mounds are to be formed of solid earth, sod and all foreign substances being excluded, and the earth well pressed down with the spade during the process. The post is to be firmly planted twelve inches in the solid ground before beginning to build the mound. In order to facilitate the speedy erection of the mound, a rope skeleton may be used. By taking hold of each corner and making a bow-knot of the three lines running to it, the line is carried without becoming tangled; or the spade used may have marked on it the distances from the post to the corners of the mound and to the sides of the pits, and small pickets be planted at those distances and in the proper direction. (See Diagram No. 4.)

Stone mounds.

8. In a stony region, the mounds may be built of stones properly piled around the post, so as to conform as nearly as possible in size and shape to the earth mounds.

Angles of mounds to be towards the cardinal points.

9. On all north and south, and on all east and west survey lines, excepting the correction lines, corner posts and mounds will be so placed that lines connecting the cardinal points will pass through the angles.

Except on correction lines, in which case they will stand square with the line.

10. The posts and mounds erected to mark the corners in either limit of the road allowance on the correction lines will be so placed that lines connecting the cardinal points will pass through the centre of the bases of the mounds or of the faces of the posts.

Posts in mounds.

11. Posts in mounds will require to be four feet four inches long, in order that they may stand twelve inches in the solid ground, two feet six inches in the mound, and ten inches above the same. The top is to be bevelled to turn rain.

Witness mounds.

12. If a township or section corner, in a situation where a bearing tree is not to be found within a reasonable distance, shall fall in a ravine, bed of a stream or in any other situation where the character of the locality may be unfavourable to the planting of a post or the erection of a mound, the surveyor will perpetuate such corner by erecting a witness mound at the nearest suitable point, the post in such witness mound being marked W. M. with a knife or

DIAGRAM Nº 3

ILLUSTRATING CORNER BOUNDARIES

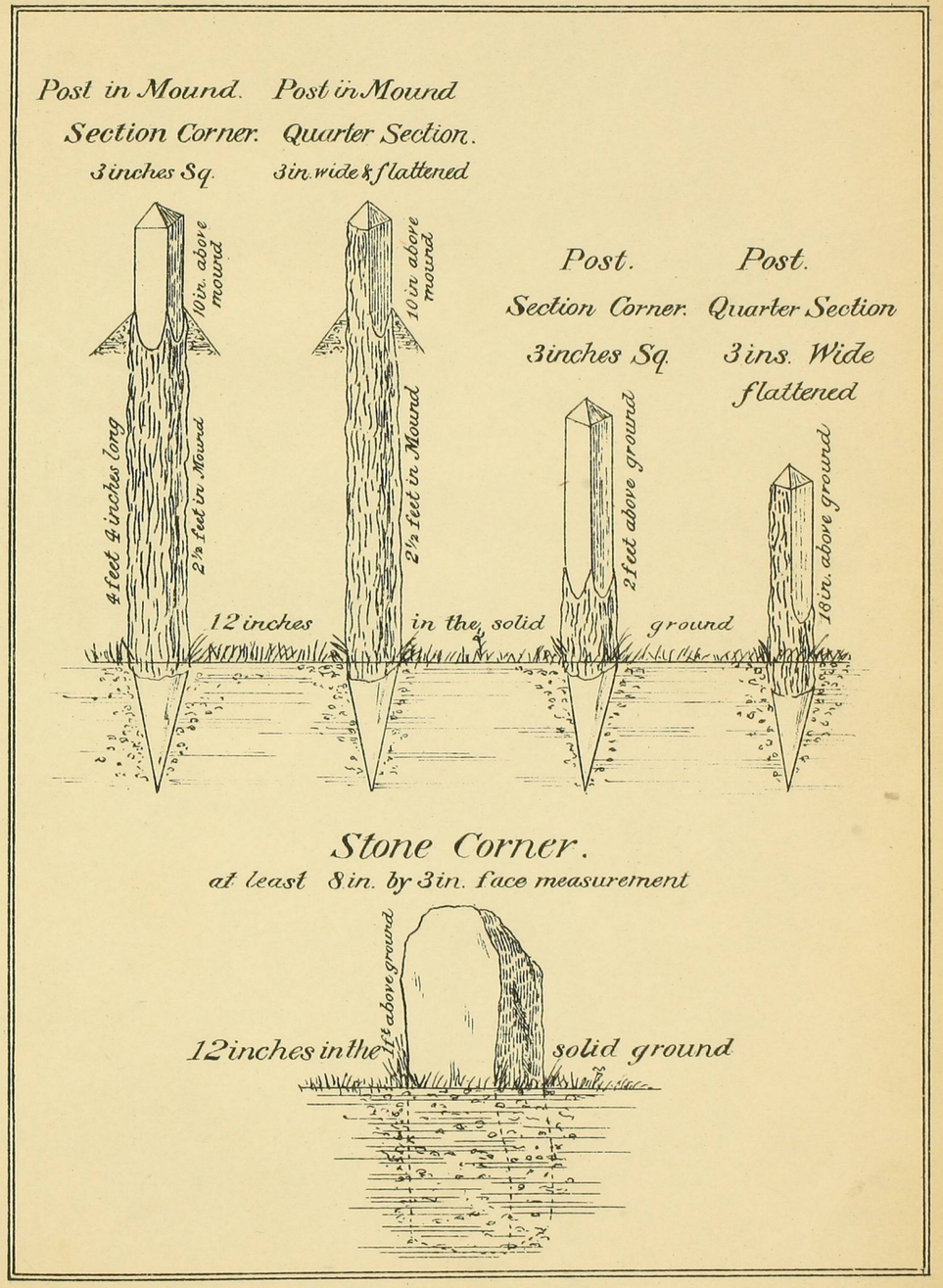


DIAGRAM No. 4

ILLUSTRATING THE MOUNDS TO BE THROWN UP ROUND CORNER POSTS.

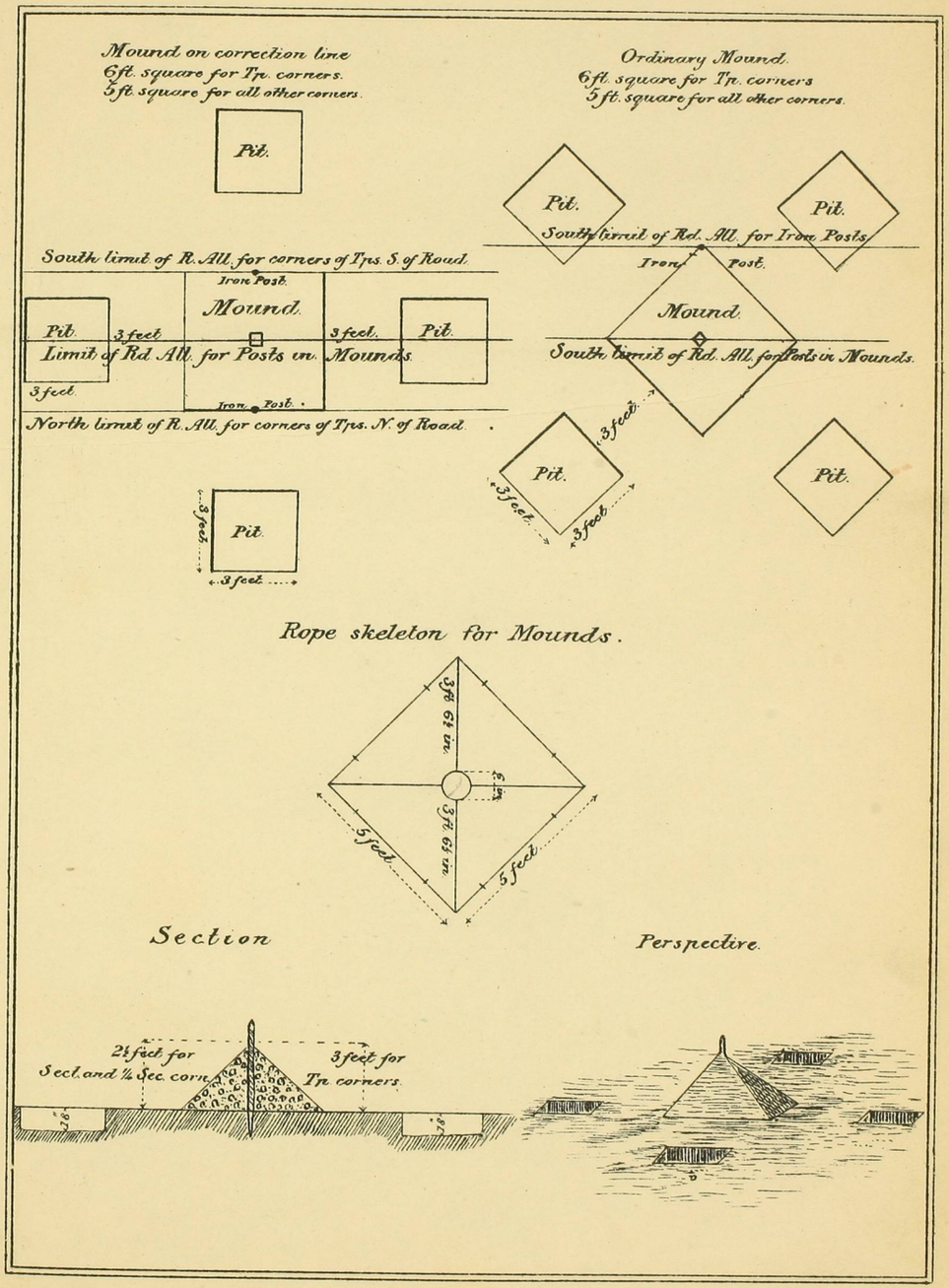
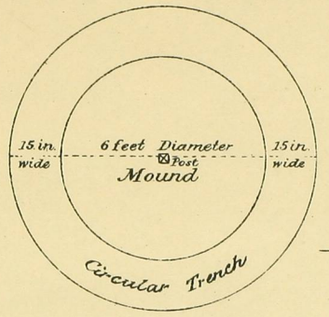
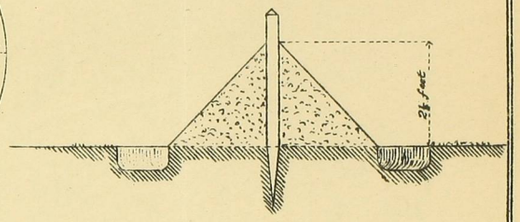


Diagram № 5.

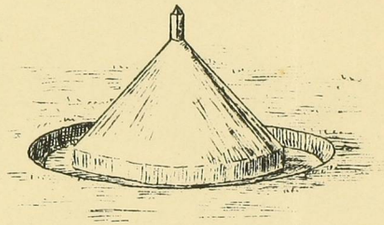
Illustrating Witness and Stone Mounds.



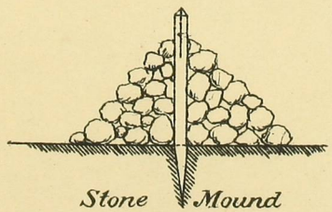
Witness Mound
Plan



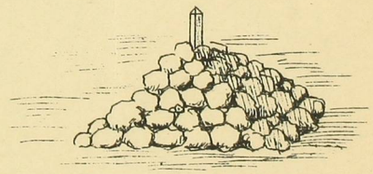
Witness Mound
Section



Witness Mound
Perspective



Stone Mound
Section



Stone Mound
Perspective

scribing iron. The bearing and distance of the site of the true corner from such mound are to be marked on the post with red chalk and entered in the field book together with all other particulars connected therewith. Attention is to be paid to the fact that the bearing is to be taken from the mound to the corner in the case of a witness mound, whilst it is to be taken from the corner to the tree in the case of a bearing tree. A witness mound will be in form a cone, six feet in diameter and two and a half feet high; the earth will be taken from a circular trench of fifteen inches wide. (See Diagram No. 5.)

Iron posts placed at township corners.

13. In projecting the standard meridians and parallels and township outlines, iron posts will be placed at every township corner.

Dimensions of iron posts.

14. The iron post is a pointed iron bar, five feet long and $1\frac{3}{8}$ inches square, or an iron tube of the same length and $1\frac{3}{8}$ inches in diameter. It is driven perpendicularly with a sledge to within ten inches from the top, and the appropriate marks and numbers, as hereinafter directed, are cut thereon with a cold chisel.

Iron posts in mounds.

15. The mounds in connection with iron boundaries, instead of being thrown up around the corners, will be so placed that the bars will stand precisely at the northerly angle thereof. (See Diagram No. 4.)

Iron posts in mounds on correction lines.

16. Except on correction lines where the mound will be so placed that the iron boundary will stand precisely in the centre of the north or south base as the corner may be intended for the township south or north of the road allowance.

Wooden post to be planted twelve inches from the iron post when there is no mound.

17. Should the site of an iron bar corner fall in a place where no mound can be erected, a wooden post, of the ordinary dimensions for section corner, shall be planted twelve inches from the iron post on the side where the mound should stand; such post to be marked I. B. The position of the iron post is besides perpetuated by bearing trees or a witness mound as directed above.

Boundary corners how to be marked.

18. Boundary stones or posts will be marked to indicate the corners they may be intended to represent, in a manner corresponding to that shewn below, and, as stated in clauses 9 and 10 above, are to be so placed that their angles will be in the directions north and south, and east and west, except on correction lines where they will stand square with the lines.

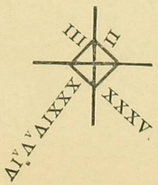
Township corners.

19. On township corners, the upper figure on a given side will indicate the township and the next one the range, as for instance:

For the corner between townships 5 and 6, and the 3rd and 4th ranges.

Section corners.

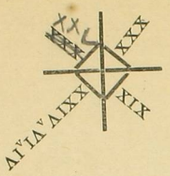
20. On all other section corners, either on town lines or in the interior of a township, the simple numbers of the sections will be placed upon the corresponding faces of the post, and in addition, on a certain one of the sides thereof will be marked the number and range of township, as for instance:



Section corner on north boundary of township.

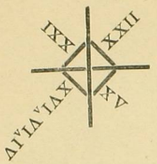
For the northerly corner between sections 34 and 35, township 5, range 4.

Section corner on east boundary of township.



For the easterly corner between sections 24 and 25, township 6, range 4.

Section corner in the interior of a township.

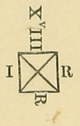


For the corner between sections 15, 16, 21, 22, township 6, range 4.

Township corners on correction lines.

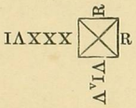
21. The corners on correction lines are to be marked exclusively for the townships and sections on the respective sides of the road allowance. Township corners will have the number of section on the west side, the number of township and range on the north side, for posts north of the road allowance and on the south side for posts south of the road. The letter R for road will be marked on the two other sides, thus :—

Township corner north of the road allowance.



For south-east corner of township 3, range 10.

Township corner south of the road allowance.



For the north-east corner of township 6, range 5.

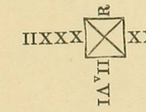
Section corner on correction lines.

22. Section corners will have the numbers of sections on the east and west sides, the letter R towards the road and the number of township and range on the other side, thus :—

Section corner north of the road allowance.

For the southerly corner between sections 3 and 4, township 7, range 7.

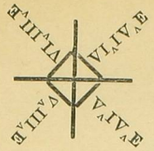
Section corner south of the road allowance.



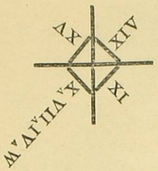
For the northerly corner between sections 32 and 33, township 2, range 6.

Marks of boundaries in ranges numbered from the First Principal Meridian.

23. In ranges numbered from the first principal meridian, the letter W or E will be marked on the post after the number of the range, to denote that it is west or east of the meridian, as for instance :—



For the township corner between townships 5 and 6, and the 3rd and 4th ranges east of the first principal meridian.



For the corner between sections 10, 11, 14, 15, township 7, range 4 west of the first principal meridian.

24. The figures on the trees and posts are to be cut neatly and distinctly with a knife or scribing iron, which is to be kept in good order by a whetstone and small file carried for the purpose. The marks on iron posts and stone corners will be effected with a cold chisel. The Surveyor will be careful to provide himself with these very indispensable implements before leaving for his survey.

THE FIELD BOOK.

Of the Field Book.

1. The first page will give its title, shewing the nature of the survey, by whom surveyed, and the dates of the commencement and the completion of the work. The second page will contain the names and duties of all assistants, and wherever a new assistant is employed or any one changed, an appropriate entry thereof with the reasons therefor will be made in the field book previous to entering any notes under the changed arrangements. The third page will contain a skeleton diagram, with each section or traverse line numbered to correspond with the page of the notes.

2. The field notes must be a faithful, distinct and minute record of everything officially done and observed by the Surveyor and his assistants pursuant to instructions, in relation to running, measuring and marking lines, establishing boundary corners, laying off road allowances, &c., and present, as far as possible, a full and complete topographical description of the country surveyed.

3. The field notes of every section line surveyed, whether in laying out the blocks or in the sub-division thereof, must be complete in themselves, and be laid down on a separate page, as illustrated by the specimens notes. (Page 16.) The following abbreviations of words, but no others will be allowed in the notes, that is to say:

Abbreviations.

"*Sec.*" for "*Section*" "*in diam.*" for "*in diameter,*" "*chs.*" for "*chains,*" "*lks.*" for "*links*" "*dist.*" for "*distance*" or "*distant,*" "*Tp.*" for "*Township,*" "*R.*" for "*Range,*" "*W.*" for "*West,*" "*N.*" for "*North,*" "*S.*" for "*South,*" "*E.*" for "*East,*" and "*P. in M.*" for "*Post in Mound,*" "*B. T.*" for "*Bearing Tree,*" "*W. M.*" for "*Witness Mound,*" and "*I. B.*" for "*Iron Boundary.*"

4. The field notes are to give the following information in relation to the survey:

5. The length of every line run, noting all necessary offsets therefrom, with the reasons for the same.

¼ Sect.	40.140
Slope.	3
"	13
"	7
"	24
"	
"	
"	
"	
"	
"	
"	
"	
Th. cor.	— 5
¼ Sect.	40.182
Sect.	41.140
Slope.	11
"	6
"	18
"	23
"	2
"	1
"	1
"	
"	
"	
"	
"	
"	
Th. cor.	— 7
Sect.	81.377

TRIANGLE No. 43 — b = 9.442

	Observed angles.	*Corrected angles.*		
A =	64° 43'	64° 44'	log. b =	0.97506
B =	55 56	55 57	cosec. B =	0.08168
C =	59 18	59 19	sin. C =	9.93450
	179 57	180 00	log. c =	0.99124
			c =	9.800

Distance to near side of obstruction = 0.050

Distance to far side " = 9.850

TRIANGLE No. 44 — b = 5.287

A =	58° 03'	58° 02'	log. b =	0.72321
B =	52 51	52 50	cosec. B =	0.09861
C =	69 09	69 08	sin. C =	9.97054
	180 03	180 00	log. c =	0.79236
			c =	6.200

Distance to near side of obstruction = 37.000

Distance to far side " = 43.200

TRIANGLE No. ---------- b = ____

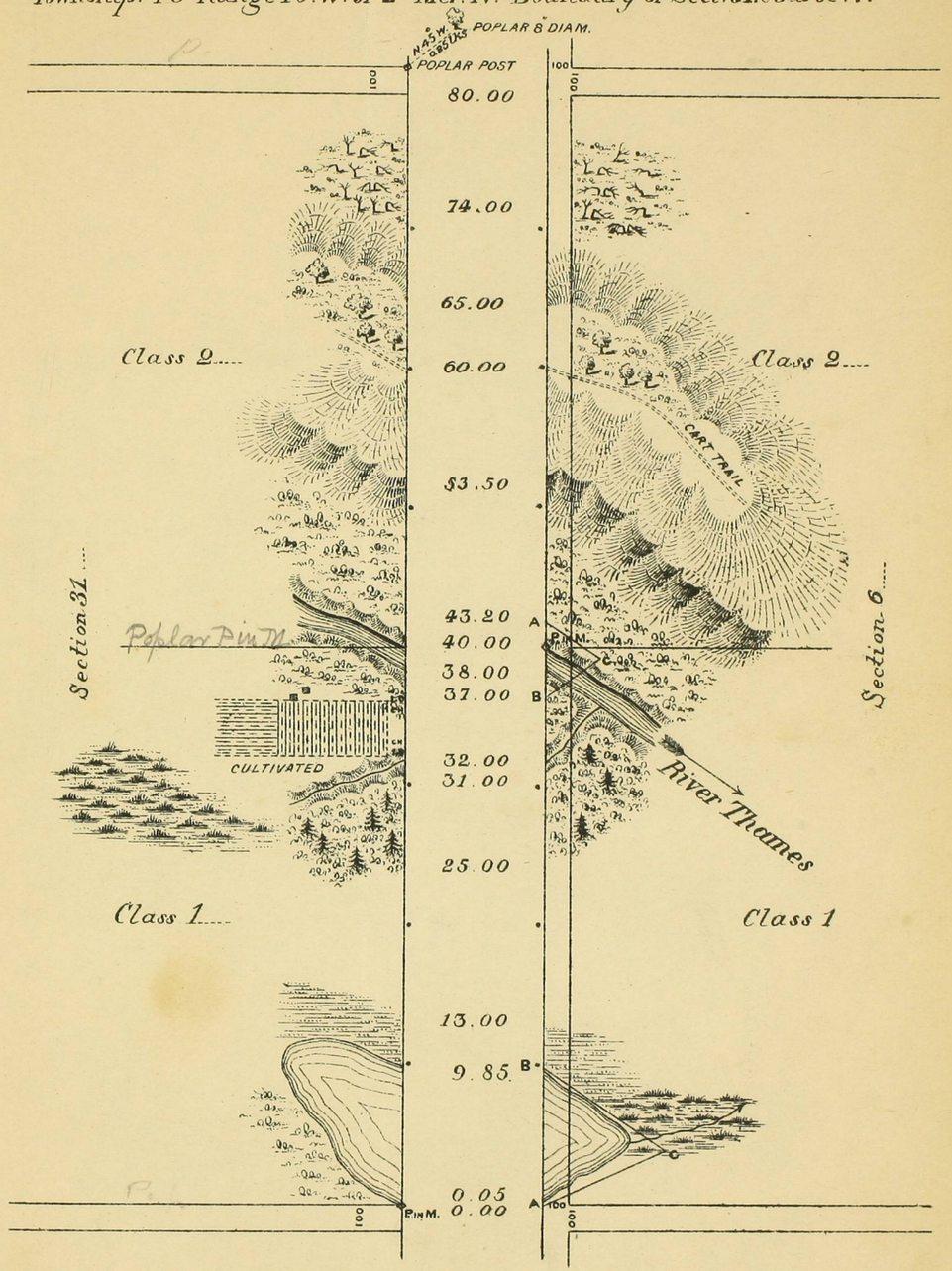
A =		log. b =	
B =		cosec. B =	
C =		sin. C	____
		log. c =	
		c =	

Distance to near side of obstruction = ____

Distance to far side " =

NORTH-WEST TERRITORIES

Township. 48 Range 10. W. of 2nd Mer. N. Boundary of Sect. 31. Course W.



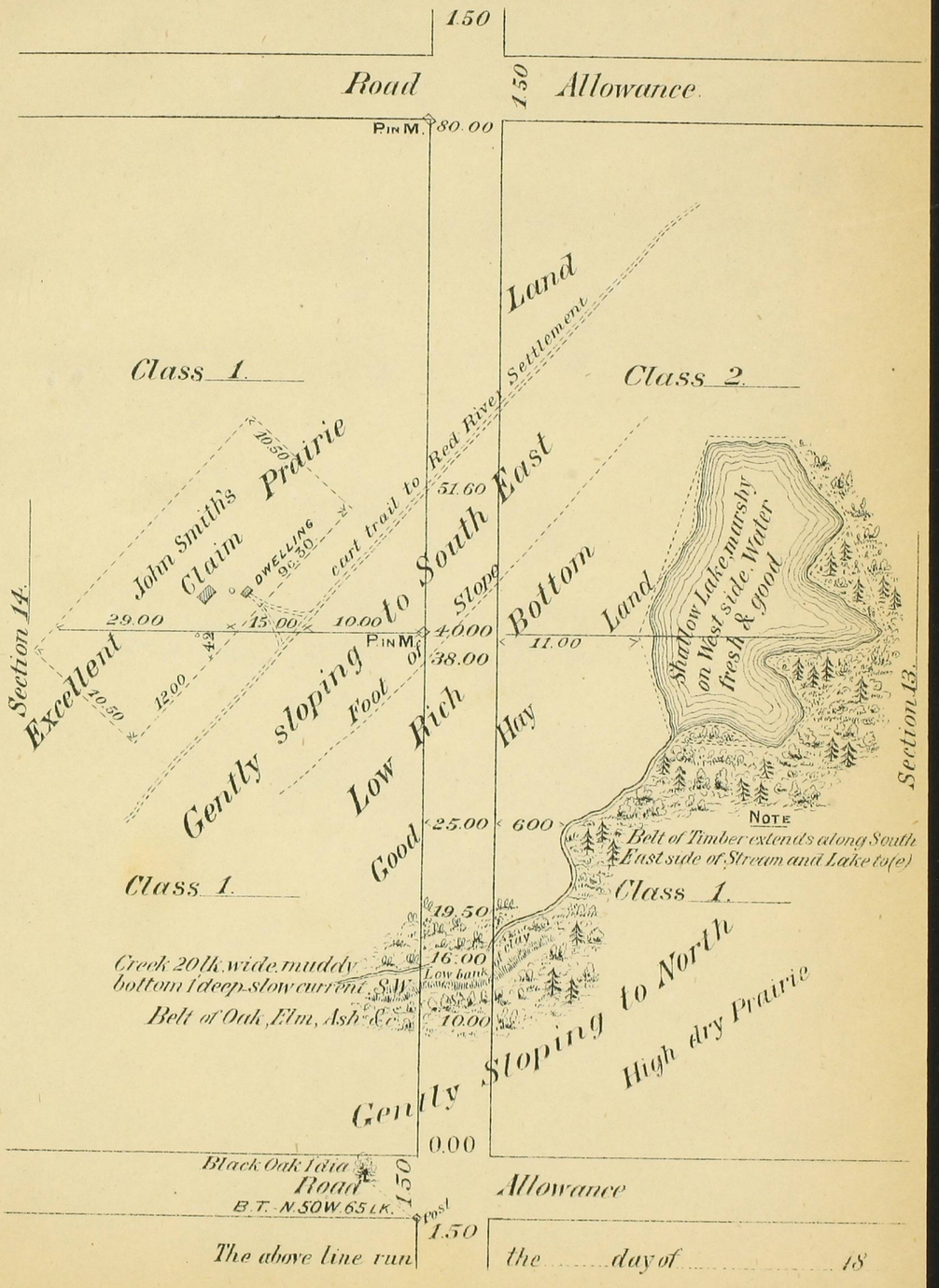
The above line ran ----------

North-West Territories, including Manitoba.

Township 5 Range 4 West

East Boundary of Section 14

Course NORTH



The above line run the ..... day of 18

6. The kind and diameter of all "bearing trees" or "witness mounds," with the course and distance of the same from their respective corners.

7. The character of corner boundaries, whether iron, post, or stone; if indicated by stone mound the fact to be stated.

8. The distances at which the line first intersects, and, also where it leaves settler's claims or improvements, lakes, ponds, rivers, bottom lands, swamps, marshes; also, the beginning of ascent, the top and the foot of descent, of all remarkable hills or ridges, with their estimated height in feet above the bottom lands near which they may be situated. Enter in the field book on the page where a stream, lake or pond is crossed, the data used for ascertaining the distance across it.

9. The course, average width and depth, and rate of current of all streams, and whether the water is fresh or salt in the lakes which may fall within the survey.

10. Whether the surface of the country is level, rolling, broken or hilly.

11. The nature of the soil, classifying it, according to its fitness for agriculture, as first, second, third, or fourth rate,—entering the class, at the time of survey, on each quarter-section where indicated with notes.

12. Careful returns and separate report are to be made of all improvements made by settlers, entering the names in full of the parties who have made them, giving a description of the position, area and nature of the same, including an estimate of their value.

13. If in timber, the kinds, quality and average dimension thereof.

14. Rapids or falls of water affording mill sites, with estimated fall and supply of water in general terms.

15. Coal deposits, minerals (transmitting specimens of the same), and salt springs, &c., &c.

16. The field-notes must be distinctly and neatly made out in language precise and clear, and their figures, letters, words and meaning, are always to be unmistakable. Field notes to be distinct and neat.

17. Besides the ordinary notes taken on the line (which notes must be always written down on the spot, leaving nothing to be supplied from memory), the surveyor will subjoin at the conclusion of his field notes, in a concise report, such further description or other information connected with the area surveyed, as he may be able to afford, which may be useful or necessary to be known, giving a *general description* of the character of the country, its soil and geological features, timbers, minerals, waters, &c.

18. Following the field-notes, the Surveyor will make affidavit as to the accuracy thereof according to the form below.

(*Form of Affidavit.*)

I, A.B., of the of , Dominion Lands Surveyor, make oath and say that the foregoing field-notes are correct and true in all their various particulars, to the best of my knowledge and belief. So help me God.

(Signed) A.B.

Sworn before me at , }
this of 18 . } *J.P. or Commissioner* (as the case may be).

SURVEY OF THE STANDARD MERIDIANS AND PARALLELS FORMING THE OUTLINES OF BLOCKS.

Dimension of blocks.

A block is to be of the dimensions embracing four townships in longitude and the same in latitude, or sixteen townships in all.

In accordance with the system of division prescribed by law for Dominion lands, its eastern and western exterior boundaries are broken lines, each consisting of two meridians separated by the "jog" on the correction line. The northern and southern limits (base lines) are parts of a polygon described on a parallel of latitude, by laying off, as chords thereto, the successive township sides, forming, as the case may be, the northern or southern outline of the block.

The road allowances along meridians are in all cases to be of the prescribed theoretic width, one chain. That the distribution of excess or defect is among the sections, and is not applied to the roads, will not materially affect the azimuth of those north and south lines involved; the displacement at the extremes—but two-thirds of a link on each mile—being less than what ordinary chaining is at all accurate enough to indicate.

Closing of blocks.

The Surveyor will invariably close his block on the correction line, projecting first the part on one side of the correction line and then the other half of the block. The north and south error in closing is to be divided equally between the two quarter sections north and south of and adjoining the correction line. In order to correct for it and to prevent the accumulation of errors, the Surveyor may deviate the two base lines of the next block equally and in opposite directions, so as to effect the required correction at the end of the four ranges. Supposing, for instance, the two quarter sections adjoining the correction line to be each 20 links short, the closing error might be corrected in the next block by deviating each base 21 seconds, the north base to the north and the south one to the south. It does not necessarily follow that the whole amount of the closing error is to be corrected for; the Surveyor should take into account the probable cause of the discrepancy and correct only for such part of it as he believes will best ensure the closing of the next block. The jog on the correction line is to be left such as found, unless it should show an error of more than one chain and fifty links in the lines of the last block, in which case they would have to be re-surveyed. The limit allowed for the north and south closing error on the correction line is also one chain and fifty links.

The block surveyor will mark on the correction lines only the township corners; all other posts are to be planted by the surveyor of township outlines.

Deflection of base lines.

When it becomes necessary to deflect the base lines for placing them in their proper latitudes, such deflection, unless instructions to the contrary be received from the head office, shall not exceed two minutes, and shall be carried to such a distance as to effect the required correction, except in closing on a principal meridian, where the last township corner is to be connected with the post on the meridian by a trial line, the deviation never extending beyond the range or fraction of a range adjoining the meridian.

Measurements.

The method of establishing the lengths and directions of the lines of the survey is to be the following :—

All lines are to be twice measured. This shall be effected by having two sets of chainmen, using Chesterman's continuous steel band chain. The leading one to be of the length of a standard Gunter's chain ; by it are to be kept all topographical and other notes, and posts planted. The following chain, to be used solely as a control, is to be a 100 feet chain.

When, at a section or quarter-section corner, the distances registered by the respective chainings for the length of the quarter section side, differ, in prairie country, more than two links, or, in woods and brush, more than three links, the two sets of chainmen shall return to the last post and measure over again, repeating their measurements until accordance within the limit here prescribed is attained.

Where the surface is so broken or uneven that it would be unreasonable to expect such accordance, and therefore, in a still greater measure, to look for any proper approximation to the absolute length of the interval chained, the Surveyor, while continuing to establish the direction and carry on the production of his line in the usual manner, shall have recourse to such application of trigonometric methods, for obtaining the distances along it, as his judgment and the necessities of the case may lead him to employ.

Standard chain.

The Surveyor shall have a standard chain with which the field chains are to be frequently compared. It will be tested at the Dominion Lands Office, and the temperature of comparison noted. As every ten degrees Fah. more or less heat would give to measurements a corresponding increment or decrement of somewhat more than half a link to the mile, and that in the North-West Territory a season of field work, extending from early spring to beginning of winter, will include variations of temperature covering a range of at least 80 degrees, and sometimes 100 degrees, the side of a block chained in July or August might, from this cause alone, differ from that of an adjacent one measured in November, fully a chain.

Correction for temperature.

In ordinary summer weather, however, the corrections for temperature would, compared with the order of precision of the work generally, be inappreciable, yet they must not be entirely neglected. The temperature error might in any given case happen to have the same sign as other uncorrected constants, or accidental errors, whose effect it would then go to aggravate. That in another case, further on, it might tend to counteract these, would not lessen the inaccuracy of position of the boundary monument planted under the first condition.

The surveyor will, therefore, apply this correction for all variations of 10° and over, from the normal temperature of 60° for which the chains are compared or adjusted to standard. This he can conveniently do, by allowing half a link to the mile for each ten degrees Fah., not attempting to note or estimate the temperature of his chain to less than ten degrees. This will keep his corrections in the convenient form of multiples of half links, and render tables unnecessary.

A thermometer attached to the end of a chain near the hand, fails to give the temperature of the rest of the chain; fastened to the middle and allowed to drag on the ground, it is liable to derangement and injury, it is therefore extremely difficult for the Surveyor to obtain even a rough approximation to the temperature of his chain. By repeating at convenient times, and under varied conditions, the experiment of placing a pocket thermometer on, or in, the grass or brushwood, as nearly as possible, similarly to the average position of the chain during the trial, and comparing the temperature attained by the thermometer so placed with that of the air, or indicated by a thermometer attached to the leading end of the chain,

a rough idea may be got of the allowances that should, in practice, be made in taking the indications of the latter, or in rudely estimating the temperature of the chain from that of the air at the time.

Attention should be paid to the condition of the chain during measurement, whether wet or dry; a wet chain will have its temperature lowered to a great extent, principally in dry weather. The colour of the chain has also some influence; a black or dark blue chain will absorb more heat than a bright one.

Steel band chains are very liable to break; this fact cannot be impressed too strongly upon the chainmen. In case such an accident should happen, the Surveyor ought to be provided with a small steel punch with sharp edges, a few copper rivets and some brass plates cut to the width of the chain. Holes can be punched through the steel band and the repair effected with two fish plates riveted together with the chain.

Correction for inclination.

Besides the small plummet line that should be carried by the chainmen to enable them to get correctly past minor irregularities of surface, the assistant should carry an Abney or Locke pocket level clinometer, by which he can obtain the inclination, and thus permit the chainmen to use the more accurate method of chaining on the inclined surface, instead of the one requiring them to hold their chain level and entailing a continuous repetition of plumbing down from the high end to the pin in the ground.

Use of clinometer.

In using his clinometer, the assistant will stand at one end of the slope, one of the chainmen standing at the other end, and he will sight through the instrument to some part of the chainman's body, the height of which shall have been previously ascertained to be the same as the height of his own eye. Such point will easily be found by using the clinometer at zero, the assistant and chainman standing close together and on the same level.

Chainage—how entered in the field book.

The field-books supplied to Surveyors contain a table of the correction per chain for given angles of slope, and also a form for applying the corrections to the chainage. The first number to be entered in this form is the length, in links of the chain used, of the quarter-section to be laid out. When the chain can be adjusted for length it is adjusted so as to be standard at 60° Fah.; the number to be entered is then the theoretic length of the quarter section, forty chains or forty-one chains as the case may be. When it cannot be adjusted the Surveyor ascertains its length at 60° Fah. by comparison with a standard, and computes the number of links of *his chain* required to give, at the above temperature, the proper length to the quarter-section. With a chain too long, the number of links will be less than the true length and vice versa. This number being entered in the field-book form, the corrections for slope will be written underneath; they are in all cases to be added. The correction for temperature, one-quarter of a link to the quarter-section for every ten degrees Fah., is to be entered next; it is added when the thermometer is below 60° and subtracted when above the same.

At the end of the quarter section, the algebraic sum of the quantities entered will give the number of chains and links to be actually measured on the ground in order to give to the said line its exact length, forty chains or forty-one chains. The same process will be followed to find the distance to be measured for the section corner.

It will be seen that the distances for the topography, being entered as found in the field, will be in error by the amount of the correction to the chainage. However, this quantity being generally small may be neglected.

The method of chaining along the slopes and correcting for inclination, will be applied only with the Gunter's chain, by which posts

are planted and boundaries ascertained; the 100 feet chain, being solely as a control, will be used in the ordinary manner, breaking chain when its full length cannot be levelled.

All calculated distances to be checked.

When the distance across an obstacle is determined by a triangle, the Surveyor must be careful to check it by another independent operation, either another triangle or a micrometer measurement, so as to conform to the principle of double independent chainage.

If a second triangle be adopted, having the side to be calculated common with the first triangle, it will be sufficient to set up the instrument at both ends of this side; any error in the angles would be shown by the calculation.

Surveyor to pass round large lakes or deep marshes.

Should the extension of a block line be hindered by a large lake or deep marsh impossible to traverse, the Surveyor will pass round the same projecting for the purpose the adjacent township lines. In working round in this way to arrive at and take up the continuation of the block line on the opposite side of the obstruction, the Surveyor will regularly post off and mark out all township, section and quarter-section corners on the several lines, reporting the circumstance fully and sending all the field-notes of such additional work, forward with the returns of survey.

Instruments.

Description of transit theodolite.

The surveyor in charge shall have a reiteration transit theodolite, with a six-inch horizontal circle reading by three verniers to 0°.004, and a three-inch vertical circle with two verniers to 0°.02, as a finder for stars in day time.

The telescope has an objective of one and a half-inch diameter, and nine-inch focus, supplied with direct eye pieces of powers equal to 12, 18 and 32 for terrestrial work, and a diagonal eye piece with powers of 30 and 60 for star work. In using his instrument, the surveyor should always employ the highest power compatible with satisfactory definition. The instrument is provided with three verniers because, by reversing the telescope and turning the azimuth plate 180°, readings will be obtained on the same object, at six equidistant points of the circle, thus tending to eliminate periodical errors of graduation to the same extent as an instrument having six verniers.

Decimal graduation.

The degree is subdivided decimally, instead of, as usual, into minutes and seconds, in order to facilitate the taking of a mean of a number of readings of the three verniers, and to lessen the chances of blunder, in so doing, by substituting the more familiar process of division of quantities counted by tens to the less familiar one of dividing quantities counted by sixties.

A small magnetic needle, attached to the instrument, is useful to find stars in daytime, when the Surveyor may happen to be elsewhere than on a line of known azimuth.

Assistant's instrument.

The assistant will be provided with a reiteration transit having a four-inch horizontal circle reading to minutes or to 0°.01; it will be used for measuring the angles of small triangles, laying out offsets for passing obstacles on the line, measuring the bearings of witness mounds or bearing trees, giving to the axemen the direction of the line to be opened out in the bush, and generally to do whatever will be done with sufficient accuracy and more conveniently than with the larger instrument used in the production of the line.

Pocket chro-

For his astronomical work the Surveyor must be provided with a

nometer or watch for astronomical work.

sidereal pocket chronometer or watch conforming in quality and performance to what is here set forth as desirable for the purpose.

For use in this service a watch with good lever escapement is to be preferred to one with chronometer escapement; the latter is not so well fitted to withstand the unavoidable vicissitudes of rough carriage while the wearer is jolting over lumpy prairie in a waggon, riding on horseback, or climbing over the trunks of prostrate trees in a windfall. In jumping down from one of these, or from his saddle, the escapement is very liable to catch and in so doing inure the point of one of the fine scape wheel teeth, rendering the watch useless till repaired by skilful hands.

The best suited to the purpose is a well-made lever watch having a compensation balance that has been subjected to trial in temperatures of opposite extremes, say freezing and 80 Fah., and carefully adjusted to good performance in both, and with good hard Berguet hair spring, well coiled and properly pinned, that is to say, being, by trial, in conjunction with its balance, fastened at such points in its length, and given such initial and terminal curves, as to insure isochronal vibrations of the balance.

This may be tested by varying the conditions of resistance to the driving power, which may be conveniently done by varying the position of the watch so as to produce change in the length of arcs, of vibration.

A watch will be approved which will have included in a range of 5 seconds all the differences of daily rate that would occur in running it for twenty four hours in each of the six positions—flat on back, in face, on edge XII up, VI up, III up, IX up.

Directions.

Azimuth of lines.

The directions of the east and west exteriors of a block being throughout coincident with those of meridians, their azimuth is constant; but, on its northern and southern outlines, consisting of the four successive chords to a parallel of latitude that are formed by the bases of the townships standing on that parallel, the azimuth varies with the progression along a chord from one corner of a township to the other, because the direction of the line is the same throughout, whilst that of each successive meridian to which it is referred differs from the direction of any proceeding one by the amount of their convergence.

Reckoning azimuth from zero at the north point round through east, south and west,—90°, 180° and 270°,—and representing the convergence of the two meridians forming the east and west outlines of a township by C, the azimuths of the chord forming its base would, at each successive section corner, beginning at the eastern corner of the township, and going westward, be $270 + \frac{C}{2}$, $270 + \frac{C}{3}$, $270 + \frac{C}{6}$, 270, $270 - \frac{C}{6}$, $270 - \frac{C}{3}$, $270 - \frac{C}{2}$. The deflection angle between a chord produced and the next one equalling C.

The quantity given in the accompanying geodetic tables Nos. III and IV, under the heading of "chord azimuth," is equal to $90° - \frac{C}{2}$, which subtracted from 360° gives the above quantity $270° + \frac{C}{2}$. C is given in those tables under the heading "Deflection."

Azimuth observations to be made on Polaris.

The reference of lines to an astronomic meridian, in order to obtain their direction, or to check the accuracy of their production, shall, as a rule, be made by observations on Polaris.

The telescopes used being amply powerful to show stars of the second magnitude within a few hours from noon, and stars of the third magnitude in twilight when it is still clear enough to read the graduation, the observations will be taken in day time, whenever practicable.

Besides avoiding the errors peculiar to all artificial illumination, and likely to be specially developed in the case of field work in unsheltered positions, and with light from reading lamps held by hand, inconstant in direction and unsteady, daylight observations have the advantage that they are conveniently made with the instrument at one of the stations for the ordinary production of the line, and during its progress, without materially, if at all, interfering therewith. Day observations also give the Surveyor more time in evening in camp for their reduction, and for checking his own and his assistants' work generally.

Programme for observing.

In observing for azimuth, the Surveyor will adopt the following programme:

The instrument being in the position which places the vertical circle to the observer's right hand when looking through the telescope, it will be directed to the reference object and the verniers read, then to the pole star, noting the time of pointing and the reading of the verniers. The level of the azimuth plate is read or the inclination of the horizontal axis measured with the striding level.

Reversing the instrument by revolving the telescope and turning the upper plate 180° in azimuth, so that the vertical circle is now to the left of the observer, the telescope is directed to the pole star, the level recorded and readings taken on the reference object, as before reversal.

In strong daylight, the Surveyor will experience some difficulty in finding Polaris, unless his telescope be in the precise direction of the star. He will readily place it so by help of the quantities given in table VI. Its use does not require any explanation.

Causes of error—yielding of stand.

In making these observations, as in angular measurements generally, care should be taken when turning the instrument in azimuth by hand, to use the same forward or backward motion throughout for every pair of pointings in same position, the angle between which is intended to be read on the horizontal circle. This tends to obviate the effect of any yielding in the instrument stand to that part of the impulse of revolution that passes down through the foot-screws to the stand head. In some much-used forms of stand this occurs to a notable extent, and as there is no certainty that in springing back, or "untwisting," the stand resumes exactly its original position, serious errors are to be apprehended in its use, unless the utmost care is taken. A source of similar error is looseness of foot screws in their nuts. The pinch screws closing these last should always be screwed up so tightly as to have the levelling screw turn stiffly in the nut. Even though this may entail more rapid wear of the screws, and be less convenient to the observer in bringing quickly, and with nicety, his level bubbles to their desired position, the certainty that it ensures warrants it.

Looseness of foot screws.

Direction of motion of tangent screw.

The tangent screw should always be turned so as to push against its counterpoise spring; because in turning in the opposite direction, the spring might fail to bring back the azimuth plate immediately and do so during the interval between the observation and the reading of the verniers. Should there be any drag of the verniers, this will also prevent it affecting the measure, as the motion would always be in the same direction.

Observations with a two vernier instrument.

If any accident has occurred to a three-vernier instrument, and a two-vernier instrument has to be used, then, after the two observations as above, a third should be made, shifting for the purpose the lower limb 90° in azimuth, if the instrument be a repetition one; 120° by lifting it off stand, and changing foot-screws one interval round, if it be a reiteration instrument, *i. e.*, has no motion of lower limb.

Reference object.

The reference object for azimuth work, whether in the daytime a picket on the line, or at night a bulls-eye lantern, should be, if possible, at least half a mile from the observer.

Such a lantern having to slide on over the lens a tin cap, across which there is a vertical slit having an opening in width of about quarter of an inch, makes an excellent reference object.

In the case of night observations, the angle between line and reference object is to be determined before observing, and not to be left till morning, thus subjecting the reference object to accident or removal.

Surveyors to observe for azimuth every clear day.

Surveyors are expected to observe for azimuth every clear day. With proper care in transporting the instrument, the levels will seldom get much out of adjustment and then the complete observation for azimuth as above does not require more than ten minutes; generally it can be done without interfering with the work on the line. The reduction will take about fifteen minutes. It is hoped that with the forms and tables supplied to surveyors, the work has been made so short and easy that no objection to the frequency of observation should fairly exist.

Watch error.

The watch error is required for the reduction of the observations; it may be found very simply, when on the line, by placing the telescope in the meridian and observing the transit of a star. The time thus deduced is sufficiently accurate for the purpose.

When not on the line, the transit of a star through the vertical of Polaris may be observed, and the time found by following the directions given in the explanation of table VII. The observations for time are entered in the form at the end of the book of record of astronomical observations.

Value of one division of the level.

The value of one division of the level is also required for the reduction of azimuth observations. To obtain this the level is placed on the azimuth plate parallel to the plane of revolution of the telescope, and a rod with two marks upon it is placed vertically at a certain carefully measured distance from the instrument and in the direction of one of the foot screws. The bubble is brought, by turning the foot screws near one end of the tube, and the telescope directed to one of the marks on the rod and firmly clamped. The front foot screw is then moved until the telescope be directed to the other mark and the displacement of the bubble noted. The difference between the inclinations of the level in the two positions will be deduced from the distance of the rod and the interval between its marks; dividing it by the number of divisions of displacement will give the value of one division.

Formula for azimuth.

Surveyors are at liberty to use any formula or process for reducing their observations, but, as forms and tables could not be prepared for every method, the following formula has been adopted; for convenience, with regard to future reference, it is desirable that all surveyors should adopt it:

$$\text{Tan } Az = \frac{\text{Tan } P., \text{ sec. } \phi, \text{ sin } t.}{1 - \text{tan } P., \text{ tan } \phi, \text{ cos } t.}$$

where $P.$ $\phi.$ $t.$ are polar distance, latitude and hour angle respectively.

Reduction of azimuth observations.

In the form of record of astronomical observations (see page 26), the letters R and L represent the positions of the instrument, circle right and circle left, H. C. R. is for horizontal circle reading; R. O. reference object; R. A. right ascension, and Az. azimuth.

Representing by W. and E. the readings of the west and east end of the level, the level correction will be equal to the inclination

$$[\tfrac{1}{4} (\text{W.} - \text{E.}) \times \text{value of one division}]$$

multiplied by the inclination factor.

It is to be added to or subtracted from the mean H. C. R. according to signs, that is to say, added when the west side is high or when W. is greater than E, and subtracted when smaller.

The logarithm of tan $P.$ is given for every tenth day in the annual tables supplied to surveyors; an interpolation at sight will give it for any intermediate day.

The logarithms of secant and tangent ϕ are given in table V for the north side of every section.

The subtraction logarithm is found in table XII, using as argument A the logarithm of "tan P, tan ϕ, cos t." The corresponding logarithm B, is to be added to the logarithm of "tan $P.$ sec ϕ, sin t" when t is comprised between 0^h and 6^h, or 18^h and 24^h; it is to be subtracted when t is comprised between 6^h and 18^h.

The following examples, one in each quadrant of a revolution of the pole star, will show how the calculation is to be made:

Ex. Required for the 6th July, 1880, at a point on the 6th base line, or 20 townships north of the 49th parallel, the azimuth of Polaris for hour angles of 2^h 10^m, 9^h 32^m, 16^h 44^m, and 19^h 52^m.

	For t = 2h. 10m.			For t = 9h. 32m.		
Tan P, (annual table),	8.36640		8.36640	8.36640		8.36640
Sec ϕ, (table V),	0.19877	Tan ϕ,	0.08772	0.19877		0.08772
Sin t,	9.73022	Cos t,	9.92603	9.77946		9.90235
	8.29539		8.38015	8.34463		8.35657
Subt. log (table XII),	+ 0.01030			− 0.00976		
Tan az,	8.30569	Az =	− 1.1581	8.33487	Az =	− 1.2386

	For t = 16h. 44m.			For t = 19h. 52m.		
Tan P, (annual table),	8.36640		8.36640	8.36640		8.36640
Sec ϕ, (table V),	0.19877	Tan ϕ,	0.08772	0.19877		0.08772
Sin t,	9.97567	Cos t,	9.51264	9.94593		9.67161
	8.54084		7.96676	8.51110		8.12573
Subt. log (table XII),	− 0.00400			+ 0.00576		
Tan Az,	8.53684	Az =	1.9715	8.51686	Az =	+ 1.8329

The log. tan. az. is transformed into logarithm of the arc by adding log T, (see page 27) thus avoiding the calculation of proportional parts.

SPECIMEN OF RECORD OF

Place, 45 chs. E. of N.E. corner Sec. 31, Tp. 28, R. 17, W. of 2nd M.

Face.		Chronometer Time.	Horizontal circle reading. A.	B.	C.
R.	R. O.		173.082	080	084
	Polaris.	h. m. s. 13 53 25	83.445	443	447
L.	Polaris.	13 56 33	473	475	477
	R. O.		173.079	082	084

Chr. Time.	13 53 25	13 56 33	Tan. P.
Chr. Error.	— 2 13	— 2 13	Sec. and tan. ϕ
Sid. Time.	13 51 12	13 54 20	Sin. and cos. t
Polaris R. A.	1 15 43	1 15 43	Sum.
t	12 35 29	12 38 37	Subt. log.
			Tan. Az.
Log. 792.	2.89873	Distance of back picket = 53·65 chs.	Log. T.
Log. tan. corr.	5.68904		Log. Az.
Log. distance.	1.80380		Az.
Log. offset.	0.39157		H. C. R. on star.
Offset in inch.	2.46		True North.
			H. C. R. on R. O.
			Azimuth R. O.
			Mean.
			Az. by account.
			Correction.

Table of inclination factors.

No. of Township.	Hour angle of Polaris. 0h or 24h	3h or 21h	6h or 18h	9h or 15h	12h
0	1.20	1.18	1.15	1.12	1.10
20	1.28	1.25	1.23	1.20	1.17
40	1.37	1.34	1.30	1.28	1.25
60	1.46	1.42	1.39	1.36	1.33
80	1.56	1.52	1.49	1.45	1.42

AZIMUTH OBSERVATIONS.

Date, 21 July, 1881. One division of level = 0·0011

Level W +	Level E —	Level Correct.	Mean H. C. R.	Corrected mean H. C. R.
				173.0820
10.2	8.5	+ 0.0019	83.4450	83.4469
11.3	7.4		.4750	.4769
				173.0817

8.36465	8.36465	8.36465	8.36465
0.20533	0.09855	0.20533	0.09855
9.18811	9.99477	9.22454	9.99381
7.75809	8.45797	7.79452	8.45701
— 1229		— 1226	
7.74580		7.78226	
1.75812		1.75812	
9.50392		9.54038	
0.3191		0.3470	
83.4469		83.4769	
83.1278		83.1299	
173.0820		173.0817	
89.9542		89.9518	
		89.9530	
		89.9502	
		.0028	

Table of log T.

Tan. Az.	log. T.
7.875	1.75812
8.045	11
·137	10
.207	09
.259	08
.299	07
.335	06
.366	05
.391	04
.415	03
.435	02
.454	01
.472	00
.490	.75799
.505	98
.519	97
.532	96
.544	95
.556	94
.567	93
.579	92
.588	91
.598	90
.608	89
.617	88
	87

The azimuth by account, when the R. O. is one of pickets on the line, is the theoretic azimuth of the line at the place of observation.

The direction of the line is corrected by placing the instrument a certain number of inches from its former position at right angles to the line. This offset is found by multiplying the distance of the back picket by the tangent of the correction.

Record of azimuth observations to be part of the returns.

The observations will be entered in the note book of astronomical observations at the time they are made, the calculations made either in pencil or in ink, and it will be sent in as part of the returns of survey. No copy will be accepted.

Production of Line.

Only one flagman to be employed.

In producing the line the Surveyor will employ but one flagman, a forward picketman; a back flagman is not necessary, as the Surveyor can have left by his men at each of his instrument stations a picket which he can set himself before leaving it.

Pickets.

Perfectly straight pickets are not indispensable; a part of the picket, exactly in the line, is indicated by some visible mark and only this part used in the production of the line.

The flagman carries an ordinary surveying picket, about nine feet long, and terminated at the lower end by an iron point exactly in the axis of the picket. A small bubble, placed at right angles to the axis would be a valuable adjunct to ensure verticality.

Production of the line.

When the flagman comes to the place where a new station is to be established, the Surveyor will give him roughly the direction of the line. A wooden slab, held to the ground by two small wooden pins or by stones on the ends, will be placed at the point determined as above and at right angles to the line. In all subsequent operations, the picket will be held on the slab, and its position marked with a pencil.

In setting a point forward on his line, the Surveyor will be careful never to do it in one position only of his instrument; in all cases, first making his back and forward sights circle right, then reversing his instrument, repeating them circle left, and having his flagman so instructed that the latter shall consider he has to make in each a separate and independent setting of his picket between which, if there be any difference, the Surveyor is carefuly to mark the middle-point. Then the process is to be once repeated, so that there shall be two pointings in each position of the instrument on the back and forward pickets respectively, or eight pointings in all.

The same rule as to the reversion and number of pointings is to be observed in offsetting the line to get past long reaches unfavorable to chaining or triangulation.

It will be seen that the slab ought to be of such a length as to allow play for collimation.

Deflection angles turned off by deflection offsets.

The deflection angles at township corners on the base lines can be turned off without any reading of the graduation, by using the "deflection offset" given in Table III. This deflection offset is the length, at the distance of one chain, of the tangent of the deflection angle, or the angle between the chord forming a township side and the next chord. When the Surveyor comes to a township corner, the last picket before the corner is placed south of the line, at a distance equal to the deflection offset of Table III, multiplied by the distance from the corner, and the instrument, instead of being set up over the point previously ascertained, is placed north of the line,

at a distance equal to the deflection offset multiplied by the number of chains between the instrument and the corner. The line is then produced from the back picket in the ordinary manner.

Supposing, for instance, that it be required to turn off the angle at a township corner on the seventh base line, the back picket being 12 chains behind the corner and the instrument 15 chains beyond the same corner. The picket will be planted at $12 \times 1{\cdot}501$ or 18·01 inches south of the line, and the instrument set up at $15 \times 1{,}501$, or 22·51 inches to the north.

How to turn at the corners of a block.

At the corners of the block, the Surveyor will turn the required angle approximately, and the flagman will hold his picket at the point determined, while the Surveyor measures accurately the angle thus turned off, in the manner explained below for measuring the angles of triangles. If the angle is not what it should be, the direction of the line will be corrected by offsetting the instrument at the next station.

Should the corner fall in such a place that the angle could not be turned off correctly, as for instance at *B* (Fig. 1), one of the stations,

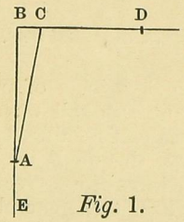


Fig. 1.

C being too near the corner, the Surveyor will have the angle at *B* approximately turned off by his assistant with the small transit, and measure the angle *E A C*. He will then set up his instrument at *C*, determine approximately the next station *D*, and measure *A C D*. The sum of the two angles *E A C*, and *A C D*, should be equal to 180° plus the angle to be turned off at *B*. The error, if any, is corrected by offsetting the instrument at *D*.

Scheme for triangulation.

In cases where a triangulation would be necessary, the following would be the scheme of direction readings at a station in a chain of triangles. Taking the stations as bearing on one side of the chain the odd numbers 1, 3, 5, 7, &c., and on the other the even ones 2, 4, 6, 8, &c., and assuming for instance the observer to be at Station 6, and representing by the letter *r* the respective azimuthal circle readings, corresponding to the successive pointings on the station under whose number the letter is placed, the series of readings would be:—

	St4.	St3.	St5.	St7.	St9.	St8.	St4.
Circle R	r	r	r	r	r	r	r
" "	r	r	r	r	r	r	r
" L	r	o	r	r	o	r	r
" "	r	o	r	r	o	r	r
	r_4	r_3	r_5	r_7	r_9	r_8	r'_4,

Representing the sum of the readings on such station by the letter *r*, with the subscript number of that station. The mean direction reading for each, would, representing it by letter *d* with similar subscript number, be—

$$d_4 = \frac{r_4 + r'_4}{8},\ d_3 = \frac{r_3}{2},\ d_5 = \frac{r_5}{4},\ \&c.,\ \&c.$$

And for one of the triangles 3...4...6 the angle at station 6, between the directions 6 to 3, and 6 to 4, is $3\cdot6\cdot4 = d_4 - d_3$.

The directions of the diagonals 6...3 and 6...9 are taken but once in each position, because they are not intended for calculation of sides, but only to serve where a gross error may have occurred, such as sighting on an object not a station, in detecting by combining therewith the various directions involved, at what station the error has been committed.

Great care should be exercised in setting station poles, to place them truly over their central marks, and in making them securely and exactly vertical; also, in centring instrument over these station marks when observing. Any neglect in this respect completely neutralizes the approximation to accuracy that is aimed at by the reiteration of the angles laid down in the programme.

Reports and Returns.

Monthly Reports.

Block surveyors shall send reports of progress at intervals as nearly monthly as circumstances will allow; such report to be accompanied by sketches on the scale of 6 miles to the inch, shewing in red the lines run up to date, the deviations of the base lines, the depth of quarter sections adjoining the correction lines and the length of the jogs on correction lines. The general character of the surrounding country shall be indicated by the following tints:

Bush,—green.
Prairie and bluffs,—small patches of green.
Prairie,—blank.

They will also inform the township outlines surveyors, working within their blocks, of the depth of quarter-sections adjoining the correction lines, the length of the jogs on the correction lines and the deviations of the block lines.

Final Returns.

The final returns of the survey will consist of—

1. A diary for the time the Surveyor has been employed.

2. A general plan of the survey, on the scale of forty chains to the inch. It will show all the topographical features of the country crossed by the block lines, as referred to in the field-book, so as to give the best idea of the character of the country.

The features of the country are to be represented on the plan in manner following, that is to say:—

Bush,—a wash of light green, without any imitation of trees.
Brulé,—a wash of light brown, " "
Swamps,—a wash of light yellow, with small strokes of green representing reeds, &c.

3. A copy of the field-notes.

4. The record of astronomical observations.

5. The formulas of oath for chainmen, duly sworn to.

6. A general report of the survey.

SURVEY OF THE TOWNSHIP OUTLINES.

Instruments.

Description of instrument.

The instrument to be used for the survey of the township outlines shall be a transit theodolite with a vertical circle, both circles reading at least to minutes. It shall be inspected and approved by the head office.

Method of subdividing Blocks.

Subdivision of a block to commence on the base lines.

In subdividing a block into sixteen townships, the Surveyor will, unless otherwise instructed, commence at one of the township corners *a* or *A*, near the east end of the block. (See Fig. 2.)

He will carefully measure one or two miles of the base before beginning the subdivision; this will enable him to compare his chaining with that of the lines previously run.

How to proceed in subdividing a block.

From the point *a*, for instance, he will run due north until he comes to the township corner *b*; from this point he will run a straight line, as a trial line, to *c*, laying off and temporarily marking each quarter-section exactly forty chains. Should the direction of the line be such as to strike exactly the post at *c*, the Surveyor will blaze the line back, divide the closing error in the last quarter-section at *c* equally among the twelve quarter-sections of *bc*, and permanently mark the section and quarter-section corners. Should the line fall to one side or the other of *c*, he will find, by Table XI, the number of minutes by which his course must be altered in order to connect the posts *b* and *c* by a straight line. He will then run and blaze this true line from *c* to *b* with the altered course, dividing, as before, the closing error in the last quarter-section, equally among all quarter-sections.

In other words the Surveyor will run a trial line from *b* to *c*, then a true line from *c* to *b*, making, at the same time, all quarter-sections equal.

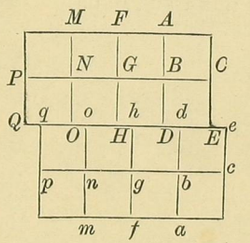


Fig. 2.

He will then produce the meridian to *d*, temporarily plant there the iron post, and run as a trial line *dD*, far enough to fairly pass the intersection of *AD* with the correction line. The angle *bdD* turned off at *d*, should be equal to 90° plus half the deflection angle given in table IV.

He will then go to *A*, on the north boundary of the block, run *AB* due south, *BC* as a trial and in coming back from *C*, as a true line. He will now produce the meridian *BD* until he intersects the trial line *dD* previously run. The closing error in the last quarter-section is to be equally divided between the two quarters sections at *d* and *D* adjoining the correction line.

The corners *d* and *D* being thus permanently marked, the Surveyor will run a trial line from *d* to *E*, leaving temporary marks for the section and quarter-section corners on both sides of the road allowance. In order to do so, he will chain, as usual, forty chains from *D*, leave a mark there for the quarter-section of the north side, measure forty-~~one~~ chains further or eighty-one chains in all, and leave the mark for the section corner. Starting his chainage again from this last corner, he measures, as before, forty chains, eighty one chains, and so on. In passing at *d*, he will note the distance recorded by his chain, and at every place where his chain shows the same distance, he will leave a mark for a section corner of the south side of the road allowance. Marks for quarter-sections are left forty chains further.

Supposing, for instance, the distance recorded at *d*, to be 30 chains; section corner marks would be left at every place where the distance indicated by the chain would be 30 chains and quarter-section marks at ~~70~~ chains.

If the distance recorded was 55 chains, marks for section corners of the south side of the road would be left at 55 chains and, for quarter-section corners, ~~40~~ chains further, that is to say at ~~14~~ chains.

The Surveyor will only run his trial line to *E*, but he will measure as far as *e* and have then two irregular quarter-sections, one west of *e* for the south side, and one west of *E* for the north side of the road allowance. The closing errors are, in each case, to be distributed among the twelve quarter-sections on the respective sides of the road.

Supposing, for instance, the last quarter-section at *e* to be 39 chains and 20 links, (road allowance included,) and the last one at *E*, 42 chains and 92 links. The closing error at *e* would be 1 chain and 80 links and at *E* 1 chain and 92 links, so that each quarter-section on the south side would have to be made 15 links shorter, and on the north side 16 links wider. In correcting back the line, the first post on the north side would be moved east 1 chain and 76 links, the second, 1 chain and 60 links, the third, 1 chain and 44 links, and so on. On the south side, the first post would be moved west 1 chain and 65 links, the second, 1 chain and 50 links, the third, 1 chain and 35 links, and so on.

The trial line is corrected in the ordinary manner, and a true line run between *E* and *d*.

The temporary marks for the north side of the road are left in the south limit, and in correcting the line back, the permanent posts are placed by measuring north the width of the road allowance.

The Surveyor will then project the meridians *f h* and *F H*, running the trial lines *g b* and *G B*, and the correction line from *H* to *D* in a manner similar to that explained for the meridians *a d* and *A D*.

In running the meridians *m o* and *M O*, besides closing on the meridian to the east, he will also run the lines *n p*, *N P*, and *O q*, closing on the western boundary of the block.

It is evident that the trial lines, as *b g* or *B G* for instance, need not to be run entirely from the points *g* or *G*, three miles may be projected west from *g* or *G*, and the remaining parts run from *g* or *G*, when the line is corrected in the usual manner. The Surveyor will adopt the method best suited to the nature of the country and to the local conditions of communication.

The jogs *eE* and *qQ* are to be posted by the Surveyor of township outlines, the township corners only being marked by the block Surveyor.

Road allowance on correction lines.

On account of the jog caused by the curvature of the earth, the road allowance on correction lines is of unequal width.

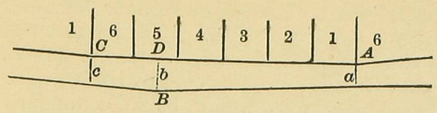


Fig. ~~2~~. 3

At township corners on the south side of the line, the road allowance is more than one chain, it is less at township corners on the north side. The excess or deficiency is found in Table IX. The width of the road allowance at every section or quarter-section corner increases in arithmetical progression from the township corners on the north side, *A* and *C*, (Fig. 3) to the township corners on the south side *B*. The ratio of this progression for each post will be found by the following formulas:

Between A and B

$$x = \frac{b - a}{12\,(1 - y)}$$

and between B and C

$$x = \frac{b - c}{y}$$

where x is the ratio of the progression, a, b, c, the widths of the road allowance at township corners, given in Table IX, and y the jog reduced to decimals of a township side by Table VIII.

Rules when departing from foregoing instructions.

If the circumstances oblige a Surveyor to deviate from the foregoing instructions, he will only do so with great circumspection; whatever may be the process followed, he shall remember that he is not allowed to depart from the following rules:—

1st. All quarter-sections of a township side are to be equal, except the last tier adjoining the correction line.

2nd. Township sides are to be straight lines.

3rd. The quarter-sections adjoining the correction line are to be of equal depth on each side.

Measurements.

Any difference in the chainage of two meridians will cause corresponding deviations in the east and west lines joining the same; great care should, therefore, be bestowed on the measurements. Chesterman's steel band chain shall be used and every precaution taken to ensure accuracy.

Limit of error.

The mean average deviation of any twelve miles meridian should not exceed one minute and thirty seconds, but single errors may be much larger, provided that the observations be frequent. Being distributed according to the law of accidental errors, they will, in a certain measure, compensate each other.

Observations for azimuth.

The direction of the line with reference to the astronomical meridian will be readily obtained by observing the sun's altitude before or after noon. Provided that the telescope be reversed during the observations, so as to eliminate instrumental errors, this method will give all the accuracy required, and will exempt the Surveyor from having to take observations at night.

The instrument should be provided with a coloured glass to enable the Surveyor to look at the sun through his telescope.

Azimuth by the sun.

The observations will be made first with the vertical circle to the

right of the observer and then with the circle to the left, reversing the telescope and turning the azimuth plate 180° in azimuth.

In the first instance the image of the sun is to be brought in one of the angles formed by the wires in the telescope so as to be tangent to both wires at the ~~the~~ same time, and the same process is to be repeated with the instrument in the second position, but with the sun's image in the opposite angle. In order to bring both wires tangent to the sun's limb at the same time, the sun's image should be placed so that it moves towards one wire while it goes off the other; then the former wire would be kept tangent to the sun's limb by the proper slow motion screw until both wires be tangent at the same time. In the opposte angle of the wires, the same process would be repeated with the other slow motion screw. Fig. 3 illustrates how the sun's image should appear in the afternoon with an inverting telescope, the apparent direction of the sun's motion being shown by the arrows. In the first position the wire AC should be kept tangent to the limb with the slow motion in azimuth, until DB be also tangent. In the second position DB would be kept tangent to the limb with the slow motion in altitude until AC be also tangent.

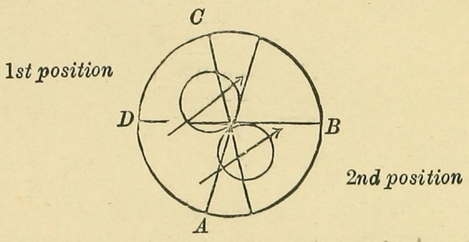


Fig. 4. inverted

The reading of the horizontal circle on the reference object, generally one of the line pickets, should also be taken in both positions of the instrument, and the approximate time of observation noted.

The best time for observation is when the sun is near the prime vertical, that is to say, nearly due east or west.

Reduction of observations.

The following formula is the simplest that may be used for the calculation :

$$\cos.\ \tfrac{1}{2}z = \sqrt{\cos.\ S \cos.\ (s-\Delta) \sec.\ \phi \sec.\ h}$$

$$\text{where } S = \frac{h+\phi+\Delta}{2}$$

h being the true altitude of the sun, ϕ the latitude, Δ the sun's polar distance, and z the angular distance between the sun and the north point. Reckoning the azimuth from 0° to 360° from the north point through east, south and west, z is the azimuth in the forenoon and 360° minus the azimuth in the afternoon.

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

The following examples, one in the afternoon and the other in the forenoon, will show how the calculation is to be made.

DATE—21st November, 1881—3.18 P. M.

PLACE—2nd base line—50 chs. W. of N. E. corner section 31, R. 14 W. of 3rd meridian.

OBSERVATIONS.

CIRCLE.	SUN'S ALTITUDE.	H. C. R. ON SUN.	H. C. R. ON LINE.
R	6° 44′ 00″	328° 07′ 00″	184° 35′ 30″
L	6 50 00	322 12 00	184 36 30
Mean.	6 47 00	~~332~~ 322 39 30	184 36 00

GREENWICH TIME.

Local time = November 21	....	3h. 18m.
Longitude	....	7h. 08m.
Greenwich time = November 21	....	10h. 26m.

Correction of altitude.

Obs. altitude	= 6° 47′ 00″
— Refraction	= 7·38
Difference	= 6° 39′ 22″
Parallax	= 9
h.	= 6° 39′ 31″

Sun's Polar Distance.

Decl. at 0h.	= 20° 01′ 35″
Var. for 10h. 26m.	= + 5·42
Decl. at 10h.26m.	= 20° 07′ 17″
Δ	= 110° 07′ 17″

h =	6° 39′ 31″
ϕ =	49 20 58
Δ =	110 07 17
2 S =	166 07 46
S =	83 03 53
$S-\Delta$ =	27 03 24

sec. h =	0·00294
sec. ϕ =	0·18612
cos. S	9·08188
cos. $S-\Delta$ =	9·94966
$\cos.^2 \frac{z}{2}$ =	19·22060
$\cos. \frac{z}{2}$ =	9·61030
$\frac{z}{2}$ =	65° 56′ 30″
z =	131 53 00
Az =	228 07 00
H. C. R. on Sun =	322 39 30
North point =	94 32 30
H. C. R. on line =	184 36 00
Az. of line =	90 03 30
Az. by account =	90 02 51
Error =	39″

Date—June 15th, 1881—7.20 A.M.

Place—8th base line—25 chs. W. of N. E. corner section 36, R. 17, W. of 2nd meridian.

OBSERVATIONS.

CIRCLE.	SUN'S ALTITUDE.	H. C. R. ON SUN.	H. C. R. ON LINE.
R	29° 50′	175° 43′	176° 38′ 00″
L	30 34	176 51	176 40 00
Mean.	30 12	176 17	176 39 30

GREENWICH TIME.

Local time = June 14	....	19h. 20m.
Longitude	....	6 57
Greenwich time = June 15		2 17

Correction of altitude.

Obs. altitude =	30° 12′.00″
— Refraction =	1.40
Diff.	= 30 10 .20
+ Parallax =	8
h	= 30 10 .28

Sun's Polar Distance.

Decl. at 0h =	23° 20′ 16″ N.
Var. for 2h17m =	+ 14
Decl. at 2h17m =	23° 20 30
Δ =	66 39 30

h =	30° 10′ 28″
ϕ =	51 26 45
Δ =	66 39 30
2 S =	148 16 43
S =	74 08 21
$S-\Delta$ =	7 28 51

Sec. h =	0.06324
Sec. ϕ =	0.20533
cos. S =	9.43664
cos ($S-\Delta$) =	9.99629
$\cos.^2 \frac{z}{2}$ =	19.70150
$\cos. \frac{z}{2}$ =	9.85075
$\frac{z}{2}$ =	44° 50′ 00″
z or Az =	89 40 00
H. C. R. on Sun =	176 17 00
North point =	86 37 00
H. C. R. on line =	176 59 30
Az. of line =	90 02 30
Az. by account =	90 03 08
Error =	38″

Reports and Returns.

Monthly reports.

The Surveyors of township outlines shall send in reports of progress at intervals as nearly monthly as possible, such reports being accompanied by sketches on the scale of one mile to the inch, showing the work done and the character of the country, in the manner directed for block Surveyors.

Sketches to be supplied to subdividers in certain cases.

These sketches will exhibit the length of every quarter-section line and the inner angles at the corners of townships. Such information is also to be sent directly by the township outline surveyor to the subdivider, when the subdivision is to follow immediately the survey of the township outlines.

Final returns.

The final returns of the survey are the same as for block surveys, with the exception of the record of astronomical observations, which is not required.

SUB-DIVISION OF TOWNSHIPS INTO SECTIONS.

Instrument and Method of Survey.

Instrument.

The instrument used in subdivision surveys is to be a transit, transit theodolite or solar compass reading at least to minutes; it shall be inspected and approved by the head office.

As explained in the exposition of the system of survey, all surveys are to be astronomical; they shall therefore be performed independently of the magnetic needle.

The subdivider will procure from the township outline surveyor or be supplied by the head office with a diagram shewing the length of all sections, with the inner angles at every corner of the township.

Before the subdivider enters on his survey he will measure carefully one or two miles of the township outline; this will enable him to compare his chaining with that of the lines previously run and to modify it so as to obtain the best agreement with the township outlines.

How townships are to be surveyed.

A township is to be subdivided by projecting the meridians and joining the opposite corners on such meridians by random and then by straight lines. Table XI will enable the Surveyor to correct his courses.

Lines to be surveyed.

The only lines to be surveyed, established, and permanently marked as boundaries are those along which the road allowances are. Their total length for every township is forty-two miles and twenty-seven chains, more or less, exclusive of township outlines.

Quarter sections along correction lines.

In arriving at or starting from the correction lines the Surveyor will give to the adjoining quarter-sections, depths proportional to that of the quarter-sections at each end of the tier, as shewn on the diagram of the township outlines.

He will be careful to connect with the posts in the inner limit of the road allowance on correction lines, not in the outer limit.

It has been explained, in the exposition of the system of survey, that sections are of unequal width, on account of the convergence or divergence of meridians. To better illustrate this fact the convergence has been greatly exaggerated in Fig. 5.

Angles of meridians with east and west lines.

The angle formed by the meridians with the east and west lines is different for each meridian and varies uniformly from one corner of the township to the other. The Surveyor shall not, therefore, start his meridians at right angles to the township outlines, but he will, in each case, calculate the angle formed

by these two lines, from the data supplied to him with the diagram of township outlines.

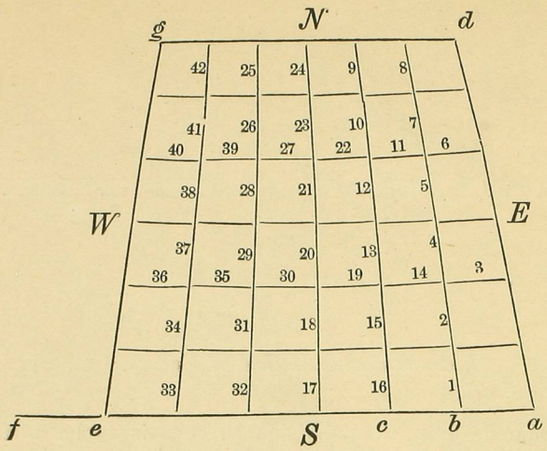


Fig. 5.

Supposing, for instance, the angle *d a f* to be 90° 03′, and *g e f* 90° 09′, he will use as angles at *b*, *c*, *S*, ...

90° 01′, 90° 05′, 90° 06′, 90° 07′, 90° 08′.

The angles between the meridians *a d* or *e g*, and the east and west lines, would be deduced in a similar manner.

Limits of error allowed. It follows, from the foregoing, that all quarter-sections on meridians are to be forty chains except in the tiers of quarter-sections adjoining the correction lines, where they should be proportional to the quarter-sections at each end of the tier. Should all the survey lines be perfectly correct, all other sections should have the theoretic width given in Table V. The maximum error in distance that will be allowed in the closing on any section corner will be fifty links. When the closing error exceeds this quantity, the lines involving the error must be re-surveyed. The opposite boundaries of sections are to be within fifty links of equal length.

All distances to be entered in the field-book such as measured on the ground.

Rivers, lakes and islands to be surveyed. In subdividing townships, all navigable rivers and lakes of twenty acres and upwards, found within the same, together with any islands that may be in them, are to be accurately surveyed. Lakes occurring entirely within a section and islands in lakes and rivers must have their traverse properly connected with the rest of the survey. When the width of navigable streams would be so great as to render it necessary for the correct calculation of the area of broken lots, the Surveyor will traverse both banks of the same, referring to such traverses in his field-notes as on the "right" or "left" bank, as the same would be on his right or left respectively looking down the stream.

Traverse points. At those points where township or section lines intersect the banks of a navigable stream, temporary posts or marks are to be established, and the distance across the river between the same ascertained trignometrically or otherwise, at the time of running

such lines. Such temporary marks or posts will be called traverse points, and are to be marked T.P., the survey of a stream will be effected by connecting them with traverse lines and offsets, on the respective sides of the river, the bearing of such lines being checked at the intersection thereof by each township or section line.

Settlers claims or improvements. Traverse lines shall be run to settlers claims or improvements, and the extent and position thereof shown on the plans of the survey.

The Surveyor will also obtain from every settler a statutory declaration, on the form supplied, setting forth the date at which he first began continuous occupation of the land; whether he is aware of any conflicting claim thereto; if so, its nature and the name of claimant.

The settler is also therein to declare whether or not he has previously had a homestead entry, if so, the number of quarter-section and township.

In signing the declaration, the settler to write clearly all his names in full and see that there is no accidental error in the spelling of these.

No blazes on traverse lines. No blazes or marks of any description are to be made on traverse lines between the points on township or section lines which intersect the same.

Reports and Returns.

Monthly reports. Subdividers will send in monthly reports of progress, accompanied by sketches on the scale of one mile to the inch, showing the sections surveyed in the same manner as block and township outline Surveyors.

Final returns. The final returns will consist of:

1. Field notes.
2. Plans of each township on the scale of forty chains to an inch.
3. A timber plan for each township.
4. A report on timber.
5. A report of settlers improvements.
6. Formulas of oath for chainmen duly sworn to.
7. A general report.

The number of chains of each class of mileage, as classified in contract, shall be marked on each page of the field-book.

Section lines are to be entered in the field-book as numbered in Fig. 5. It was the order formerly adopted for the subdivision of townships.

Plans. The plans will exhibit the length of all quarter-section lines and the area of every ~~broken~~ quarter section in acres and hundreths. In quarter-sections broken by lakes of 20 acres or upwards, the area of such broken quarter-section is to be shown thereon, and the broken distance on the section line. In cases where a quarter-section is divided into two or more parts by a stream or lake large enough to require traversing, each of the parts is to have its area shown thereon. The plan will also contain a table exhibiting the area of the township thus:

	Acres.
Net area less roads.....	
Roads.....	
Water.....	
Total area.	

Topography to be represented as on the plans of block or township outlines.

Traverse lines. Traverse lines are not to be shown on the plan, but to be plotted on one of blank pages at the end of the field-book. In case the lake, pond, &c., is of too great an area to admit of it being plotted on a page, then the plot should be made on tracing linen and pasted in the end of the field book. Traverse lines are to be plotted on a scale of 20 chains to an inch.

Timber plan. The timber plan shall be coloured so as to show the predominant timber in the belts or islands met with in the different townships surveyed. The colours to be used to represent timber are as follows: (See specimen of timber plan, page 51.)

Poplar,—light green.
Spruce,—carmine.
~~Oak~~,—brown.

Timber report. In the timber report the Surveyor will state whether, in his judgment, from the knowledge gained on the ground, it would be desirable to reserve the timber for the needs of the settlers, or whether it would be advisable to set apart the same as a timber berth; if the latter, he will give a general statement as to the quality and extent of timber over 10 inches in diameter suitable for lumbering purposes. If reporting on several timbered townships, he shall make a statement as to the relative value between them, taking into account the extent, quality and facilities afforded by streams, &c., for getting out the timber. (See specimen of timber report).

Plans and field notes returned to Surveyor in certain cases. The field-notes shall be neatly written, in a clear manner and with a fair hand. The plans shall be drawn with care and should be fair specimens of draughtsmanship.

Any plans or field-notes not complying with the above conditions will be returned to the Surveyor and will have to be written or drawn again.

SYSTEM OF SURVEY IN CERTAIN PARTS OF MANITOBA AND THE NORTH-WEST TERRITORIES.

The system of survey which has been described is a slight modification of the system formerly adopted for the subdivision of Dominion Lands.

The points of difference are the following:—

First system of survey. There is, in the older system, a road allowance of one chain and fifty links on every township or section line, and the deficiency or surplus, resulting from convergence or divergence of meridians, is left in the last tier of quarter-sections adjoining the western boundary of the township instead of being distributed equally among all quarter-sections. It follows that all quarter section sides are exactly forty chains in length, except in the last tier adjoining the western boundary of each township.

All north and south lines are, then, parallel to the eastern boundary of the township, they intersect, therefore, the east and west lines at the same angle as the aforesaid boundary.

The operation of this earlier system is restricted to the area bounded as follows, viz:—

To the south, by the International Boundary line, to the west by the Second Principal Meridian, as far as the eighth correction line; by said correction line as far as the meridian between ranges twenty-eight and twenty-nine west of the First Principal Meridian; by said meridian between ranges twenty-eight and twenty-nine, as far as the seventh correction line; by said correction line as far as the meridian between ranges four and five, west of the First Principal Meridian; by said meridian, between ranges four and five, as far as the ~~fifth~~ correction line; by said correction line, as far as the meridian between ranges ten and eleven east of the First Principal Meridian; by said meridian, between ranges ten and eleven, as far as the third correction line; by said correction line, as far as the meridian between ranges thirty and thirty-one, east of the First Principal Meridian; by said meridian, between ranges thirty and thirty-one, as far as the International Boundary line.

West of the Second Principal Meridian the above system has been followed for the survey of tps. 44, r. 21; tp. 45, r. 21, 22, 26, 27, 28; tps. 46 and 47, r. 25, 26, 27 and 28; tp. 48, r. 24 and 25.

West of the Third Principal Meridian the same system has been followed in the survey of tps. 42 to 47 inclusive, r. 1; and tps. 43 and 44, r. 2 and 3.

Second system of survey. In ~~this~~ system, adopted for some townships west of the Second Principal Meridian, there are also road allowances of one chain and fifty links on every township and section line; but the deficiency or surplus resulting from convergence or divergence of meridians is distributed equally between all quarter-sections, as in the actual system of survey.

In this, as in the first system, all section lines are to be surveyed, marked and established on the ground, and every section and quarter-section post is to be planted at its proper place.

The operation of the second system of survey is restricted to tps. 1 and 2, r. 1 to 8 inclusive; tps. 19 to 30, r. 1 to 12 inclusive; and tps. 27 to 30, r. 13 to 16 inclusive; the above ranges being all west of the Second Principal Meridian.

Surveys to be made according to system in force.

Surveyors who may have surveys to effect in any of the above described areas will be careful to conform to the system of survey in force within such area.

Whenever a "gore" occurs between two adjoining townships or ranges surveyed according to different systems, and when the number of the fractional township or range is the same as the adjoining one surveyed formerly, such township or range shall be designated by its number, followed by the letter A, as for instance:

Tp. XIX, A,

For the gore between townships 18 and 19 west of the Second Principal Meridian, and

Range XXI, A,

For the gore between ranges 20 and 21 west of the Second Principal Meridian.

The line between two parts of the country surveyed according to different systems is to be established as a correction line, that is to say, posts are to be planted on both sides of the road allowance on such line, each row governing the position of the boundary lines on its own side. Such road allowance is, in all cases, to be one chain and fifty links.

APPENDICES.

APPENDIX A.

EQUIPMENT OF SURVEYING PARTIES AND ALLOWANCES TO SURVEYORS.

—o—

Equipment of Surveying Parties.

Surveyors who are employed by the day, will receive before leaving for their surveys, advances sufficient to procure their outfit and supplies.

When new credits are desired, they will send in with the requisition for such credit, a complete statement of the expenses to date.

No draft on the Department or order or power of attorney, for moneys on account of the survey, will be accepted until the returns of the survey have been examined and approved.

At the end of the survey, the horses will be left in charge of responsible parties, to be wintered at so much per head, and the carts, buckboard, and all articles fit for another campaign will be stored. Receipts to be taken for horses and goods stored.

Articles which cannot be used during another season will be sold and the proceeds of the sale duly accounted for. The Surveyor's allowances are indicated in the annexed schedule.

Accounts.

The accounts must be in duplicate and entered in the forms supplied. They will consist of:

1. An account of personal services and allowances.

2. A pay list of the party, showing the date of engagement and discharge of every man, his occupation and rate of pay. It must be signed by each of the party.

3. A transport account with vouchers duly numbered. It shall be accompanied by a separate and detailed statement of travelling expenses.

4. A camp equipage and plant account with vouchers duly numbered.

5. A stationery account with vouchers duly numbered.

6. An abstract account showing the amounts of personal services, pay list, transport, camp equipage and plant and stationery accounts; also all the advances made and any sums received from the sale of camp equipage with a separate statement of such sale.

To accompany the instructions of
J. McLatchie D.L.S. dated 19th April 1881

Surveyors' Outfit and Allowances.

	Stand. M. & P.		Township out.	
	Number.	Prices or salary per diem.	Number.	Prices or salary per diem.
Personal Services and Allowances.		$ cts.		$ cts.
Salary of Surveyor in charge, per diem		6.00		
Ration allowance, per diem		0.50		
Men				
One assistant, per diem	1	1.50	1	
Chainmen	2	1.00		
Cook	1	1.00	1	
Laborers	9	.80	5	
Ration allowances	13	0.50	7	0.50
Transport.				
Horses	7		5	
Buckboard	1		1	
Carts with iron axles and tires	5		3	
Cart covers	5		3	
Sets of harness	6		4	
Hobbles	7		5	
Saddle	1		1	
Horse bells	4		3	
Leather, twine, oil, etc., for repairing and keeping harness in order; horse shoes, etc., not more than		15.00		12.00
Freight and storage expenses in connection with the Survey				
Travelling expenses of Surveyor in charge, from his home to Winnipeg and return				
~~Travelling expenses of assistant, from his home to Winnipeg~~				
Camp Equipage and Plant.				
Tents	4		2	
Hardware, cooking utensils, dishes, plates, forks, knives, etc.; candles, oil and soap, bags and toweling, not more than		40 00		30.00
Cooking stove	1		1	
Camp stoves	2		1	
~~Pairs of blankets (for winter expeditions only)~~	~~11~~		~~8~~	
Tools				
Rope, twine, wire				
Axes, brush hooks, spades				
Grindstone, whetstones				
Scythe	1		1	
Packing belts	8		5	
Surveying pickets	2		2	
Scribing irons	2		2	
Sets of chain pins	3		2	
Stationery.				
~~Not more than~~ Supplied		~~15.00~~		~~15.00~~

Where no price is mentioned the Surveyor is expected to exercise his own judgement keeping in view the efficiency of his party and due economy

A Russell
for the
Surveyor General

APPENDIX B.

CONTRACT SURVEYS.

The subdivision of townships is to be made, according to law, at certain rates per mile. The mileage is classified as follows:

1st class—Open prairie.

2nd class—Poplar and other soft woods, where occurring in alternation with prairie.

3rd class—Contracts composed of townships all woods, and wherever they occur, heavy underbrush, hard woods, windfalls, thick, willows.

Traverse lines will be classed for pay similarly to the principal lines of the survey, except in prairie or on ice, where they will be paid for at second-class rate.

Nothing will be paid for trial lines or for offsets.

In addition to the above rates, the surveyor will receive:—

One dollar for every triangle laid down and calculated in producing his survey lines, the distance found and calculated being paid at the same rate as the remaining part of the section line.

Fifty cents for each description of settler's improvements.

Fifty cents for taking the affidavit of occupation of such settler.

It is to be clearly understood that the prices sent in are to include the making up of plans, field notes, reports, &c., &c., as well as the cost of survey. The Surveyor receives skeleton township plans, field books, and forms of account free of charge.

A Surveyor upon obtaining a contract will be required to enter into a bond, jointly with two approved sureties, to the Crown in a sum equal to the estimated total amount of his contract, for the due and faithful fulfilment thereof. To be approved, the sureties will require to have certified by their County or City Registrar, or Clerk of the municipality in which they reside, that they possess real estate of the value of the sum specified in the bond.

The lines embraced in any survey under contract must be run by the Surveyor in person, and no payment will be made on such contract work if otherwise performed.

A rigid inspection of the work will be made. Any impropriety or unfaithfulness in the execution of surveying contracts will subject the offending Surveyor and his sureties to the penalty of the bond to the Crown, and will further debar such Surveyor from future employment on the public surveys. In case of any Surveyor disputing the accuracy of the check measurements made in inspection of his survey, and refusing to be bound by the same, and that verification by a third Surveyor is ordered by the Minister, the cost of such verification shall be defrayed by the disputant, if the first inspection is sustained.

On receipt of the bond, properly executed, from a Surveyor to whom a contract has been given, an advance of $200 will be sent to his address, and a further advance of $800 on account of contract, will be placed to his credit in a bank at Winnipeg, payable there to himself in person.

Monthly advances, on account of contract, will be made by the Department, but the successive advances made will bear such proportion to the total amount of work done up to date, as to leave a balance of 25 per cent. in the hands of the Government, this balance will be held until the Surveyor's returns have been finally examined

and approved. In order to obtain such advances, the Surveyor will have to send, with his monthly report, a statement of the number of miles of each class of mileage surveyed, with the value thereof, and the credit to which he is entitled, thus:

First class.....miles, at $.....per mile, $.....
Second do. ..... do. ..... do. .....
Third do. ..... do. ..... do. .....

Total..... .....
Minus 25 per cent.... .....

Credit..... ....

On receipt of such report, the balance of the credit will be placed to the credit of the Surveyor in a bank at Winnipeg.

(*Form of Contract for Subdivision Surveys.*)

THIS AGREEMENT, made this day of 188 between Dominion Land Surveyor of the first part, and Her Majesty the Queen, represented and acting herein by the Honorable the Minister of the Interior of Canada, of the second part.

WITNESSETH, That the said part of the first part, for and in consideration of the conditions, terms, provisions and covenants hereinafter expressed, and according to the true intent and meaning thereof, do hereby covenant and agree with Her Majesty, that the said part of the first part, in own proper person, with the aid of such chainmen, and other assistants as may be necessary, the same to be provided and paid for at the sole cost of the said part of the first part, and in strict conformity with such instructions as may receive from the Minister of the Interior or the Surveyor-General of Dominion Lands, will well, truly and faithfully survey and subdivide

and that will complete these surveys, in the manner aforesaid, and return the plans, the true and original field-notes and other returns thereof required of , to the Department of the Interior, on or before the day of next ensuing the date thereof.

AND Her Majesty covenants and agrees with the said part of the first part that, on the completion of the surveys above named, in manner aforesaid, and to the satisfaction of the Minister of the Interior, there shall be paid to the said part of the first part upon the receipt of account at the Dominion Lands Office of the said Department, properly certified and accompanied by the approved plans and field-notes of the surveys for which the account is rendered, such sum, as a full compensation for the whole expense of surveying and making return thereof, as shall be found by summation of the number of miles in such surveys (random lines and offsets not included) actually run and marked in the field, as shewn in the classification made and sworn to by the said part

of the first part, and accompanying the said account, according to the following schedule rates:—

SCHEDULE OF RATES.

CHARACTER OF SURVEY.	1ST CLASS. — Open Prairie.	2ND CLASS. — Poplar and other soft woods where occurring in alternation with prairie.	3RD CLASS. — Contracts composed of Townships all woods; and wherever they occur, heavy underbrush, hardwoods, windfalls, thick willows.
Township Subdivision Surveys.	Per Mile. $	Per Mile. $	Per Mile. $

It being further understood that main traverse lines of lakes, navigable rivers or settler's improvements, as shown in Field Notes, shall be paid for according to above schedule, except in prairie or on ice, where they will be paid for at second class rate.

AND IT IS FURTHER UNDERSTOOD AND AGREED, between the parties to this agreement, that the said surveys will not be approved by the Minister of the Interior, unless they shall be found to be in exact accordance with the above mentioned instructions: Provided, no sub-contractor shall have any part in this contract, and that no payment shall be made for any surveys not executed by the said Dominion Land Surveyor, in own proper person.

IN TESTIMONY WHEREOF, The parties to these articles of agreement have hereunto set their hands and seals, the day and year first above written.

Signed, Sealed and acknowledged before us.

.....

.....

..... {L. S.}

Dominion Land Surveyor.

..... {L. S.}

Minister of the Interior.

Countersigned,

.....

Surveyor General.

(*Form of Bond.*)

KNOW ALL MEN BY THESE PRESENTS, THAT WE

Dominion Land Surveyor, as Principal, and

of

and

of

as sureties, are held and firmly bound unto Her Majesty the Queen, Her Successors and Assigns, in the sum of

dollars, lawful money of Canada, to be paid to Her Majesty, Her Heirs and Successors, for which payment, well and truly to be made, we bind ourselves, our heirs, executors and administrators, and each and every of us and them jointly and severally, firmly by these presents, signed with our hands and sealed with our seals this day of 18 .

THE CONDITION OF THE ABOVE OBLIGATION IS SUCH, that if the above bounden

shall well and truly and faithfully, according to the instructions mentioned in the preceding contract, make and execute the surveys which are to be made by under the said contract and return the plans and field notes of the said survey to the Minister of the Interior in the manner and within the period named in the said contract, then this obligation to be void or otherwise it shall remain in full force and virtue.

Signed, sealed and acknowledged before us.

..... {L. S.}

Dominion Land Surveyor.

..... {L. S.}

Surety.

..... {L. S.}

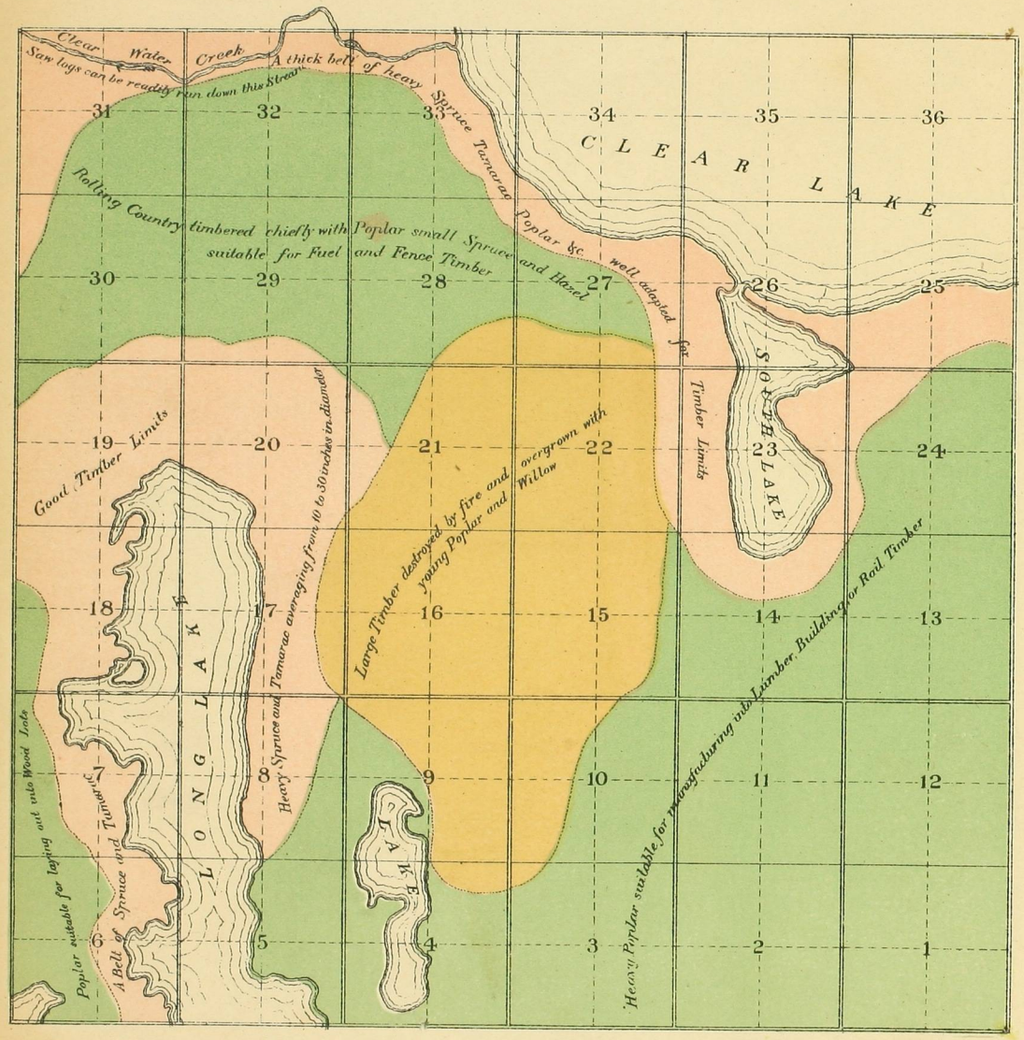
Surety.

SPECIMEN OF

TIMBER PLAN

TOWNSHIP Nº 19.

RANGE 19 WEST OF 1ST MERIDIAN



APPENDIX C.

SPECIMEN TIMBER REPORT.

Township 19, *Range* 19, *West of* 1st *Meridian.*

This township is covered entirely with a growth of timber, which, for the purposes of description, may be divided into three divisions, viz.:—

1st, Timber suitable for being manufactured into marketable lumber.

2nd. Building and fence rail timber.

3rd. Timber for fuel only.

The 1st division comprises the lands bordering on Long Lake, Clear Lake and Clear Water Creek; these are covered chiefly with heavy spruce and tamarac averaging in size from 10 to 30 inches in diameter, generally sound, and running up to a height of from 50 to 60 feet. Clumps and ridges of poplar are also found; these trees are, however, generally unfit for manufacturing into lumber, owing to their being rotten at the heart. The timber adjoining the Clear Water Creek and the north end of Long Lake, viz:—on parts of sections 31, 32, 33, 17, 18, 19, 20, I consider the most valuable on account of its superior quality and size.

The timber in the northerly sections can be readily driven down the Clear Water Creek to the Little Saskatchewan in the spring, and that bordering on Long Lake could be run down the Rolling River, which flows out of the south end of this lake and joins the Little Saskatchewan near the 5th Base. I would recommend that the land in the 1st division should be reserved from sale and settlement and set apart to be licensed as timber limits.

2nd Division.—As the lands to the south of this township are well adapted for settlement, this being evidenced by the fact that a number of settlers have taken up homesteads in the townships adjoining, the lands in this division, especially sections 1, 2, 3, 4, 10, 11, 12, should be set apart to be divided into wood lots of not more than 20 acres each, and sold to the settlers as they are required.

3rd Division.—The central portion of the township is almost entirely covered with windfall.

The timber, as it lies at present, is well suited for fuel, being quite dry and sufficiently elevated above the ground to prevent immediate decay. I would recommend that permits be given to settlers who may apply for them, to cut fuel to supply their needs on the sections shown, as covered with windfall, on the accompanying plan.

APPENDIX D.

FORM OF ENGAGEMENT FOR MEN.

ARTICLES OF AGREEMENT, made and entered into at
this day of , A.D. 188 ,
BETWEEN of
Dominion Land Surveyor and
of

(1) The party hiring.
(2) The Surveyor.
(3) The party hiring.
(4) The Surveyor.
(5) Laborer, cook, or as the case may be.
(6) Or from the date of this agreement until the said shall have completed the survey of or as the case may be.

WITNESS that the said (1)
agrees with the said (2)
to faithfully and diligently serve him, and his assistant or assistants, or any person under whose charge the said (3)
may for the time being, be placed by order and direction of the said (4)
as (5)
for the period of (6)
from the date of this agreement.

IN CONSIDERATION WHEREOF the said
agrees to pay the said
at the rate of
per and to board him
so long as the said
continues to serve under this agreement.

AND IT IS AGREED between the parties hereto that the provisions of Ordinance number Five of 1879, of the Lieutenant Governor in Council of the North West Territories, shall apply to the same under this agreement.

IN WITNESS WHEREOF the parties hereto have hereunto set their hands the day and year first above written.

Signed in presence of

Dominion Land Surveyor.

APPENDIX E.

ORDINANCES OF THE NORTH-WEST TERRITORIES.

No. 5 OF 1879.

AN ORDINANCE RESPECTING MASTERS AND SERVANTS.

(*Passed 26th September*, 1879.)

Be it enacted by the Lieutenant-Governor of the North-West Territories, in Council, as follows:—

I. Every contract of hire for personal service for any period more than a year shall be in writing, signed by the contracting parties.

II. Any person engaged, bound or hired, whether as a clerk, journeyman, apprentice, servant, laborer, or otherwise howsoever, guilty of ill behavior, drunkenness, refractory conduct or idleness,—of absenting himself by day or night, without leave, from his proper service or employment, or from the house or residence of his employer, of refusing or neglecting to perform his just duties, or to obey the lawful commands of his master,—of dissipating his employer's property or effects, or of any unlawful act that may affect his employer's interests,—shall, upon being convicted of any or either of the said offences, before any justice of the peace, for every such offence forfeit and pay such sum of money not exceeding thirty dollars as to the said justice seems meet, together with costs of prosecution; and in default of payment thereof, forthwith be imprisoned for any period not exceeding one month, unless the fine imposed and costs, together with the costs of commitment and conveying such person convicted to the place of imprisonment, be sooner paid.

III. Any person convicted before any justice of the peace of harboring or concealing any apprentice or servant who has deserted his master's service, or instigating any such apprentice or servant to desert such service, or of keeping such apprentice or servant in his service after being notified or informed of the fact, shall be liable to the same penalties as are enacted in the next preceding section of this Ordinance.

IV. It shall be lawful for any justice of the peace, on complaint on oath by any employee or other servant, of ill usage, non-payment of wages (not exceeding two month's wages, the same having been first demanded), or improper dismissal by his master or employer, to cause such master or employer to be brought before him, and upon proof to his satisfaction of the complaint being well founded, to order such complainant to be discharged from his engagement, and to order such master or employer to pay such complainant one month's wages in addition to the amount of wages then actually due him, not exceeding two month's wages as aforesaid, together with the costs of prosecution, the same to be levied by distress and sale of the offender's goods and chattels; and in default of sufficient distress, to be imprisoned for any term not exceeding one month, unless the said moneys and costs be sooner paid.

V. The provisions of this Ordinance shall be held to apply in the North West Territories to contracts and agreements made at any place outside the same.

VI. On the trial of any complaint made under this Ordinance, the complainant and accused shall be admitted to give evidence.

VII. Nothing in this Ordinance shall in any wise curtail, abridge or defeat any civil or other remedy for the recovery of wages or damages, which employers or masters may have against servants or employees, or which servants or employees may have against their masters or employers.

VIII. Prosecution for offences under this Ordinance shall be commenced within three months after the offence has been committed, and not after.

IX. Any Ordinance heretofore in force in the North West Territories respecting masters and servants is hereby repealed.

TABLES.

EXPLANATION OF THE TABLES.

The elements of the figure of the earth on which the geodetic tables are based are those given by Capt. A. R. Clarke in his "Comparisons of Standards of Length, &c., 1866."

These elements are:—

Equatorial semi-axis = a = 6378206·4 metres.

Polar semi-axis = b = 6356583·8 metres.

His value of the metre (which has also been used) is 39-370432 inches.

TABLE I.

The first column of this table gives the argument—the latitude of the place.

From the second column with this argument we take out the logarithm of the length of, in Gunter's chains, N sin 1″, *i.e.*, of one second (1″) of the great circle of the earth perpendicular to the meridian at that place.

The third column gives the logarithm of the length in chains of P sin 1″, *i.e.*, of one second (1″) of longitude.

The fourth column gives the logarithm of R sin 1″, *i.e.*, of one second (1″) of latitude.

These values have been used in computing the following tables.

TABLE II.

The argument in this table is the number of the base or correction line, or (in the first column) the number of townships intervening between the 49th parallel of latitude and the line.

The next column contains the latitude of the line, and the next three columns give log N sin 1″, log P sin 1″, and log R sin 1″ as before.

The last column of the table gives the difference of longitude between two points on the line 486 chains apart.

For interpolating, in this table and in Table I, the logarithm of N sin 1″, P sin 1″ and R sin 1″, for any latitude intermediate between the latitudes given in the table, N sin 1″ and R sin 1″ may be interpolated directly, in the usual way, by first differences. But to obtain P sin 1″ for an intermediate latitude, it is necessary, if accuracy be required, to first interpolate N sin 1″ for the latitude, and then to multiply the result by the cosine of that latitude.

For $\qquad P \sin 1'' = N \sin 1'' \times \cos \phi.$

TABLE III.

This table gives for the argument—number of the base line: first, the chord azimuth, *i. e.*, the angle measured from the north towards the west which a township chord makes with the meridian, in degrees, minutes and seconds. In the next column is given the chord azimuth, in degrees and decimals of a degree.

The two columns headed "Deflection" give the angle between one chord produced and the next chord; or 180° less twice the chord angle. One column gives it in minutes and seconds, and the other in decimals of a degree. The "Deflection Offset" is the tangent subtended by this deflection angle at a distance of one chain.

In the column headed "Longitude for one range" is given the number of seconds to be added to or subtracted from the time shown by a chronometer to correct it for the difference of longitude between one corner of a township and to the other. In other words, if a watch or chronometer be carried across a township it will be that number of seconds slower or faster, if it has no gaining or losing rate of its own.

TABLE IV.

This table gives for correction lines the chord azimuths, deflections and deflection offsets for running the chords along the *south* side of the road allowance.

The table also gives the length of one range on the *north* and *south* sides of the road allowance. The length on the north side is the distance included on the correction line, between two meridians from the base next north of the correction line. The longitude covered by this length is of course the same as that covered by one range on the next base north, and is given in the last column of Table III. Similarly for the south side.

The difference between the lengths of one range on the north and south sides of the road allowance is the "jog."

Half the jog is very nearly the narrowing or extension of one range in going north or south from a base to a correction line.

One twenty-fourth of the jog is the "convergence or divergence" of the meridians for one quarter-section on the correction lines, this should be the difference from forty chains of every quarter-section. For the township line mid-way between the base and correction line, half of this quantity is to be taken.

TABLE V

Gives the latitude, the logarithms of its secant and tangent and the width of quarter sections for the north side of every section. The logarithms of secant and tangent ϕ are given to simplify the calculation of the azimuth formula (page 24.) The width of quarter-sections is what it would be, were the survey perfectly correct.

TABLE VI

Is intended to facilitate the observation of the pole star in strong daylight, by placing the telescope precisely in the direction of the star. The second column gives the approximate azimuth at different times and for townships 0 to 80. The last column contains the distance of Polaris above or below the pole, which added to or subtracted from the latitude, gives the approximate altidude.

TABLE VII

is for determining the watch error by the observation, at any time, of the transits of Polaris and another star across the same vertical plane.

Let ϕ be the latitude of the place, α' and δ' the right ascension and declination of Polaris, α and δ the same quantities for the other star, and T' and T the chronometer times at which each of the stars was respectively observed to cross the same vertical. Let p be the arc of the great circle perpendicular to the meridian and comprised between the pole star and the meridian.

The hour angle of the time star, at the instant it was observed, was equal to

$$t = p\ (\text{tan. } \phi - \text{tan. } \delta)$$

which, when p is known, is easily calculated by taking (tan. ϕ — tan. δ) from a table of natural tangents to three places of decimals. Were no such table at hand, the following logarithmic form of the same formula would be employed:

$$t = p\ \frac{\text{sin. } (\phi - \delta)}{\text{cos. } \phi\ \text{cos. } \delta}$$

For stars below the pole, the formula would be:

$$t = p\ (\text{tan. } \phi + \text{tan. } \delta)$$

or

$$t = p\ \frac{\text{sin. } (\phi + \delta)}{\text{cos. } \phi\ \text{cos. } \delta}$$

Table VII. gives the values of p computed for the mean declination.

$$88°\ 41' = 88°.6833.$$

For any other value of δ', p must be multiplied by

$$\frac{\text{cos. } \delta'}{\text{cos. } 88°\ 41'}$$

The logarithm of the above factor is very simply found by adding

1·63857

to log. tan. P given in the annual ephemeris of Polaris.

The arguments of the table are the declination of the time star, δ, and

$$t - t' = (\alpha - \alpha') - (T - T')$$

With carefully adjusted collimation and axis well levelled, the surveyor needs to observe but one star to obtain a chronometer correction sufficiently approximate for azimuth work.

The table has been computed by the following formula:

$$p = P \sin (t - t') + \frac{P^2}{2} \sin 2 (t - t') \tan \delta.$$

Only in exceptional cases will the neglected terms of the development cause an error of one quarter of a second in the time deduced.

The example below will show the calculation by both formulas.

To deduce the chronometer error from the following chronometer times of transit across the same vertical plane.

Polaris..... 6h. 33m. 27s.....15th April, 1881.
α Canis Majoris..... 6 36 42..... do

Chronometer supposed to keep sidereal time without daily rate. Place, 6th base line.

α (Ann. Ephemeris) = 6h. 39m. 55s. 4	T = 6h. 36m. 42s.	ϕ (Table V) = 50°.77
α' do = 1 14 29 8	T' = 6 33 27	δ(an.Eph.) = −16 .56
$\alpha - \alpha'$ = 5 25 25 6	T − T' = 3 15	$\phi - \delta$ = 67 .33
T − T' = 3 15 0		
$t - t'$ = 5 22 10 6		
log p (Table VII) = 2.49293		

By Natural Tangents.	By Logarithms.
Const. log. = 1.63857	Const. log. = 1.63857
Nat. tan ϕ = 1.2248	log tan P (Ann. Eph) = 8.36363
Nat. tan ϕ = − 0.2974	log. p (Table VII) = 2.49293
tan ϕ − tan ϕ = 1.5222	log. (tan. ϕ − tan. ϕ) = 0.18247
	log. sec. ϕ (Table V) = 0.19897
log. t = 2.67760	log. sec. ϕ = 0.01840
t = 7m. 56s .0	log. t = 2.67758
α − ϕ = 6 39 55 .4	t = 476s .0
Sid. time of transit = 6 31 59 .4	
T = 6 36 42 .0	
Chronometer error = − 4 42 .6	

TABLE VIII

Gives chains in decimals of a township side; the average length of north or south sides, viz.: 486 chs. has been used in the computation of the second column of this table.

TABLE IX

Contains the correction to be applied to the normal width of road allowance, to obtain its value at township corners on correction lines. It is to be added to one chain for township corners north of the road, and subtracted for corners south of it.

TABLE X

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 found with a table of logarithms of numbers, without having to compute proportional parts. This table is intended to replace the table printed on the record of astronomical observations, when the instrument employed is divided sexagesimally.

TABLE XI

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

TABLE XII

Is the part of the table of addition and substraction logarithms, useful in reducing time azimuth observations with Polaris. Suppose two numbers a and b, and $a > b$; then we have, as long as A is less than 10.

For Sums.	For Differences.
Take 10 + log. b − log. a = A and then log.$(a + b)$ = log. a + B	Take log. a − log. b = B and then log. $(a - b)$ = log. b + A − 10.

TABLE XIII

Gives the correction for refraction to be applied to the sun's polar distance when using solar instruments. It is always to be subtracted.

This table was computed by a graphical construction.

TABLE I.

LOGARITHMS of the Lengths in Gunter's Chains of certain Geodetic Lines computed from Clarke's elements of the Figure of the Earth.

Latitude.	Log. N. sin. 1".	Log. R. sin. 1".	Log. P. sin. 1".	Latitude.	Log. N. sin. 1".	Log. R. sin. 1".	Log. P. sin. 1".
° ′				° ′			
49 00	0·1875572	0·1862852	0·0045001	54 40	0 1876988	0 1867100	9·9498763
49 10	5615	2981	0·0030469	54 50	7029	7223	9·9480928
49 20	5657	3107	0·0015849	55 00	7068	7340	9·9462981
49 30	5699	3233	0·0001143	55 10	7110	7466	9 9444925
49 40	5741	3359	9·9986350	55 20	7150	7586	9.9426754
49 50	5784	3488	9·9971470	55 30	7190	7706	9·9408470
50 00	5826	3614	9·9956501	55 40	7230	7826	9·9390072
50 10	5869	3743	9·9941444	55 50	7270	7946	9 9371557
50 20	5911	3869	9·9926296	56 00	7309	8063	9·9352926
50 30	5953	3995	9·9911058	56 10	7349	8183	9·9334177
50 40	5995	4121	9 9895730	56 20	7390	8306	9 9315311
50 50	6037	4247	9 9880309	56 30	7429	8423	9·9296324
51 00	6079	4373	9·9864797	56 40	7468	8540	9·9277216
51 10	6121	4499	9·9849192	56 50	7507	8657	9·9257986
51 20	6163	4625	9 9833493	57 00	7546	8774	9·9238634
51 30	6205	4751	9·9817701	57 10	7586	8894	9·9219158
51 40	6247	4877	9·9801813	57 20	7625	9011	9·9199557
51 50	6288	5000	9 9785829	57 30	7665	9131	9·9179830
52 00	6330	5126	9·9769750	57 40	7703	9245	9·9159974
52 10	6372	5252	9.9753574	57 50	7742	9362	9·9139991
52 20	6413	5375	9·9737299	58 00	7781	9479	9·9119878
52 30	6455	5501	9·9720926	58 10	7819	9593	9·9099633
52 40	6497	5627	9 9704455	58 20	7857	9707	9·9079256
52 50	6538	5750	9·9687882	58 30	7896	9824	9·9058747
53 00	6578	5870	9·9671208	58 40	7934	0·1869938	9·9038102
53 10	6620	5996	9·9654435	58 50	7972	0·1870052	9·9017321
53 20	6662	6122	9·9637559	59 00	8010	0166	9 8996403
53 30	6702	6242	9·9620578	59 10	8048	0280	9·8975347
53 40	6744	6368	9·9603495	59 20	8086	0394	9·8954150
33 50	6785	6491	9·9586307	59 30	8123	0505	9·8932812
54 00	6825	6611	9·9569012	59 40	8161	0619	9·8911331
54 10	6866	6734	9·9551612	59 50	8198	0730	9 8889706
54 20	6907	6857	9 9534104	60 00	0·1878235	0·1870841	9·8867935
54 30	0·1876948	0·1866980	9·9516488				

TABLE II.

LATITUDES, &c., of Base and Correction Lines.

Name of Line.	Latitude.	Log. N. sin. 1".	Log. P. sin. 1".	Log. R. sin. 1".	Longitude covered by 486 Chains.	No. of Township.
	° ′ ″				′ ″	
1st Base	49 00 00·00	0·1875572	0·0045001	0·1862852	8 00·990	0
Correction	10 29·05	5617	0 0029764	2987	02·681	2
2nd Base	20 58·07	5661	0·0014431	3119	04·388	4
Correction	31 27·08	5705	9·9999003	3251	06·112	6
3rd Base	41 56 08	5749	9·9983480	3383	07·852	8
3rd Correction	52 25·05	5794	9·9967861	3518	09·610	10
4th Base	50 02 54·01	5838	9·9952143	3650	11·385	12
Correction	13 22·96	5883	9·9936329	3786	13·178	14
5th Base	23 51·88	5927	9·9920418	3918	14·988	16
Correction	34 20·77	5971	9·9904407	4050	16 816	18
6th Base	44 49·65	6015	9·9888297	4182	18·662	20
Correction	55 18·51	6059	9·9872086	4314	20·527	22
7th Base	51 05 47·35	6103	9·9855774	4446	22·411	24
Correction	16 16·17	6147	9·9839365	4578	24·313	26
8th Base	26 44·98	6191	9·9822842	4710	26·235	28
8th Correction	37 13·76	6235	9·9806224	4842	28·176	30
9th Base	47 42·53	6279	9·9789500	4974	30·136	32
Correction	58 11·26	6322	9·9772671	5103	32·117	34
10th Base	52 08 39·98	6366	9 9755737	5235	34·118	36
Correction	19 08·69	6409	9·9738694	5364	36·139	38
11th Base	29 37·37	6453	9 9721545	5496	38·181	40
Correction	40 06·04	6497	9 9704288	5628	40·245	42
12th Base	50 34·69	6540	9·9686921	5757	42·329	44
Correction	53 01 03·31	6582	9·9669442	5883	44·436	46
13th Base	11 31·92	6626	9 9651855	6015	46·564	48
13th Correction	22 00·52	6670	9 9634156	6147	48·714	50
14th Base	32 29·09	6712	9·9616342	6273	50·887	52
Correction	42 57·65	6756	9·9598417	6405	53·083	54
15th Base	53 26·19	6799	9 9580375	6534	55·302	56
Correction	54 03 54·71	6841	9·9562218	6660	57·545	58
16th Base	14 23·21	6884	9·9543945	6789	8 59·811	60
Correction	24 51 69	6927	9·9525554	6918	9 02·102	62
17th Base	35 20·15	6969	9 9507044	7044	04·417	64
Correction	45 48·59	7012	9·9488415	7173	06·758	66
18th Base	56 17·01	7054	9·9469665	7298	09·123	68
18th Correction	55 06 45·42	7096	9 9450792	7424	11·515	70
19th Base	17 13 82	7139	9·9431798	7553	13 932	72
Correction	27 42·20	7181	9·9412680	7679	16·376	74
20th Base	38 10·55	7223	9·9393437	7805	18 847	76
Correction	48 38·89	7264	9·9374066	7928	21·345	78
21st Base	59 07·20	7305	9·9354569	8051	23·871	80
Correction	56 09 35·49	7347	9 9334945	8177	26·424	82
22nd Base	20 03·77	7390	9·9315192	8306	29·006	84
Correction	30 32·03	7431	9 9295307	8429	31·618	86
23rd Base	41 00·28	7472	9·9275290	8552	34·258	88
23rd Correction	51 28·51	7513	9·9255140	8675	36·929	90
24th Base	57 01 56·70	7554	9·9234856	8798	39·630	92
Correction	12 24·89	7595	9 9214436	8921	42·362	94
25th Base	22 53·07	7637	9·9193880	9047	45·125	96
Correction	33 21·22	7678	9·9173186	9170	47·919	98

TABLE II.

LATITUDES, &c., of Base and Correction Lines—*Continued.*

Name of Line.	Latitude.	Log. N. sin. 1".	Log. P. sin. 1".	Log. R. sin. 1".	Longitude covered by 486 Chains.	No. of Township.
	° ′ ″				′ ″	
26th Base	57 43 49·36	0·1877718	9·9152351	0·1869290	9 50·747	100
Correction	54 17·48	7759	9·9131376	9413	53 607	102
27th Base	58 04 45·57	7799	9·9110259	9533	56·500	104
Correction	15 13·66	7839	9·9088998	9653	9 59·427	106
28th Base	25 41·73	7879	9·9067591	9773	10 02·389	108
28th Correction	36 09·78	7919	9·9046039	0·1869893	05·386	110
29th Base	46 37·81	7959	9·9024339	0·1870013	08·418	112
Correction	57 05·83	7999	9·9002490	0133	11·487	114
30th Base	59 07 33·83	8039	9·8980490	0253	14·593	116
Correction	18 01·81	8078	9·8958337	0370	17·735	118
31st Base	28 29·77	8117	9 8936029	0487	20·917	120
Correction	38 57·71	8157	9·8913568	0607	24·136	122
32nd Base	49 25·64	8196	9·8890948	0724	27·396	124
Correction	59 53·55	0·1878235	9 8868170	0·1870840	10 30 695	126

TABLE III.

CHORD Azimuths, Deflections, Deflection Offsets, &c., for Base Lines.

Number of Base Line.	Chord Azimuth Sexagesimal.	Chord Azimuth Decimal.	Deflection Sexagesimal.	Deflection Decimal.	Deflection Offset for 1 chain distance.	Longitude covered by 1 range.	Number of Township.
	° ′ ″	°	′ ″	°	inches.	s	
1	89 56 58·5	89·9496	6 03·0	0·1008	1·394	32·1	0
2	56·3	·9490	07·5	·1021	1·411	32·3	4
3	54·0	·9483	12·0	·1033	1·429	32·5	8
4	51·7	·9477	16·6	·1046	1·447	32·8	12
5	49·4	·9471	21·3	·1059	1·465	33·0	16
6	47·0	·9464	26·1	·1072	1·483	33·2	20
7	44·6	·9457	30·9	·1086	1·501	33·5	24
8	42·1	·9450	35·8	·1099	1·520	33·7	28
9	39·6	·9443	40·8	·1113	1·539	34·0	32
10	37·1	·9436	45·9	·1127	1·558	34·3	36
11	34·5	·9429	51·0	·1142	1·578	34·5	40
12	31·9	·9422	56·2	·1156	1·598	34·8	44
13	29·3	·9415	7 01·5	·1171	1·619	35·1	48
14	26·6	·9407	06·9	·1186	1·639	35·4	52
15	23·8	·9399	12·4	·1201	1·660	35·7	56
16	21·0	·9392	18·0	·1217	1·682	36·0	60
17	18·2	·9384	23·7	·1232	1·704	36·3	64
18	15·3	·9376	29·4	·1248	1·726	36·6	68
19	12·4	·9368	35·3	·1265	1·749	36·9	72
20	09·4	·9359	41·3	·1281	1·772	37·3	76
21	06·3	·9351	47·4	·1298	1·795	37·6	80
22	03·2	·9342	53·6	·1316	1·819	37·9	84
23	00·1	·9334	59·8	·1333	1·843	38·3	88
24	89 55 56·9	·9325	8 06·3	·1351	1·867	38·6	92
25	53·6	·9316	12·8	·1369	1·892	39·0	96
26	50·3	·9306	19·5	·1387	1·918	39·4	100
27	46·8	·9297	26·3	·1406	1·944	39·8	104
28	43·4	·9287	33·3	·1426	1·971	40·2	108
29	39·9	·9277	40·3	·1445	1·998	40·6	112
30	36·2	·9267	47·6	·1465	2·026	41·0	116
31	32·6	·9257	54·9	·1486	2·054	41·4	120
32	28·8	·9247	9 02·4	·1507	2·083	41·8	124

TABLE IV.

CHORD Azimuths, Deflections, Deflection Offsets, Jogs, &c., for Correction Lines.

Number of Correction Line.	Chord Azimuth Sexagesimal.	Chord Azimuth Decimal.	Deflection Sexagesimal.	Deflection Decimal.	Deflection Offset for 1 Chain distance.	Length of one Range on Correction Line.		Jog.	Convergence or Divergence for one-half section.	Number of Township.
						N. side of Road.	S. side of Road.			
	° ′ ″	°	′ ″	°	Inches.	Chains.	Chains.	Chains.	Chains.	
1	89 56 57·4	89·9493	6 05·2	0·1014	1·403	487·719	484·297	3·421	0·143	2
2	55·1	·9486	09·8	·1027	1·420	·740	·276	·463	·144	6
3	52·9	·9480	14·3	·1040	1·438	·762	·255	·507	·146	10
4	50·5	·9474	19·0	·1053	1·456	·784	·233	·551	·148	14
5	48·2	·9467	23·7	·1066	1·474	·806	·212	·594	·150	18
6	45·8	·9461	28·5	·1079	1·492	·829	·188	·641	·152	22
7	43·3	·9454	33·4	·1093	1·510	·852	·167	·685	·154	26
8	40·9	·9447	38·3	·1106	1·529	·875	·144	·731	·155	30
9	38·3	·9440	43·4	·1120	1·548	·899	·120	·779	·157	34
10	35·8	9433	48·4	·1134	1·568	·923	·097	·826	·159	38
11	33·2	·9426	53 6	·1149	1·588	947	·072	·875	·161	42
12	30·6	·9418	58·8	·1163	1·608	·972	·047	·925	·164	46
13	27 9	·9411	7 04·2	·1178	1·629	487·997	484·024	3·973	·166	50
14	25·2	·9403	09·6	·1193	1·650	488·023	483 998	4·025	·168	54
15	22·4	·9396	15·2	·1209	1·671	·049	·972	·077	·170	58
16	19 6	·9388	20·8	·1224	1·693	·075	·946	·129	·172	62
17	16 7	·9380	26·6	·1241	1·715	·102	·919	·183	·174	66
18	13·8	·9372	32·4	·1257	1·737	·130	892	·238	·177	70
19	10·9	·9364	38 3	·1273	1·760	·158	·865	·293	·179	74
20	07·8	·9355	44 4	·1290	1 783	·187	·837	·350	·181	78
21	04·8	·9347	50·5	·1307	1·807	·215	·809	·406	·184	82
22	89 56 01·7	·9338	56·7	·1324	1·831	·245	·779	·466	·186	86
23	89 55 58·5	·9329	8 03·0	·1342	1·855	·275	·750	·525	·189	90
24	55·2	·9320	09·6	·1360	1·879	·306	·720	·586	·191	94
25	51·9	·9311	16·2	·1378	1·905	·338	·690	·648	·194	98
26	48·6	·9302	22·9	·1397	1·931	·369	·658	·711	·196	102
27	45·1	·9292	29·8	·1416	1·957	·402	·627	·775	·199	106
28	41·6	·9282	36·8	·1436	1·984	·434	·594	·840	·202	110
29	38·0	·9272	44·0	·1456	2·012	·469	·561	·908	·204	114
30	34·4	·9262	51·2	·1476	2·040	·503	·528	4·975	·207	118
31	30·7	·9252	58 6	·1496	2·068	·538	·493	5·045	·210	122
32	89 55 26·9	89·9241	9 06·2	·1517	2·097	488·574	483,458	5·116	·213	126

TABLE V.

LATITUDE, with Logarithms of Secant and Tangent for each Section, and width of Quarter-Sections.

Township.	Section.	Latitude.	Sec. ϕ	Difference for 10 chains.	Tan. ϕ	Difference for 10 chains.	Quarter-Section.
	36	49°.0000	0·183 06		0·060 84		40·000
1	1	0147	19		0·061 06		39·988
	12	0291	31		28		976
	13	0438	44		51		964
	24	0582	57		73		953
	25	0729	69		95		941
	36	0874	82		0·062 17		929
2	1	1020	95		40		917
	12	1165	0·184 08		62		905
	13	1311	20		85		893
	24	1456	33		0·063 07		882
	25	1603	46		29		870
	36	1747	59		51		39 858 40·143
3	1	1894	71		74		131
	12	2039	84		96		119
	13	2185	97		0·064 18		107
	24	2330	0 185 10		41		095
	25	2476	23		63		084
	36	2621	35		85		072
4	1	2768	48		0·065 08		060
	12	2912	61		30		048
	13	3059	74		52		036
	24	3203	87	0·000 02	74	0·000 03	024
	25	3350	0·186 00		97		012
	36	3495	12		0·066 19		000
5	1	3641	25		42		39·988
	12	3786	38		64		976
	13	3932	51		86		964
	24	4077	64		0·067 08		952
	25	4224	77		31		940
	36	4368	90		53		928
6	1	4515	0·187 03		76		916
	12	4659	15		98		904
	13	4806	28		0·068 20		892
	24	4951	41		43		880
	25	5097	54		65		868
	36	5242	67		87		39·858 40·145
7	1	5388	80		0·069 10		133
	12	5533	93		32		121
	13	5680	0 188 06		54		109
	24	5824	19		77		097
	25	5971	32		99		085
	36	6115	45		0·070 21		073
8	1	6262	58		44		060
	12	6407	71		66		048
	13	6553	84		89		036
	24	6698	97		0 071 11		024
	25	6844	0 189 10		33		012
	36	6989	23		56		000

TABLE V.—*Continued.*

LATITUDE, with Logarithms, of Secant and Tangent, for each Section, and width of Quarter-Sections.

Township.	Section.	Latitude.	Sec. ϕ	Difference for 10 chains.	Tan. ϕ	Difference for 10 chains.	Quarter-Section.
9	1	49°.7136	0·189 36		0·071 78		39·988
	12	7280	49		0·072 00		976
	13	7427	62		23		964
	24	7571	75		45		951
	25	7718	88		68		939
	36	7863	0·190 01		90		927
10	1	8009	14		0·073 12		915
	12	8154	27		35		903
	13	8300	40		57		891
	24	8445	53		79		879
	25	8592	66		0·074 02		867
	36	8736	79		24		39·855 40·147
11	1	8883	93		47		135
	12	9027	0·191 06		69		122
	13	9174	19		92		110
	24	9319	32		0·075 14		098
	25	9465	45		36		086
	36	9610	58		59		073
12	1	9756	71		81		061
	12	9901	84		0·076 03		050
	13	50°.0047	98		26		037
	24	0192	0·192 11		48		024
	25	0339	24	0·000 02	71	0·000 03	012
	36	0483	37		93		000
13	1	0630	50		0·077 16		39·988
	12	0775	63		38		975
	13	0921	77		60		963
	24	1066	90		83		951
	25	1212	0·193 03		0·078 05		939
	36	1357	16		28		926
14	1	1503	29		50		914
	12	1648	43		72		902
	13	1795	56		95		890
	24	1939	69		0·079 17		877
	25	2086	82		40		865
	36	2230	96		62		39·853 40·149
15	1	2377	0·194 09		85		137
	12	2522	22		0 080 07		124
	13	2668	35		30		112
	24	2813	49		52		099
	25	2959	62		75		087
	36	3104	75		97		074
16	1	3250	89		0·081 20		062
	12	3395	0·195 02		42		050
	13	3542	15		64		037
	24	3686	28		87		025
	25	3833	42		0·082 09		012
	36	3977	55		32		000

TABLE V—*Continued.*

LATITUDE, with Logarithms of Secant and Tangent for each Section and with Quarter-Sections.

Township.	Section.	Latitude.	Sec. ϕ	Difference for 10 chains.	Tan. ϕ	Difference for 10 chains.	Quarter-Section.
17	1	50°.4124	0·195 69		0·082 54		39·988
	12	4269	82		77		975
	13	4415	95		99		963
	24	4560	0 196 09		0·083 22		950
	25	4706	22		44		940
	36	4851	35		67		925
18	1	4997	49		89		913
	12	5142	62		0·084 12		901
	13	5289	76		34		888
	24	5433	89		56		876
	25	5580	0·197 02		79		863
	36	5724	16		0·085 01		{39·851 40·150
19	1	5871	29		24		138
	12	6016	43		46		125
	13	6162	56		69		113
	24	6307	69		91		100
	25	6453	83		0·086 14		088
	36	6598	96		36		075
20	1	6744	0·198 10		59		063
	12	6889	23		81		050
	13	7035	37	0·000 02	0·087 04	0·000 03	038
	24	7180	50		27		025
	25	7327	64		49		013
	36	7471	77		72		000
21	1	7618	91		94		39·987
	12	7762	0·199 04		0 088 17		975
	13	7909	18		39		962
	24	8054	31		62		950
	25	8200	45		84		937
	36	8345	58		0·089 07		925
22	1	8491	72		29		912
	12	8636	85		52		899
	13	8782	99		74		887
	24	8927	0·200 13		97		874
	25	9073	26		0·090 20		862
	36	9218	40		42		{39·849 40·152
23	1	9365	53		65		140
	12	9509	67		87		127
	13	9656	81		0·091 10		114
	24	9800	94		32		102
	25	9947	0·201 08		55		089
	36	51°·0091	21		77		076
24	1	0238	35		0·092 00		064
	12	0383	49		22		051
	13	0529	62		45		038
	24	0674	76		68		025
	25	0820	90		90		013
	36	0965	0·202 03		0·093 13		000

TABLE V.—*Continued.*

LATITUDE with Logarithms of Secant and Tangent for each Section, and width of Quarter-Sections.

Township.	Section.	Latitude.	Sec. ϕ	Difference for 10 chains.	Tan. ϕ	Difference for 10 chains.	Quarter-Section.
25	1	51°·1111	0·202 17		0·093 35		39·987
	12	1256	31		58		975
	13	1402	44		81		962
	24	1547	58		094 03		949
	25	1694	72		26		936
	36	1838	85		48		924
26	1	1985	99		71		911
	12	2129	203 13		93		898
	13	2276	27		095 16		885
	24	2420	40		39		873
	25	2567	54		61		860
	36	2712	68		84		{39·847 40·154
27	1	2858	82		096 07		141
	12	3003	95		29		129
	13	3149	204 09		52		116
	24	3294	23		74		103
	25	3440	37		97		090
	36	3585	51		097 19		077
28	1	3731	64		42		064
	12	3876	78		65		051
	13	4023	92		87		039
	24	4167	205 06		098 10		026
	25	4314	20	0·000 02	33	0·000 03	013
	36	4458	33		55		000
29	1	4605	47		78		39·987
	12	4749	61		099 00		974
	13	4896	75		23		962
	24	5040	89		46		949
	25	5187	206 03		69		936
	36	5332	17		91		923
30	1	5478	31		100 14		910
	12	5623	44		36		897
	13	5769	58		59		884
	24	5914	72		82		871
	25	6060	86		101 05		858
	36	6205	207 00		27		{39·846 40·156
31	1	6351	14		50		143
	12	6496	28		72		130
	13	6642	42		95		117
	24	6787	56		102 18		104
	25	6934	70		41		091
	36	7078	84		63		078
32	1	7225	99		86		065
	12	7369	208 12		103 08		052
	13	7516	26		31		039
	24	7660	40		54		026
	25	7807	54		77		013
	36	7951	68		99		000

TABLE V.—*Continued.*

LATITUDE with Logarithms of Secant and Tangent for each Section, and width of Quarter-Sections.

Township.	Section.	Latitude.	Sec. ϕ	Difference for 10 chains.	Tan. ϕ	Difference for 10 chains.	Quarter-Section.
33	1	51°.8098	0·208 82		104 22		39·987
	12	8243	96		45		974
	13	8389	209 10		68		961
	24	8534	24		90		948
	25	8680	38		105 13		935
	36	8825	52		35		922
34	1	8971	66		58		909
	12	9116	80		81		896
	13	9262	94		106 04		883
	24	9407	210 08		26		869
	25	9553	22		49		856
	36	9698	36		72		{ 39·843 / 40·158
35	1	9844	51		95		145
	12	9989	65		107 17		132
	13	52°·0135	79		40		119
	24	0280	93		63		106
	25	0427	211 07		86		092
	36	0571	21		108 08		079
36	1	0718	36		31		066
	12	0862	50		54		053
	13	1009	64		77		040
	24	1153	78		99		026
	25	1300	92	0·000 02	109 22	0·000 03	013
	36	1444	212 06		45		000
37	1	1591	21		68		39·987
	12	1735	35		90		974
	13	1882	49		110 13		960
	24	2027	63		36		947
	25	2173	77		59		934
	26	2318	92		81		921
38	1	2464	213 06		111 04		907
	12	2609	20		27		894
	13	2755	34		50		881
	24	2900	49		73		868
	25	3046	63		96		855
	36	3191	77		112 18		{ 39·841 / 40·160
39	1	3337	92		41		147
	12	3482	214 06		64		134
	13	3628	20		87		120
	24	3773	34		113 09		107
	25	3919	49		32		093
	36	4064	63		55		080
40	1	4210	77		78		067
	12	4355	92		114 01		053
	13	4501	215 06		24		040
	24	4646	20		46		027
	25	4794	35		69		013
	36	4937	49		92		000

TABLE V.—*Continued.*

LATITUDE with Logarithms of Secant and Tangent for each Section, and width of Quarter-Sections.

Township.	Section.	Latitude.	Sec. ϕ	Difference for 10 chains.	Tan. ϕ	Difference for 10 chains.	Quarter-Section.
41	1	52° ·5084	0·215 64		0·115 15		39·987
	12	5228	78		38		973
	13	5375	92		61		960
	24	5519	216 07		83		946
	25	5666	21		116 06		933
	36	5810	35		29		920
42	1	5957	50		52		906
	12	6101	64		75		893
	13	6248	79		98		879
	24	6392	93		117 21		866
	25	6539	217 08		44		853
	36	6683	22		66		{ 39·839 / 40·162
43	1	6830	37		89		149
	12	6974	51		118 12		135
	13	7121	66		35		122
	24	7266	80		58		108
	25	7412	95		81		095
	36	7557	218 09		119 04		081
44	1	7703	24		27		068
	12	7848	38		49		054
	13	7994	53		73		041
	24	8139	67		95		027
	25	8285	82	0·000 02	120 18	0·000 03	014
	36	8430	96		41		000
45	1	8576	219 11		64		39·986
	12	8721	25		87		973
	13	8867	40		121 10		950
	24	9012	55		33		946
	25	9158	69		56		932
	36	9303	84		79		919
46	1	9449	98		122 02		905
	12	9594	220 13		25		891
	13	9740	28		48		878
	24	9885	42		70		864
	25	53° ·0031	57		93		851
	36	0176	71		123 16		{ 39·837 / 40·164
47	1	0321	86		39		151
	12	0467	221 01		62		137
	13	0612	15		85		123
	24	0758	30		124 08		110
	25	0903	45		31		096
	36	1049	59		54		082
48	1	1195	74		77		068
	12	1340	89		125 00		055
	13	1486	222 04		23		041
	24	1631	18		46		027
	25	1777	33		69		014
	36	1922	48		92		000

TABLE V.—*Continued.*

LATITUDE with Logarithms of Secant and TANGENT for each Section, and width of Quarter-Sections.

Township.	Section.	Latitude.	Sec. ϕ	Difference for 10 chains.	Tan. ϕ	Difference for 10 chains.	Quarter-Section.
49	1	53° ·2068	0·222 63		0·126 15		39·986
	12	2213	77		38		972
	13	2359	92		61		958
	24	2504	223 07		84		945
	25	2650	22		127 07		931
	36	2795	36		30		917
50	1	2941	51		53		903
	12	3086	66		76		889
	13	3233	81		99		875
	24	3377	96		128 22		861
	25	3524	224 10		45		848
	36	3668	25		68		{ 39·834 / 40·166
51	1	3815	40		91		153
	12	3959	55		129 14		139
	13	4106	70		37		125
	24	4250	85		60		111
	25	4397	225 00		83		097
	36	4541	14		130 06		083
52	1	4688	29		30		069
	12	4832	44		53		055
	13	4979	59		76		042
	24	5123	74		99		028
	25	5270	89	0·000 02	131 23	0·000 03	014
	36	5414	226 04		45		000
53	1	5561	19		68		39·986
	12	5705	34		91		972
	13	5852	49		132 14		958
	24	5996	63		37		944
	25	6143	79		60		930
	36	6287	93		83		917
54	1	6434	227 08		133 07		903
	12	6578	23		30		890
	13	6725	38		53		875
	24	6869	53		76		861
	25	7016	68		99		847
	36	7160	83		134 22		{ 39·833 / 40·169
55	1	7307	99		45		155
	12	7451	228 13		68		140
	13	7598	29		91		126
	24	7742	44		135 14		112
	25	7889	59		38		098
	36	8033	74		61		084
56	1	8180	89		84		070
	12	8324	229 04		136 07		056
	13	8471	19		30		042
	24	8615	34		53		028
	25	8762	49		77		014
	36	8906	64		137 00		000

TABLE V.—*Continued.*

LATITUDE with Logarithms of Secant and Tangent for each Section, and width of Quarter-sections.

Township.	Section.	Latitude.	Sec. ϕ	Difference for 10 chains.	Tan. ϕ	Difference for 10 chains.	Quarter-Section.
57	1	53· 99052	0·229 79		0·137 23		39·986
	12	9197	95		46		972
	13	9343	230 10		69		958
	24	9488	25		92		944
	25	9634	40		138 16		930
	36	9779	55		39		915
58	1	9925	70		62		901
	12	54°· 0070	85		85		887
	13	0216	231 01		139 08		873
	24	0361	16	0·000 02	31	0·000 03	859
	25	0507	31		55		845
	36	0652	46		78		{ 39·831 / 40·171
59	1	0798	62		140 01		157
	12	0943	77		24		142
	13	1089	92		48		128
	24	1234	232 07		71		114
	25	1380	23		94		100
	36	1525	38		141 17		085
60	1	1671	53		41		071
	12	1816	68		64		057
	13	1962	84		87		043
	24	2107	99		142 10		028
	25	2253	233 14		34		014
	36	2398	29		57		000
61	1	2544	45		80		39·986
	12	2689	60		143 03		971
	13	2835	76		27		957
	24	2980	91		50		943
	25	3126	234 06		73		929
	36	3271	21		96		914
62	1	3417	37		144 20		900
	12	3562	52		43		886
	13	3708	68		66		872
	24	3853	83		89		857
	25	3999	98		145 13		843
	36	4144	235 14		36		{ 39·829 / 40·173
63	1	4290	29		59		159
	12	4435	45		83		144
	13	4581	60		146 06		130
	24	4725	75		29		115
	25	4872	91		53		101
	36	5016	236 06		76		086
64	1	5163	22		99		072
	12	5307	37		147 22		058
	13	5454	53		46		043
	24	5598	68		69		029
	25	5745	84		93		014
	36	5889	99		148 16		000

TABLE V.—*Continued.*

LATITUDE with Logarithms of Secant and Tangent for each Section, and width of Quarter-Sections.

Township.	Section.	Latitude.	Sec. ϕ	Difference for 10 chains.	Tan. ϕ	Difference for 10 chains.	Quarter-Section.
65	1	54°·6036	0·237 15		0·148 39		39·986
	12	6180	30		63		971
	13	6327	46		86		957
	24	6471	61		149 09		942
	25	6618	77		33		928
	36	6762	92		56		913
66	1	6909	238 08		80		899
	12	7053	24		150 03		884
	13	7199	39		26		870
	24	7344	55		50		855
	25	7490	70		73		841
	36	7635	86		96		{ 39·827 / 40·175
67	1	7781	239 02		151 20		161
	12	7926	17		43		146
	13	8072	33		67		131
	24	8217	49		90		117
	25	8363	64		152 13		102
	36	8508	80		37		088
68	1	8654	96		60		073
	12	8799	240 11		84		058
	13	8945	27	0·000 02	153 07	0·000 03	044
	24	9090	43		31		029
	25	9236	58		54		015
	36	9381	74		77		000
69	1	9527	90		154 01		39·985
	12	9672	241 05		24		971
	13	9818	21		48		956
	24	9962	37		71		941
	25	55°·0109	53		95		927
	36	0253	68		155 18		912
70	1	0400	84		42		898
	12	0544	242 00		65		883
	13	0691	16		89		868
	24	0835	31		156 12		854
	25	0982	47		36		839
	36	1126	63		59		{ 39·824 / 40·177
71	1	1274	79		83		163
	12	1417	95		157 06		148
	13	1563	243 11		30		133
	24	1708	26		53		118
	25	1854	42		77		104
	36	1999	58		158 00		089
72	1	2145	74		24		074
	12	2290	90		47		059
	13	2436	244 06		71		044
	24	2581	22		94		030
	25	2727	38		159 18		015
	36	2872	53		41		000

TABLE V.—*Continued.*

LATITUDE, with Logarithms, of Secant and Tangent, for each Section and width of Quarter-Sections.

Township.	Section.	Latitude.	Sec. ϕ	Difference for 10 chains.	Tan. ϕ	Difference for 10 chains.	Quarter-Section.
73	1	55°.3018	0·244 69		0·159 65		39·985
	12	3163	85		89		970
	13	3309	245 01		160 12		956
	24	3454	17		36		941
	25	3600	33		59		926
	36	3744	49		83		911
74	1	3891	65		161 07		896
	12	4035	81		30		881
	13	4182	97		54		867
	24	4326	246 13		77		852
	25	4473	29		162 01		837
	36	4617	45		24		{ 39·822 / 40·180
75	1	4764	61		48		165
	12	4908	77		72		150
	13	5054	93		95		135
	24	5199	247 09		163 19		120
	25	5345	25		43		105
	36	5490	41		66		090
76	1	5636	57		90		075
	12	5781	73		164 13		060
	13	5927	90		37		045
	24	6072	248 06		61		030
	25	6218	22	0·000 02	85	0·000 03	015
	36	6363	38		165 08		000
77	1	6509	54		32		39·985
	12	6654	70		55		970
	13	6800	86		79		955
	24	6944	249 02		166 03		940
	25	7091	19		27		925
	36	7235	35		50		910
78	1	7382	51		74		895
	12	7526	67		98		880
	13	7672	83		167 21		865
	24	7817	250 00		45		850
	25	7963	16		69		835
	36	8108	32		92		{ 39·820 / 40·182
79	1	8254	48		168 16		167
	12	8399	64		40		152
	13	8545	81		64		137
	24	8690	97		87		122
	25	8836	251 13		169 11		106
	36	8981	30		35		091
80	1	9127	46		59		076
	12	9272	62		82		061
	13	9418	79		170 06		046
	24	9562	95		30		030
	25	9709	252 11		54		015
	36	9853	27		77		000

TABLE V.—*Concluded.*

LATITUDE, with Logarithms, of Secant and Tangent, for each Section and width of Quarter-Sections.

Township.	Section.	Latitude.	Sec. ϕ	Difference for 10 chains.	Tan. ϕ	Difference for 10 chains.	Quarter-Section.
81	1	56°.0000	0·252 44		0·171 01		39 985
	12	0144	60		25		970
	13	0291	77		49		954
	24	0435	93		72		939
	25	0581	253 09		96		924
	36	0726	26	02	172 20	03	909
82	1	0872	42	0·000	44	0·000	893
	12	1017	58		68		878
	13	1163	75		92		863
	24	1308	91		173 15		848
	25	1454	254 08		39		833
	36	1599	24		63		{ 39·817 / 40·185

TABLE VI for finding the Pole Star.

Degrees & decimals

Hour Angle.	Azimuth. Tp. 0	Tp. 10	Tp. 20	Tp. 30	Tp. 40	Tp. 50	Tp. 60	Tp. 70	Tp. 80	Distance above or below Pole.	Hour Angle.
H.M.	°										H.M.
0.10	0·09	0·09	0·09	0·09	0·09	0·09	0·09	0·10	0·10	1·32	11.50
0.20	·18	·18	·18	·19	·19	·19	·20	·20	·21	·32	11.40
0 30	·26	·27	·27	·28	·28	·29	·30	·30	·31	·31	11.30
0.40	·35	·36	·36	·37	·38	·38	·39	·40	·41	·30	11.20
0.50	·44	·45	·46	·47	·47	·48	·49	·50	·51	·29	11.10
1.00	·52	·53	·54	·55	·56	·57	·59	·60	·61	·28	11.00
1.10	·61	·62	·63	·64	·65	·67	·68	·70	·71	·26	10.50
1.20	·69	·70	·71	·73	·74	·75	·77	·79	·81	·24	10.40
1.30	·77	·78	·80	·81	·83	·85	·87	·89	·91	·22	10.30
1.40	·85	·87	·88	·90	·92	·94	·96	·98	1·00	·20	10.20
1 50	·93	·95	·96	·98	1.00	1·02	1·05	1·07	·09	·17	10.10
2.00	1·01	1·02	1·04	1·06	·08	·11	·13	·16	·18	·14	10.00
2.10	·08	·10	·12	·14	·17	·19	·22	·24	·27	·11	9.50
2.20	·15	·18	20	·22	·24	·27	·30	·33	·36	·08	9.40
2.30	·22	·25	·27	·30	·32	·35	·38	·41	·44	·05	9.30
2.40	·29	·32	·34	·37	·39	·42	·45	·49	·52	·01	9.20
2.50	·36	·38	·41	·44	·47	·50	·53	·56	·60	0·97	9.10
3.00	·42	·45	·48	·50	·53	·57	·60	·64	·67	·93	9.00
3.10	·48	·51	·54	·57	·60	·63	·67	·70	·74	·89	8.50
3.20	·54	·57	·60	·63	·66	·70	·73	·77	·81	·85	8.40
3.30	·60	·63	66	·69	·72	·76	·80	·84	·88	·80	8.30
3.40	·65	·68	·71	·74	·78	·81	·85	·89	·94	·76	8.20
3.50	·70	·73	·76	·79	·83	·87	·91	·95	·99	·71	8.10
4.00	·74	·77	·81	·84	·88	·92	·96	2·00	2·05	·66	8.00
4.10	·78	·82	·85	·89	·92	·96	2·01	·05	·10	·61	7.50
4.20	·82	·86	·89	·93	·97	2·01	·05	·10	·14	·56	7.40
4.30	·86	·89	·93	·97	2·01	·05	·09	·14	·19	·51	7.30
4.40	·89	·92	·96	2·00	·04	·08	·13	·17	·22	·45	7.20
4.50	·92	·95	·99	·03	·07	·11	·16	·21	·26	·40	7.10
5.00	·94	·98	2·02	·06	·10	·14	·19	·23	·28	·34	7.00
5.10	·96	2·00	·04	·08	·12	·16	·21	·26	·31	·29	6.50
5.20	·98	·02	·06	·10	·14	·18	·23	·28	·33	·23	6.40
5.30	2·00	·03	·07	·11	·15	·20	·24	·29	·35	·17	6.30
5.40	·01	·04	·08	·12	·16	·21	·25	·30	·36	·12	6.20
5.50	·01	·05	·09	·13	·17	·21	·26	·31	·36	·06	6.10
6.00	·01	·05	·09	·13	·17	·21	·26	·31	·37	·00	6.00

TABLE VII.—For finding the Time by transits across the vertical of Polaris.

$t-t'$		Declination North.													$t-t'$	
		0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°		
H.	M.														H.	M.
0 or 12	10	1·13925	1·14019	1·14114	1·14176	1·14301	1·14395	1·14489	1·14613	1·14768	1·14922	1·15106	1·15320	1·15625	11 or 23	50
	20	·43996	·44091	·44170	·44264	·44358	·44451	·44560	·44685	·44824	·44979	·45163	·45393	·45682		40
	30	·61542	·61627	·61721	·61805	·61899	·62003	·62107	·62232	·62366	·62521	·62706	·62931	·63225		30
	40	·73933	·74020	·74107	·74194	·74288	·74390	·74500	·74617	·74749	·74904	·75089	·75312	·75603		20
	50	·83506	·83588	·83677	·83765	·83860	·83954	·84067	·84180	·84317	·84466	·84652	·84874	·85163		10
1 or 13	00	1·91270	1·91355	1·91440	1·91529	1·91619	1·91719	1 91824	1·91939	1·92070	1·92226	1·92402	1·92624	1·92906	11 or 23	00
	10	·97782	·97864	·97950	·98046	·98127	·98223	·98327	·98444	·98574	·98722	·98900	·99118	·99401	10 or 22	50
	20	2·03375	2·03455	2·03539	2·03627	2·03715	2·03810	2·03914	2·04025	2·04155	2·04301	2·04477	2·04693	2·04969		40
	30	·08254	·08332	·08415	·08500	·08586	·08682	·08782	·08895	·09019	·09167	·09339	·09552	·09823		30
	40	·12564	·12643	·12723	·12808	·12892	·12985	·13085	·13194	·13316	·13459	·13628	·13836	·14101		20
	50	·16412	·16489	·16566	·16649	·16732	·16823	·16921	·17026	·17149	·17286	·17452	·17658	·17918		10
2 or 14	00	2·19866	2·19943	2·20016	2·20096	2·20181	2·20268	2·20363	2·20466	2·20586	2·20721	2·20884	2·21082	2·21338	10 or 22	00
	10	·22991	·23065	·23139	·23215	·23297	·23381	·23475	·23575	·23697	·23825	·23982	·24178	·24425	9 or 21	50
	20	·25828	·25900	·25971	26045	·26124	·26207	·26298	·26397	·26507	·26637	·26793	·26980	·27221		40
	30	·28414	·28484	·28554	·28625	·28702	·28782	·28868	·28966	·29072	·29199	·29347	·29531	·29763		30
	40	·30775	·30841	·30910	·30980	·31052	·31131	·31214	·31306	·31412	·31534	·31677	·31854	·32079		20
	50	·32938	·33003	·33068	·33135	·33205	·33280	·33361	·33449	·33552	·33668	·33806	·33977	·34193		10
3 or 15	00	2·34918	2·34980	2·35042	2·35106	2·35174	2·35247	2·35324	2·35409	2·35507	2·35618	2·35751	2·35916	2·36124	9 or 21	00
	10	·36732	·36791	·36851	·36912	·36977	·37046	·37120	·37201	·37295	·37401	·37528	·37685	·37883	8 or 20	50
	20	·38394	·38449	·38507	·38566	·38627	·38693	·38762	·38841	·38929	·39032	·39151	·39301	·39491		40
	30	·39915	·39969	·40023	·40078	·40137	·40199	·40264	·40339	·40422	·40520	·40634	·40775	·40955		30
	40	·41306	·41357	·41407	·41459	·41514	·41572	·41636	·41706	·41783	·41875	·41984	·42116	·42287		20
	50	·42572	·42619	·42665	·42714	·42767	·42820	·42880	·42945	·43022	·43104	·43206	·43331	·43491		10
4 or 16	00	2·43722	2·43767	2·43810	2·43856	2·43905	2·43955	2·44010	2·44070	2·44140	2·44218	2·44314	2·44430	2·44579	8 or 20	00
	10	·44762	·44803	·44843	·44886	·44929	·44977	·45028	·45083	·45148	·45220	·45307	·45415	·45553	7 or 19	50
	20	·45697	·45734	·45772	·45818	·45850	·45894	·45941	·45992	·46050	·46117	·46197	·46295	·46421		40
	30	·46529	·46562	·46597	·46634	·46668	·46708	·46749	·46796	·46849	·46911	·46982	·47071	·47186		30
	40	·47268	·47297	·47328	·47360	·47392	·47428	·47465	·47506	·47554	·47608	·47673	·47753	·47856		20
	50	·47911	·47937	·47965	·47995	·48021	·48051	·48084	·48122	·48163	·48210	·48267	·48337	·48429		10
5 or 17	00	2·48462	2·48486	2·48508	2·48533	2·48557	2·48583	2·48612	2·48643	2·48678	2·48721	2·48769	2·48830	2·48907	7 or 19	00
	10	·48927	·48946	·48966	·48985	·49006	·49028	·49052	·49077	·49108	·49142	·49184	·49234	·49300	6 or 18	50
	20	·49304	·49319	·49335	·49350	·49367	·49385	·49405	·49425	·49449	·49477	·49510	·49550	·49603		40
	30	·49596	·49607	·49620	·49631	·49643	·49657	·49671	·49687	·49706	·49726	·49751	·49782	·49821		30
	40	·49803	·49811	·49818	·49827	·49835	·49844	·49853	·49864	·49876	·49890	·49907	·49927	·49954		20
	50	·49927	·49931	·49935	·49938	·49944	·49948	·49952	·49958	·49965	·49972	·49979	·49989	·50003		10

6 or 18	00	2·49969	2·49969	2·49969	2·49969	2·49969	2·49969	2·49969	2·49969	2·49969	2·49969	2·49969	2·49969	2·49969	6 or 18	00
	10	·49927	·49923	·49919	·49917	·49911	·49907	·49903	·49897	·49890	·49883	·49875	·49865	·49852	5 or 17	50
	20	·49803	·49795	·49789	·49780	·49772	·49763	·49754	·49742	·49730	·49717	·49700	·49679	·49652		40
	30	·49596	·49585	·49572	·49561	·49549	·49535	·49521	·49505	·49486	·49465	·49440	·49410	·49370		30
	40	·49304	·49289	·49273	·49258	·49241	·49223	·49203	·49182	·49158	·49130	·49097	·49056	·49003		20
	50	·48927	·48908	·48889	·48869	·48848	·48826	·48802	·48776	·48745	·48711	·48668	·48618	·48551		10
7 or 19	00	2·48462	2·48440	2·48417	2·48393	2.48369	2·48341	2 48313	2·48281	2·48245	2·48203	2·48154	2·48093	2·48014	5 or 17	00
	10	·47911	·47885	·47858	·47828	·47802	·47771	·47738	·47701	·47659	·47611	·47553	·47481	·47388	4 or 16	50
	20	·47268	·47239	·47208	·47176	·47144	·47108	·47070	·47029	·46981	·46926	·46860	·46779	·46673		40
	30	·46529	·46497	·46463	·46426	·46390	·46351	·46309	·46261	·46209	·46146	·46072	·45980	·45862		30
	40	·45697	·45661	·45623	·45583	·45543	·45500	·45452	·45400	·45342	·45274	·45192	·45091	·44961		20
	50	·44762	·44722	·44682	·44638	·44595	·44546	·44495	·44439	·44373	·44300	·44211	·44099	·43957		10
8 or 20	00	2·43722	2·43678	2·43635	2·43589	2·43540	2·43489	2·43433	2·43372	2·43302	2·43222	2·43123	2·43005	2·42849	4 or 16	00
	10	·42572	·42524	·42477	·42428	·42376	·42322	·42261	·42195	·42116	·42032	·41927	·41799	·41633	3 or 15	50
	20	·41306	·41256	·41207	·41154	·41098	·41039	·40974	·40904	·40824	·40730	·40618	·40481	·40303		40
	30	·39915	·39861	·39808	·39752	·39693	·39630	·39564	·39487	·39403	·39303	·39185	·39039	·38851		30
	40	·38394	·38339	·38281	·38222	·38161	·38093	·38023	·37944	·37853	·37747	·37623	·37468	·37269		20
	50	·36732	·36672	·36613	·36551	·36485	·36416	·36340	·36257	·36162	·36051	·35921	·35757	·35549		10
9 or 21	00	2·34918	2·34856	2·34794	2·34729	2·34661	2·34587	2·34508	2·34422	2·34321	2·34207	2·34068	2·35897	2·33678	3 or 15	00
	10	·32938	·32873	·32807	·32746	·32669	·32593	·32510	·32420	·32315	·32195	·32052	·31873	·31645	2 or 14	50
	20	·30775	·30709	·30641	·30570	·30496	·30417	·30333	·30237	·30129	·30003	·29855	·29669	·29432		40
	30	·28414	·28344	·28274	·28201	·28124	·28042	·27955	·27854	·27745	·27614	·27460	·27268	·27021		30
	40	·25828	·25756	·25684	·25610	·25529	·25445	·25353	·25251	·25137	·25003	·24841	·24645	·24388		20
	50	·22991	·22917	·22843	·22766	·22683	·22598	·22502	·22398	·22275	·22141	·21977	·21772	·21508		10
10 or 22	00	2·19866	2·19789	2·19714	2·19634	2·19549	2·19459	2·19362	2·19257	2·19134	2·18994	2·18822	2·18614	2·18341	2 or 14	00
	10	·16412	·16334	·16256	·16173	·16089	·15996	·15897	·15788	·15661	·15518	·15345	·15128	·14851	1 or 13	50
	20	·12564	·12486	·12405	·12320	·12235	·12139	·12037	·11926	·11800	·11651	·11474	·11254	·10972		40
	30	·08254	·08175	·08092	·08005	·07918	·07820	·07718	·07602	·07475	·07220	·07140	·06915	06625		30
	40	2·03375	2·03294	2·03209	2·03121	2·03032	2·02934	2·02829	2·02715	2·02580	2·02428	2·02243	2·02015	2·01720		20
	50	1·97782	1·97699	1·97612	1·97516	1·97433	1·97336	1·97230	1·97109	1·96974	1·96820	1·96633	1·96402	1·96099		10
11 or 23	00	1·91270	1 91185	1·91100	1·91009	1·90918	1·90816	1·90709	1·90590	1·90455	1·90293	1 90108	1·89873	1·89570	1 or 13	00
	10	·83506	·83423	·83334	·83245	·83149	·83046	·82937	·82821	·82679	·82523	·82393	·82092	·81783	0 or 12	50
	20	·73933	·73846	·73759	·73672	·73576	·73472	·73360	·73239	·73102	·72941	·72746	·72509	·72198		40
	30	·61542	·61458	·61363	·61278	·61183	·61077	·60970	·60842	·60703	·60541	·60347	·60108	·59791		30
	40	·43996	·43902	·43823	·43727	·43632	·43537	·43425	·43297	·43152	·42991	·42797	·42553	·42243		20
	50	·13925	·13830	·13735	·13672	·13545	·13450	·13354	·13226	·13066	·12905	·12710	·12483	·12156		10
		0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°		

Declination South.

TABLE VIII.

For Converting Chains into Decimals of a Township side.

Chains.	Equivalent decimal of a Township side.		Chains.	Equivalent decimal of a Township side.		Chains.	Equivalent decimal of a Township side.	
	N. or S. side.	E. or W. side.		N. or S. side.	E. or W. side.		N. or S. side.	E. or W. side.
1	·00206	·00207	9	·01852	·01863	70	·14403	·14493
2	·00412	·00414				80	·16461	·16563
3	·00617	·00621	10	·02058	·02070	90	·18518	·18634
4	·00823	·00828	20	·04115	·04141			
			30	·06173	·06211	100	·20576	·20704
5	·01029	·01035	40	·08230	·08282	200	·41152	·41408
6	·01235	·01242				300	·61728	·62112
7	·01440	·01449	50	·10288	·10352	400	·82304	·82816
8	·01646	·01656	60	·12346	·12422			

TABLE IX.

Correction to width of Road Allowance on Correction Lines.

Jog in Chains.	Number of Correction Line.				Jog in Chains.	Number of Correction Line.			
	1	11	21	31		1	11	21	31
10	0·9	1·0	1·1	1·3	70	5·3	6·0	6·8	7·8
20	1·7	1·9	2·2	2·5	80	5·9	6·7	7·6	8·7
30	2·5	2·8	3·2	3·7	90	6·5	7·3	8.4	9·5
40	3·3	3·7	4·2	4·8	100	7·0	8·0	9·0	10·3
50	4·0	4·5	5·1	5 8	110	7·5	8·5	9·7	11·1
60	4·7	5·3	6·0	6·8	120	8·0	9.1	10·3	11·8

TABLE X.

For Converting the Logarithm Tangent of Small Arcs into Logarithm of Seconds of Arc.

Log. tan.	Log. T.	Log. tan.	Log. T.	Log. tan.	Log. T.
7·920	5·314 42	8·419	5·314 33	8·547	5·314 25
8·071	41	·440	32	·558	24
·157	40	·459	31	·570	23
·221	39	·477	30	·581	22
·269	38	·493	29	·591	21
·309	37	·508	28	·601	20
·342	36	·521	27	·610	19
·371	35	·535	26	·619	18
·396	34				

TABLE XI

Showing the Deflection of a Trial Line for Deviations from 1 to 149 links at the end of eighty-one chains.

Links.	Decimal Division.	Sexagesimal Division.	Links.	Decimal Division.	Sexagesimal Division.	Links.	Decimal Division.	Sexagesimal Division.	Links.	Decimal Division.	Sexagesimal Division.	Links.	Decimal Division.	Sexagesimal Division.
	°	′ ″		°	′ ″		°	′ ″		°	′ ″		°	′ ″
0	0·000	0 00	30	0·212	12 44	60	0·424	25 28	90	0·637	38 12	120	0·849	50 55
1	·007	25	31	·219	13 09	61	·432	53	91	·644	37	121	·856	51 21
2	·014	51	32	·226	35	62	·439	26 19	92	·651	39 03	122	·863	46
3	·021	1 16	33	·233	14 00	63	·446	44	93	·658	28	123	·870	52 12
4	·028	42	34	·241	26	64	·453	27 10	94	·665	54	124	·877	37
5	·035	2 07	35	·248	51	65	·460	35	95	·672	40 19	125	·884	53 03
6	·042	33	36	·255	15 17	66	·467	28 01	96	·679	44	126	·891	28
7	·050	58	37	·262	42	67	·474	26	97	·686	41 10	127	·898	54
8	·057	3 24	38	·269	16 08	68	·481	52	98	·693	35	128	·905	54 19
9	·064	49	39	·276	33	69	·488	29 17	99	·700	42 01	129	·912	45
10	·071	4 15	40	·283	59	70	·495	43	100	·707	26	130	·919	55 10
11	·078	40	41	·290	17 24	71	·502	30 08	101	·714	52	131	·927	35
12	·085	5 06	42	·297	50	72	·509	33	102	·721	43 17	132	·934	56 01
13	·092	31	43	·304	18 15	73	·516	59	103	·729	43	133	·941	26
14	·099	57	44	·311	41	74	·523	31 24	104	.736	44 08	134	·948	52
15	·106	6 22	45	·318	19 06	75	·531	50	105	·743	34	135	·955	57 17
16	·113	47	46	·325	31	76	·538	32 15	106	·750	59	136	·962	43
17	·120	7 13	47	·332	57	77	·545	41	107	·757	45 24	137	·969	58 08
18	·127	38	48	·340	20 22	78	·552	33 06	108	·764	50	138	·976	34
19	·134	8 03	49	·347	48	79	·559	32	109	·771	46 15	139	·983	59
20	·141	29	50	·354	21 13	80	·566	57	110	·778	41	140	·990	59 25
21	·149	55	51	·361	39	81	·573	34 23	111	·785	47 06	141	·997	50
22	·156	9 20	52	·368	22 04	82	·580	48	112	·792	32	142	1·004	60 16
23	·163	46	53	·375	30	83	·587	35 13	113	·799	57	143	·011	41
24	·170	10 11	54	·382	55	84	·594	39	114	·806	48 23	144	·018	61 06
25	·177	37	55	·389	23 21	85	·601	36 04	115	·813	48	145	·026	32
26	·184	11 02	56	·396	46	86	·608	30	116	·820	49 14	146	·033	57
27	·191	28	57	·403	24 12	87	·615	55	117	·828	39	147	·040	62 23
28	·198	53	58	·410	37	88	·622	37 21	118	·835	50 05	148	·047	48
29	·205	12 19	59	·417	25 02	89	·630	46	119	·842	30	149	·054	63 39

TABLE XII.

Addition and Subtraction Logarithms.

A.	0	1	2	3	4	5	6	7	8	9	A.
5·0	B0·0 0000	0001	0001	0001	0001	0001	0002	0002	0003	0003	5·0
6 0	0 0 0004	0004	0005	0005	0005	0005	0005	0005	0005	0005	6 0
1	0005	0006	0006	0006	0006	0006	0006	0006	0007	0007	1
2	0007	0007	0007	0007	0008	0008	0008	0008	0008	0008	2
3	0009	0009	0009	0009	0010	0010	0010	0010	0010	0011	3
4	0011	0011	0011	0012	0012	0012	0013	0013	0013	0013	4
5	0014	0014	0014	0015	0015	0015	0016	0016	0017	0017	5
6	0017	0018	0018	0019	0019	0019	0020	0020	0021	0021	6
7	0022	0022	0023	0023	0024	0024	0025	0026	0026	0027	7
8	0027	0028	0029	0029	0030	0031	0031	0032	0033	0034	8
9	0034	0035	0036	0037	0038	0039	0040	0041	0041	0042	9
7·0	0.0 0043	0044	0045	0047	0048	0049	0050	0051	0052	0053	7·0
1	0055	0056	0057	0059	0060	0061	0063	0064	0066	0067	1
2	0069	0070	0072	0074	0075	0077	0079	0081	0083	0085	2
3	0087	0089	0091	0093	0095	0097	0099	0102	0104	0106	3
4	0109	0111	0114	0117	0119	0122	0125	0128	0131	0134	4
5	0137	0140	0144	0147	0150	0154	0157	0161	0165	0169	5
6	0173	0177	0181	0185	0189	0194	0198	0203	0207	0212	6
7	0217	0222	0227	0233	0238	0244	0249	0255	0261	0267	7
8	0273	0280	0286	0293	0299	0306	0313	0321	0328	0336	8
9	0344	0352	0360	0368	0377	0385	0394	0403	0413	0422	9
8·00	0·0 0432	0433	0434	0435	0436	0437	0438	0439	0440	0441	8·00
01	0442	0443	0444	0445	0446	0447	0448	0449	0450	0451	01
02	0452	0453	0454	0456	0457	0458	0459	0460	0461	0462	02
03	0463	0464	0465	0466	0467	0468	0469	0470	0471	0473	03
04	0474	0475	0476	0477	0478	0479	0480	0481	0482	0483	04
05	0485	0486	0487	0488	0489	0490	0491	0492	0494	0495	05
06	0496	0497	0498	0499	0500	0502	0503	0504	0505	0506	06
07	0507	0508	0510	0511	0512	0513	0514	0515	0517	0518	07
08	0519	0520	0521	0523	0524	0525	0526	0527	0529	0530	08
09	0531	0532	0533	0535	0536	0537	0538	0540	0541	0542	09
8·10	0·0 0543	0545	0546	0547	0548	0550	0551	0552	0553	0555	8·10
11	0556	0557	0558	0560	0561	0562	0564	0565	0566	0567	11
12	0569	0570	0571	0573	0574	0575	0577	0578	0579	0581	12
13	0582	0583	0585	0586	0587	0589	0590	0591	0593	0594	13
14	0595	0597	0598	0599	0601	0602	0604	0605	0606	0608	14
15	0609	0611	0612	0613	0615	0616	0618	0619	0620	0622	15
16	0623	0625	0626	0628	0629	0630	0632	0633	0635	0636	16
17	0638	0639	0641	0642	0644	0645	0646	0648	0649	0651	17
18	0652	0654	0655	0657	0658	0660	0661	0663	0664	0666	18
19	0667	0669	0671	0672	0674	0675	0677	0678	0680	0681	19
8·20	0 0 0683	0684	0686	0688	0689	0691	0692	0694	0696	0697	8·20
21	0699	0700	0702	0703	0705	0707	0708	0710	0712	0713	21
22	0715	0716	0718	0720	0721	0723	0725	0726	0728	0730	22
23	0731	0733	0735	0736	0738	0740	0741	0743	0745	0747	23
24	0748	0750	0752	0753	0755	0757	0759	0760	0762	0764	24
25	0766	0767	0769	0771	0773	0774	0776	0778	0780	0781	25
26	0783	0785	0787	0789	0790	0792	0794	0796	0798	0799	26
27	0801	0803	0805	0807	0809	0810	0812	0814	0816	0818	27
28	0820	0822	0823	0825	0827	0829	0831	0833	0835	0837	28
29	0839	0841	0842	0844	0846	0848	0850	0852	0854	0856	29

TABLE XII.—Addition and Subtraction Logarithms.—*Concluded.*

A.	0	1	2	3	4	5	6	7	8	9	A.
8·30	B0·0 0858	0860	0862	0864	0866	0868	0870	0872	0874	0876	8·30
31	0878	0880	0882	0884	0886	0888	0890	0892	0894	0896	31
32	0898	0900	0902	0904	0906	0908	0910	0912	0915	0917	32
33	0919	0921	0923	0925	0927	0929	0931	0933	0936	0938	33
34	0940	0942	0944	0946	0948	0951	0953	0955	0957	0959	34
35	0962	0964	0966	0968	0970	0973	0975	0977	0979	0981	35
36	0984	0986	0988	0990	0993	0995	0997	0999	1002	1004	36
37	1006	1009	1011	1013	1016	1018	1020	1022	1025	1027	37
38	1030	1032	1034	1037	1039	1041	1044	1046	1048	1051	38
39	1053	1056	1058	1060	1063	1065	1068	1070	1073	1075	39
8·40	0·0 1077	1080	1082	1085	1087	1090	1092	1095	1097	1100	8·40
41	1102	1105	1107	1110	1112	1115	1117	1120	1122	1125	41
42	1128	1130	1133	1135	1138	1140	1143	1146	1148	1151	42
43	1153	1156	1159	1161	1164	1167	1169	1172	1175	1177	43
44	1180	1183	1185	1188	1191	1193	1196	1199	1202	1204	44
45	1207	1210	1213	1215	1218	1221	1224	1226	1229	1232	45
46	1235	1238	1240	1243	1246	1249	1252	1255	1257	1260	46
47	1263	1266	1269	1272	1275	1278	1280	1283	1286	1289	47
48	1292	1295	1298	1301	1304	1307	1310	1313	1316	1319	48
49	1322	1325	1328	1331	1334	1337	1340	1343	1346	1349	49
8·50	0·0 1352	1355	1358	1361	1364	1368	1371	1374	1377	1380	8·50
51	1383	1386	1389	1393	1396	1399	1402	1405	1408	1412	51
52	1415	1418	1421	1424	1428	1431	1434	1437	1441	1444	52
53	1447	1450	1454	1457	1460	1464	1467	1470	1474	1477	53
54	1480	1484	1487	1490	1494	1497	1501	1504	1507	1511	54
55	1514	1518	1521	1525	1528	1531	1535	1538	1542	1545	55
56	1549	1552	1556	1559	1563	1566	1570	1574	1577	1581	56
57	1584	1588	1591	1595	1599	1602	1606	1610	1613	1617	57
58	1621	1624	1628	1632	1635	1639	1643	1646	1650	1654	58
59	1658	1661	1665	1669	1673	1676	1680	1684	1688	1692	59
8·60	0·0 1695	1699	1703	1707	1711	1715	1719	1722	1726	1730	8·60

TABLE XIII.

Correction for Refraction to be applied to the Sun's Polar Distance when using Solar Instruments.

LATITUDE 49°

Sun's Hour Angle.	Sun's Declination. North. 25°	20°	15°	10°	5°	0°	Sun's Declination. South. 5°	10°	15°	20°	25°	Sun's Hour Angle.
h. m.	′	′	′	′	′	′	′	′	′	′	′	h. m.
0 00	0·4	0·5	0·7	0·8	1·0	1·2	1 4	1·7	2 1	2·6	3·5	0 00
1 00	0·5	0·6	0·7	0·8	1 0	1·2	1·4	1·8	2·2	2·8	3·7	1 00
2 00	0·5	0·7	0·8	0·9	1·1	1·3	1 6	2 0	2·5	3·3	4·7	2 00
2 30	0·6	0·7	0·9	1·0	1·2	1·5	1·8	2·2	2·8	3·9	6·0	2 30
3 00	0·7	0·8	1·0	1·1	1·4	1·7	2·0	2·6	3·4	4·9	8·8	3 00
3 30	0·8	0·9	1·1	1·3	1·6	1·9	2·4	3·2	4·4	7·3		3 30
4 00	0·9	1·1	1·3	1·5	1·9	2·3	3·0	4·2	6·8			4 00
4 30	1·1	1·3	1·5	1·9	2·4	3·0	4·3	6 9				4 30
5 00	1·3	1·6	1·9	2·4	3·2	4·5	7·7					5 00
5 30	1·6	2·0	2·5	3·4	5·0	8·8						5 30
6 00	2·1	2·7	3·6	5·4								6 00
6 30	3·0	4·2	6·6									6 30

LATITUDE 54°

0 00	0 5	0·6	0·8	0·9	1·1	1·3	1·6	1·9	2·5	3·3	5·0	0 00
1 00	0·6	0·7	0·8	1·0	1·1	1·4	1·7	2·0	2·6	3·6	5·5	1 00
2 00	0 6	0·7	0·9	1·1	1·3	1·5	1·9	2·3	3·1	4·5	7·9	2 00
2 30	0·7	0·8	1·0	1·1	1·4	1·7	2·0	2·6	3·5	5·5		2 30
3 00	0·7	0·9	1·0	1·2	1·5	1·8	2·3	3·0	4·3	7·5		3 00
3 30	0·8	1·0	1 2	1·4	1·7	2·2	2·8	3·8	6·1			3 30
4 00	0·9	1 1	1·4	1·6	2 0	2·6	3·6	5·4				4 00
4 30	1 1	1·3	1·6	2·0	2·5	3·4	5·1					4 30
5 00	1·3	1·6	2·0	2·5	3·4	5·0						5 00
5 30	1·6	2·0	2·5	3·4	5·1							5 30
6 00	2·1	2·7	3·6	5·4								6 00
6 30	2·7	3·6	5 5									6 30