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Memorandum
to accompany Instructions for the
Survey of Standard Meridians and Parallels forming
the outline of
Blocks of Sixteen Townships.
31 Dec. 1879

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1879

ANNUAL REPORT

OF THE

DEPARTMENT OF THE INTERIOR

FOR THE

YEAR ENDED 30TH JUNE,

1879.

Printed by Order of Parliament.

OTTAWA:
PRINTED BY MACLEAN, ROGER & Co., WELLINGTON STREET.
1880.

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PART I

OF

REPORT OF DEPARTMENT OF INTERIOR.

DEPARTMENT OF THE INTERIOR,
DOMINION LANDS OFFICE,
OTTAWA, 31st December, 1879.

To the Right Honorable
SIR JOHN A. MACDONALD, K.C.B.,
Minister of the Interior.

SIR,—I have the honor to submit the following Report upon the work of this branch of your Department during the twelve months ending the 31st October last, also, where the information might be useful or of interest, on the operations of its outside service, to the close of the calendar year.

DOMINION LANDS.

The returns from the Central Office at Winnipeg, and the different outside agencies in Manitoba and the North-West Territory, show a large proportionate increase in the rate of settlement and purchase of these lands.

The entries were for the year, to 31st October, as follows:—

	ENTRIES.	ACRES.
Homesteads	3,876	600,797
Pre-emptions	1,729	269,178
Forest Tree Culture	192	31,040
Sales	877	233,862
Bounty Warrants	108	19,195
	6,782	1,154,072

The comparative statement for the past five years will stand thus:—

	ENTRIES.	ACRES.
1875	1,021	163,277
1876	807	153,535
1877	2,283	400,423
1878	4,065	682,591
1879	6,782	1,154,072

The receipts since the last Annual Report are as follows:—

Homestead fees	$38,760 00
Pre-emption fees	4,150 00
Tree culture entries	1,920 00
Sales for cash	9,154 00
Sales for scrip and bounty warrants	209,255 00
Total	$263,239 00

ORDNANCE LANDS.

The appended schedules, prepared and signed by Mr. William Mills, the Accountant, are similar to those previously annually given. They consist of:—

A. A statement of sales during the year, amounting to $5,517.31.

B. Showing the receipts from Ordnance lands for the year, arranged according to the locality in which they are situated, the total amount being $40,849.56.

C. Is the same as the preceding but in more detail, and arranged in the form of an abstract of monthly returns or cash accounts, dividing the receipts into the three classes of principal, rent or interest and fees, and indicating in what branch of the Bank of Montreal the moneys were deposited.

D. Is a statement of the indebtedness of purchasers or lessees of Ordnance lands, arranged according to locality, and indicating amounts overdue remaining unpaid: and those not yet fallen due, but to be paid to complete purchases; the former being classified according to their nature as capital instalments or as interests and rents. The totals would stand thus:—

Payments in arrear.....	$109,268 01
Payments not yet due.....	85,094 00
Total indebtedness of purchasers or lessees.	$194,362 01

The principal lands remaining that may be sold are, in Ontario, at Kingston and Prescott, and in the Province of Quebec, at Montreal, Quebec, St. John, South River, Blairfindie and Sorel, besides small lots scattered throughout both Provinces.

It is respectfully suggested that measures be taken to secure the collection of at least the rentals and interest due on lands held under lease, and on instalments of purchase moneys. Notifications of the risk of cancellation incurred by non-payment have failed to produce the desired result. The immediate cancellation of sale or lease in those cases where there has been the most flagrant disregard of indebtedness to the Government, or of any official notice given in relation thereto, would have a wholesome effect on the remaining number, and tend to prevent the further accumulation of an arrear that has been steadily increasing during several years past in the collection of a valuable revenue. Such action is at the present time the more called for, in that the existing position in this respect, of purchasers and lessees of Ordnance lands, would form an undesirable precedent and example for those obtaining lands under the system of time purchase lately inaugurated for the disposal of the reserves set apart for the purposes of the Canadian Pacific Railway, any unpunctuality in the payments for which would tend to defeat the object with which the reservation was made.

The opinion is ventured that if in this matter the same powers of enforcing payments were accorded to all subordinate officers or agents that are, in like case, vested in officials whose duty it is to collect the Customs revenues or those of direct taxation, and that they were similarly held responsible for the due collection of such payments, benefit to the general revenue could not fail to accrue.

When subordinates are not thus responsible, it is much easier, more pleasant for them, to refrain from exercising even the little stringency that may be within their competence, and to confine themselves to reporting delinquencies when ordered by those in authority to do so.

Of the lands belonging to the estate of the Bank of Upper Canada, and under the supervision of this branch of your Department, no sales were made during the past year, but $2,887.46 was received on account of sales of previous years.

III. SURVEYS.

The number of townships subdivided in the year was 51, covering an area of 1,191,000 acres. They were surveyed under the inspection of Mr. Milner Hart, Inspector of Surveys.

Of standard meridians and parallels for block outlines, a total length of 875 miles was surveyed.

Schedule E. appended hereto, indicates for both subdivision and outline work, the name of the surveyor employed, and the locality of his survey.

The reports received up to the present time from the outline surveyors are also appended. Three of these latter, however, viz: Messrs. Webb, O'Hanly and Beatty, have not yet handed in their final reports, but are daily expected to do so.

As in every former year, the surveys made during the past season go to show that previously held estimates of quantities of first-class arable land in any given part of the territory, have been within the mark. Districts hitherto roughly classified as inferior, prove to be but partly so, and those defined as fertile areas, have their limits more extended the fuller our information becomes. As a particular instance may be cited the so-called "infertile lands of the Souris," the basin of that river having been supposed to include little else than sandy plains, broken by ridges of shale or gravel, and beyond its deposits of lignite coal, to possess but scanty resources, and to give but little promise as a field for settlement. But, as the writer who first used the expression warningly states, the generalization of infertility is by no means to be too sweepingly applied. The term would be altogether incorrect if used to qualify the country on the lower part of the river's course, the returns of both outline and subdivision surveys showing that of 25 townships surveyed there, but four or five may be called much inferior to the general average of previously surveyed lands in Manitoba and the North-West Territories.

From the character thus given of that part of the country between the Assiniboyne River and the international boundary, and from personal observation during a short journey last season in the unsurveyed part of the interval, I am led to judge that but a small proportion of the about 100 townships included between the 15th and 25th ranges, and south of the Assiniboine, will prove unsuitable for cultivation.

The central and western parts of the area thus defined are without wood for building or fuel, but a comparatively near supply is to be found on the one side in the thick forest on the Turtle Mountain to the eastward, and on the other side in the woods along the Assiniboine River, and in rear of the Pembina Mountain. The need for fuel will, no doubt, be more conveniently and fully met when the lignite deposits before mentioned are opened up and made available.

In two other cases the surveys of the year enable us to include with certainty large additional areas in our class of fertile lands.

From information obtained on the block surveys immediately to the east of Carlton and south of the Forks of Saskatchewan River, and from an exploratory survey of the Root River, it would appear that there is a belt of about thirty miles in width, extending along the south side of the Saskatchewan and covering the valley of the Root River, that would include about 4,000 square miles, or over two and a-half millions of acres of lands offering most attractive advantages to incoming settlers. Throughout this area the soil is of the finest and favourably conditioned for cultivation, the surface being sufficiently undulated to afford thorough drainage; good water abounds everywhere, and there is an ample supply of wood for building and fuel. It is also picturesque. The alternations of clumps of wood and prairie glade have a most pleasing effect, the landscape wanting but dwellings to give it the appearance of long-established settlement.

Again, between Fort Pitt and Edmonton, the report of the survey of the 4th Principal Meridian and the 14th Base Line, informs us that in the whole distance surveyed between the 4th and 5th Principal Meridians, an interval of nearly 170 miles, not a single mile of what the surveyor would deem worthless land was met with, and he describes the country passed over as one of mixed prairie and forest, the woods of the latter reaching, in places, dimensions making them valuable as timber for milling purposes.

He also speaks of the luxuriance of vegetation and the excellence of the water throughout. He does not assign any transverse dimension to the district so qualified, but it is to be inferred from his language that he means it to apply northward all the

way to the shore of the Saskatchewan; no southern limit is defined. It is, therefore difficult to make even a rude estimation of the area in this case.

The surveys of Indian Reserves, made under the supervision of this office for the Indian Branch of the Department, have also furnished much valuable information respecting the parts of the territory in which they were carried on, or traversed by the surveyors in reaching the locality of their work. The descriptive reports received to the present time of these surveys are appended hereto.

A survey of timber berths on Lake Winnipegosis, and another on the River Winnipeg, were made during the year. The cost of these is eventually defrayed by the lessees.

While speaking of the surveys, it may be in place to mention that it is, with your approval, proposed, next season, to make some slight modifications in the manner of survey of the block outlines; to try their effect in reduciug, if possible, the average cost per acre of the survey of the lands. This kind of survey is unavoidably much more expensive than that of interior subdivision.

Hitherto the outlines of every square of four townships were so surveyed. It is now proposed to increase the size of the square to sixteen townships, thus materially diminishing, proportionately to the area surveyed, the length of the more costly lines, and to survey the quartering lines, or those which form the remaining boundaries of the townships within the square, by a method which, in precison and cost, would be intermediate between sub division work and that of standard outlines.

A memorandum is appended setting forth, in detail, the modifications of the process of the survey hitherto employed, necessary to effect what is here proposed, and otherwise instructing surveyors as to the methods to be pursued. It also includes a series of geodetic tables, which Mr. W. F. King, D.L.S, has, by direction, computed especially for the purpose, and a series of azimuth tables prepared by myself in furtherance of the same object.

Meetings of the Board of Examiners for Dominion Land Surveyors were held in November, 1878, and May, 1879. The following gentlemen passed at these the requiste examinations, and received commissions and higher certificates:—

Montague Aldous, D.L.S.,	higher certificate,	Ont.
Geo. H. Beasley, P.L.S.,	commission,	Ont.
J. J. Burrows, P.L.S.,	"	Ont.
J. Y. Checkley,	"	Ont.
J. J. Dalton, P.L.S.,	"	Ont.
T. S. Gore, P.L.S.,	"	Ont.
L. A. Hamilton, P.L.S.,	"	Ont.
T. H. Jones, P.L.S.,	"	Ont.
J. J. McArthur, P.L.S.,	"	Que.
A. McFee,	"	Man.
J. M. O'Hanly,	"	Ont.
J. J. Sing, P.L.S.,	"	Ont.
C. E. Wolfe, P.L.S.,	"	Ont.

Several candidates passed the preliminary examination.

I have the honor to be, Sir,

Your obedient servant,

LINDSAY RUSSELL,

Surveyor-General.

PART II.

APPENDICES

TO THE

REPORT OF THE SURVEYOR-GENERAL

OF

DOMINION LANDS.

APPENDIX No. 10.

DOMINION LANDS SURVEYS.

Memorandum to accompany Instructions for the Survey of the Standard Meridians and Parallels forming the outlines of Blocks of sixteen Townships.

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 lines are to be Astronomical Meridians. The northern and the southern ones (correction lines), 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 northren or southern outlines of the Block.

As the Block must have at its middle, *i.e.* on the base line, the exact theoretic width in longitude of four (4) Townships, or 1,956 chains, it must, through divergence of its meridian exteriors southward, measure more along its south outline, and, through their convergence northward, less along the northern one. The excess in the first case is to be distributed equally among the 48 quarter sections involved by making each one the necessary number of links wider than the theoretic 40 chains, and on the northern outline of the Block similar equal distribution of the defect occasioned by convergence shall be made.

The Road allowances along meridians are in all cases to be of the prescribed theoretic width, one chain fifty links. 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.

The order of survey of the Block is left to the discretion of the Surveyor, with a view to the best management, in the effective application of the force at his disposal, under local conditions of communication, and the nature of country, in which he has to work.

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 of a length that, in standard units, is incommensurable with the first, and for convenience of comparison at the planting of the post at each successive section corner is to be an aliquot part of 81 chains 50 links. These two conditions are fulfilled by making it that nine tallies with it will equal that distance; the length of the chain will then be $\frac{81{\cdot}50}{90} = 90{\cdot}555$ links or $55{\cdot}767$ feet. Or the control may be effected by making the second measurement in feet, using a 100 feet chain.

When, at any section corner, the distances registered, by the respective chainings for the length of that section side, differ, in prairie country, more than 3 links, or, in woods and brush, more than 5 links, the two sets of chainmen shall return to the last section 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 method, for obtaining the distances along it, as his judgment and the necessities of the case may lead him to employ.

Besides a spare steel band chain to meet the occurrence of accidental injury to those in use, the Surveyor shall have a standard one with which the field chains are to be frequently compared. It will be adjusted in the Department to length at 60° Fah., and tested at the office of the Commissioner of Standards. 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.

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 constant, 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 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 written calculation or 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 chain from that of the air at the time.

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 in charge of chaining should, for longer and uniform slopes, carry an Abney or Locke pocket level clinometer, by which he can obtain their approximate average inclination, and thus permit the chainmen to use the more expeditious and accurate method of chaining on the inclined surface, instead of requiring them to hold their chains level and entailing a continuous repetition of plumbing down from the high end to the pin in the ground.

A printed card table of the corrections to measurement for given angles of slope is pasted on the fly-leaf of note-books supplied from this office.

Direction and Production of Lines, Measurement of Angles and Determinatien of Astronomic Azimuths.

The instrument to be used in any of these operations shall be of following description, and shall be inspected and approved by this office:—

A reiteration transit theodolite, having a six-inch horizontal circle, reading by three verniers to either 10" or 0°·002, a three-inch vertical circle with two verniers to 1' or 0°·01, as a finder for stars in daytime, and for slope angles, should occasion require. The telescope, having an objective of one and a half-inch diameter and nine-inch focus, supplied with eye-pieces of powers ranging from 15 to 30 for terrestrial work, and one of 50 for specially favorable conditions of the atmosphere and star work. In using his instrument, the Surveyor should always employ the highest power compatible with satisfactory definition.

Directions.

The directions of the east and west exteriors of a Block being throughout coincident with that of a meridian, 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."

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, preferably at or near the times of greatest elongation, but that is not to be held as a restriction that would oblige the interruption of work on the line, or lead to the observations being made at night when other circumstances would permit successful daylight ones. The telescopes used being amply powerful for the purpose, it is desirable to make the azimuth comparisons during the last hour before sunset, whilst the daylight is yet good enough to permit careful pointings both on star and reference object, and accurate reading of verniers, without artificial illumination of either telescope wires or graduated azimuth circle.

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.

In observing for azimuth, the Surveyor will adopt the following programme, and reduce his observations in manner set forth in the printed forms with which he will be supplied for this purpose.

In what follows, the letters *R, f. L, b.* are meant to indicate:—The first that the instrument is in the position which places the vertical circle to the observer's right hand when looking through the telescope, and that in revolving the telescope and verniers in azimuth, the motion is uniformally from left to right, or in the direction in which the hands of a watch move, and is called forward motion. The second *L, b.* that the instrument has been reversed by rovolving the telescope and turning the upper

plate 180° in azimuth, so that the circle is now on the left of the observer, and further, that in any necessary movement of the telescope in azimuth, whether by hand or tangent screw, the motion is uniformally backward, *i. e.* from right to left, or against that of the hands of a watch. Shortly, the letters *R, f.* and *L, b.* are contractions standing for "Circle Right Position, Forward Motion," and "Circle Left Position, Backward Motion," respectively. The letters R, O. stand for Reference Object.

R, f.	Readings on Star.	Readings on R. O.
L, b.	do	do
L, b.	do	do
R, f.	do	do

For his astronomical work the Surveyor must be provided with a 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 injure 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 extreme, say freezing and 80 Fah., and carefully adjusted to good performance in both, and with good hard Breguet 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, on face, on edge XII up, VI up, III up, IX up.

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 is a reiteration instrument, *i. e.*, has no motion of lower limb.

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

In making these observations, as in angular measurements generally, care should be taken when turning the instrument in azimuth, either by hand, or by tangent screw, 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. Should there be any "drag" in the verniers, or lost motion in tangent screw, this prevents either affecting the measure; it also 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 occurrs 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.

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.

Production of Line.

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.

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, he is carefully 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 off-setting the line to get past long reaches unfavorable to chaining or triangulation.

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.
Rf	r	r	r	r	r	r	r
Lb	r	r	r	r	r	r	r
Lb	r	o	r	r	o	r	r
Lf	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—

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

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.

L. R.

AZIMUTH TABLES.

These tables have been prepared with a view to affording the surveyor an entirely independent check on calculations of azimuth made by direct application of Trigonometric formulas. Any calculation should be made, at least, in duplicate, and if each time the processes and figures used in computation are wholly different and that concordant results are obtained, almost absolute certainty can be affirmed without further revision.

The tables also offer, when the degree of precision that suffices for our surveys is taken into account, some advantage, in saving of labor, over the direct calculation by Napier's analogies, or by a formula in which a table of addition or subtraction Logarithms is used.

The quantities S., R. and P. given by tables I, II, and III, respectively, are Logarithms. Those M. and N. given by tables IV and V are natural numbers. Table VI is an Ephemeris of Polaris, giving places for 1880, and will require yearly renewal; but the rest of the tables will serve, without amendment, for several years to come.

The following examples, one in each quadrant of a revolution of the pole star, will show the manner of using them.

The arguments with which to enter the tables are, for table I, the place of observation as defined by distance in townships from the 49th parallel of latitude (the International Boundary); for table II, the polar distance of Polaris, for the date, (obtained in table VI); for tables III, IV and V, the argument is the hour angle of the star counted from upper transit round through each of the 24 hours to the next upper transit.

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.	$2^h\ 10^m$.	$9^h\ 32^m$.	$16^h\ 44^m$.	$19^h\ 52^m$.
Table I, S. =	0·19897			
do II, R. =	0·00137			
Constant C. =	0·20034	0·20034	0·20034	0·20034
Table III, P. =	9·85335	9·90259	0·09880	0·06906
Log n. =	0 05369	0·10293	0·29914	0·26940
n. =	—1°·1316	—1°.2674	+1°·9913	+1°·8595
Table IV, M. =	—0 ·0271	+0 ·0287	—0 ·0183	+0 ·0247
do V.N. =	—0 ·0007	− 0 ·0006	—0 ·0003	—0 ·0006
Azimuth =	—1°·1594	—1°·2393	+1°·9727	+1°·8836

The same examples, calculated by the formula—

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

where $P.$ $\phi.$ $t.$ are polar distance, latitude and hour angle respectively, and using a table of addition and substraction logarithms (to be found in almost every good collection of tables now published), would stand thus:—

	For $t = 2^h\ 10^m$		For $t = 9^h\ 32^m$	
Tan P =	8·36643	8·36643		
Sec. ϕ =	0·19897	Tan ϕ 0 (8804		
Constants	8·56540	8·45447	8·56540	8·45447
Sin. and Cos. t.	9·73022	9 92603	9·77946	9·90235n
	8 29562	8 38050	8 34486	8·35682
Tab. Subt. Log	+0·01055		—0 00977	
Tan Az	8·30617	Az = —1°·1594	8·33509	Az = —1°·2395

	$t = 16^h\ 44^m$		$t = 19^h\ 52^m$	
Constants	8 56540	8·45447	8·56540	8·45447
Sin. and Cos. t	9·97561	9·51264	8·94593	9·67161
	8·54107	7·96711n	8·51133	8·12608
Tab. Subt. Log	—401		+577	
Tan Az	8·53706	Az = +1°·9725	8·51710	Az = +1°·8839

COMPARISON OF RESULTS.

Azimuth for—	$2^h\ 10^m$	$9^h\ 32^m$	$16^h\ 44^m$	$19^h\ 52^m$
By direct calculation	1°·1594	1°·2395	1°·9725	1° 8839
By tables	1°·1594	1° 2393	1° 9727	1°·8836
Difference	0°·0000	0°·0002	0° 0002	0°·0003
In sexagesimals	0″·0	0″·7	0″·7	1″·1

As the instruments employed cannot, at most favorable estimate, be read to less than 5″, or 0°.002—according to their graduation—and that the limit of precision of the work generally, even where the mean of a number of readings is taken, and great care exercised otherwise, cannot be fixed at anything closer than 3″ or 4″, these differences are, for the purposes for which the tables were intended, inappreciable.

Azimuth is here reckoned, from zero at the north point, round through east, south and west, and the algebraic signs of the tables are arranged in correspondence with this convention, and with the usage of graduating the horizontal circles of azimuthal instruments from left to right, in the direction of the figures on a watch, and from 0 continuously to 360.

The reason that the degree is subdivided decimally instead of, as usually, into minutes and seconds, is that the instruments to be employed in conjunction with the tables have their graduation so divided. This latter was done to facilitate the taking the mean of a number of readings of the three verniers with which they are provided, and to lessen the chances of blunder, in so doing, by substituting the more

familiar process of division of quantities counted by tens for the less familiar one of dividing those counted by sixties. In the decimally-arranged tables of logarithms supplied to surveyors is a convenient table for conversion of minutes and seconds into decimals of degree, so that those using our older pattern of instruments reading sexagesimally, can, with slight additional labor, use the present azimuth tables.

When using table No. IV, if extreme accuracy is desired, intermediate values of M. should be obtained by direct interpolation from the values given, and not by numbers in the difference columns, as each of these last is but the mean of the five differences between the six quantities opposite which it is written, and therefore does not give exactly the difference between any two. The maximum error entailed by this is about three units in last place of decimals, but the error might have the same sign as the one of similar magnitude that is from other causes involved in the tables, and six units in last place, or 2"·2, might, in some special case, be of importance, though not so in their ordinary use.

Table VII, gives the apparent places, for each month of the year 1880, of the brighter stars, with a view to convenience in preparing for and reducing daylight observations of a time star, in the same vertical with Polaris, to obtain the necessary chronometer correction for azimuth work as above.

L. R.

AZIMUTH TABLE I.

THE Logarithm S. for intervals of one Township from 49th Parallel, or 1st Base, to 13th Correction Line.

No. of Base or Correction Line.	Townships.	S.	Difference for one Section.	No. of Base or Correction Line.	Townships.	S.	Difference for one Section.
1st Base	0	0·18306			25	0·20311	
	1	0 18383	12·8	7th Correction Line..	26	0·20395	14·0
1st Correction Line..	2	0·18460	12·8		27	0·20478	14·0
	3	0 18538	13·0	8th Base	28	0·20562	14·0
2nd Base.	4	0·18616	13·0		29	0·20647	14·0
	5	0·18694	13·0				14·0
2nd Correction Line.	6	0·18773	13·2	8th Correction Line..	30	0·20731	
	7	0·18852	13·2		31	0·20816	14·2
3rd Base	8	0·18930	13·2	9th Base	32	0·20901	14·2
	9	0·19009	13·2		33	0·20986	14·2
			13·3	9th Correction Line..	34	0·21072	14·3
3rd Correction Line..	10	0·19089			35	0·21158	14·3
	11	0 19169	13·3	10th Base	36	0·21245	14·3
4th Base	12	0·19249	13 3		37	0·21331	14·3
	13	0·19329	13·3	10th Correction Line	38	0·21418	14·5
4th Correction Line..	14	0·19409	13·3		39	0·21505	14·5
	15	0·19490	13·5				14·5
5th Base	16	0·19571	13·5	11th Base	40	0·21592	
	17	0·19652	13·5		41	0·21680	14·5
5th Correction Line..	18	0·19734	13·7	11th Correction Line	42	0·21767	14·5
	19	0·19816	13·7		43	0·21856	14·7
			13·7	12th Base	44	0·21944	14·7
6th Base	20	0·19897			45	0·22032	14·7
	21	0·19980	13·8	12th Correction Line	46	0·22122	14·8
6th Correction Line..	22	0·20062	13·8		47	0·22211	14·8
	23	0·20145	13·8	13th Base	48	0·22300	14·8
7th Base	24	0·20228	13·8		49	0·22390	15·0
	25	0·20311	13·8	13th Correction Line	50	0·22481	15·0

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tables of logarithms
minutes and seconds
f instruments reading
azimuth tables.
l, intermediate values
es given, and not by
the mean of the five
ritten, and therefore
ximum error entailed
error might have the
auses involved in the
ial case, be of import-

the year 1880, of the
nd reducing daylight
o obtain the necessary

L. R.

Parallel, or 1st Base,

Townships.	S.	Difference for one Section.
25	0·20311	
26	0·20395	14·0
27	0·20478	14·0
28	0·20562	14·0
29	0·20647	14·0
		14·0
30	0·20731	
31	0·20816	14·2
32	0·20901	14·2
33	0·20986	14·2
34	0·21072	14·3
35	0·21158	14·3
36	0·21245	14·3
37	0·21331	14·3
38	0·21418	14·5
39	0·21505	14·5
		14·5
40	0·21592	
41	0·21680	14·5
42	0·21767	14·5
43	0·21856	14·7
44	0·21944	14·7
45	0·22032	14·7
46	0·22122	14·8
47	0·22211	14·8
48	0·22300	14·8
49	0·22390	15·0
50	0·22481	15·0

AZIMUTH TABLE II.

Log $\frac{p}{po}$ = R calculated for $po = 1°·3278$.

p.	R.	p.	R.	p.	R.	p.	R.
1·300	9·99081	1·310	9·99414	1·320	9·99744	1·330	0·00072
1	115	1	447	1	777	1	105
2	148	2	480	2	810	2	137
3	181	3	513	3	843	3	170
4	215	4	547	4	876	4	203
5	248	5	580	5	909	5	235
6	281	6	613	6	941	6	268
7	315	7	646	7	974	7	300
8	348	8	679	8	0·00007	8	333
9	381	9	711	9	039	9	365

Diffs. for ten thousandths of a degree in units of fifth decimal of R.

Args d p	1	2	3	4	5	6	7	8	9
Diffs d R.....	3	7	10	13	16	20	23	26	30

AZIMUTH TABLE No. III.—The Logarithm P. for Polaris. Calculated for Polar Distance 1°·3278. Argument—Hour angle of Polaris or Interval from Upper Culmination in Secteral Time=AR—Sect. T of Observation.

Argument.	0h or 12h − +	Difference for 10s.	1h or 13h − +	Difference for 10s.	2h or 14h − +	Difference for 10s.	3h or 15h − +	Difference for 10s.	4h or 16h − +	Difference for 10s.	5h or 17h − +	Difference for 10s.	Argument.
M.	P.		P.		P.		P.		P.		P.		M.
0	0 00000	.....	9·53613	117	9·82210	54	9·97261	31	0 06066	18	0·10807	8	60
1	7·76295	.....	9·54313	115	9·82536	54	9 97450	31	0·06175	18	0·10858	8	59
2	8·06397	.....	9·55003	113	9·82860	53	9·97637	31	0·06283	17	0·10907	8	58
3	8·24006	.....	9·55680	111	9·83180	53	9·97823	30	0 06389	17	0·10956	7	57
4	8·36499	.....	9 56347	109	9·83497	52	9 98006	30	0 06495	17	0·11003	7	56
5	8·46188	.....	9·57002	107	9 83811	52	9·98189	30	0·06599	17	0·11050	7	55
6	8·54105	.....	9·57647	106	9·84121	51	9 98369	29	0·06703	17	0·11096	7	54
7	8·60798	.....	9·58282	104	9 84429	51	9 98548	29	0 06805	16	0·11141	7	53
8	8·66595	.....	9·58906	104	9 84734	50	9·98726	29	0 069 6	16	0·11185	7	52
9	8·71708	.....	9·59522	101	9·85036	50	9·98902	29	0 07007	16	0 11229	7	51
10	8·76281	.....	9 60127	99	9 85335	49	9 99076	29	0·07106	16	0·11271	.....	50
11	8·80417	.....	9 60724	98	9·85631	49	9 99249	28	0 07204	16	0·11313	7	49
12	8 84193	.....	9 61311	96	9 85924	48	9 99420	28	0·07301	16	0·11353	6	48
13	8·87666	.....	9·61890	95	9·86214	48	9 99590	28	0 07397	15	0 11393	6	47
14	8 90881	.....	9·62461	93	9·86502	47	9 99759	27	0 07492	15	0·11432	6	46
15	8 93873	.....	9·63023	92	9 86787	47	9 99925	.....	0·07586	15	0·11470	6	45
16	8·96671	.....	9 63577	91	9·87069	46	0·00091	27	0·07679	15	0·11508	6	44
17	8·99300	.....	9·64124	89	9·87349	47	0 00255	27	0·07771	15	0 11544	6	43
18	9·01777	.....	9 64662	88	9·87626	45	0·00418	26	0·07862	15	0·11580	5	42
19	9·04120	.....	9 65194	87	9·87900	45	0·00579	26	0·07952	14	0·11614	5	41
20	9·06343	.....	9·65718	86	9·88172	45	0·00738	26	0·08041	.....	0·11648	5	40
21	9·08456	336	9·66235	85	9·88441	44	0·00897	26	0·08128	14	0·11681	5	39
22	9·10470	321	9·66745	84	9·88708	44	0·01054	25	0·08215	14	0·11713	5	38
23	9·12395	306	9·67249	83	9 88973	43	0·01209	25	0·08301	14	0·11745	5	37
24	9·14230	295	9·67746	81	9 89235	43	0·01363	25	0·08386	14	0·11775	5	36
25	9·16003	283	9 68236	80	9·89494	43	0·01516	25	0·08470	13	0 11805	4	35
26	9·17699	272	9·68720	79	9·89752	42	0·01667	25	0·08553	13	0·11833	.....	34
27	9·19331	262	9·69199	78	9 90007	42	0 01817	24	0·08635	13	0·11861	4	33
28	9·20902		9·69670		9·90259		0·01966		0·08716		0·11888	4	32

Argument.	11^h or 23^h — +	Difference for 10s.	10^h or 22^h — +	Difference for 10s.	9^h or 21^h — +	Difference for 10s.	8^h or 20^h — +	Difference for 10.	7^h or 19^h — +	Difference for 10s.	6^h or 18^h — +	Difference for 10s.	Argument.
20	9·06343	.....	9·65718	87	9·88172	45	0·00738	26	0·08041	14	0·11618	5	40
21	9·08456	.....	9·66235	86		45		26		.....		5	41
22	9·10470	356	9·66745	85	9·[illegible]	44	0·00897	26	0·08128	14	0·11681	5	[illegible]
23	9·12395	321	9·67249	84	9·[illegible]	44	0·01054	25	0·08215	14	0·11713	5	38
24	9·14230	306	9·67746	83	9·89235	43	0·01209	25	0·08301	14	0·11745	5	37
25	9·16003	295	9·68236	81	9·89494	43	0·01363	25	0·08386	14	0·11775	5	36
		283		80		43	0·01516	25	0·08470	13	0·11805	4	35
26	9·17699		9·68720		9·89752		0·01667		0·08553		0·11833	.....	34
27	9·19331	272	9·69199	79	9·90007	42	0·01817	25	0·08635	13	0·11861	4	33
28	9·20902	262	9·69670	78	9·90259	42	0·01966	24	0·08716	13	0·11888	4	32
29	9·22419	253	9·70137	77	9·90510	41	0·02114	24	0·08796	13	0·11914	4	31
30	9·23883	244	9·70597	76	9·90758	41	0·02260	24	0·08874	13	0·11940	4	30
		236		75		41		24		13		4	
31	9·25298	229	9·71052	74	9·91004	40	0·02404		0·08952	13	0·11964	4	29
32	9·26669	221	9·71501	73	9·91247	40	0·02548	23	0·09030	12	0·11988	3	28
33	9·27996	215	9·71944	73	9·91489	39	0·02690	23	0·09106	12	0·12011	3	27
34	9·29283	208	9·72383	72	9·91728	39	0·02831	23	0·09181	12	0·12033	3	26
35	9·30533	202	9·72816	71	9·91965	39	0·02970	23	0·09255	12	0·12054	3	25
36	9·31746	197	9·73244	70	9·92200	39	0·03109	22	0·09328	12	0·12074	3	24
37	9·32926	191	9·73667	69	9·92433	38	0·03246	22	0·09400	12	0·12094	3	23
38	9·34074	186	9·74086	69	9·92664	38	0·03380	22	0·09472	11	0·12113	2	22
39	9·35191	181	9·74499	68	9·92893	38	0·03516	22	0·09542	11	0·12130	2	21
40	9·36280	177	9·74908	67	9·93120	37	0·03649	22	0·09612	11	0·12147	2	20
41	9·37341	171	9·75312	66	9·93345	37	0·03781	21	0·09680	11	0·12164	2	19
42	9·38366	170	9·75711	65	9·93567	37	0·03912	21	0·09748	11	0·12179	2	18
43	9·39386	163	9·76106	65	9·93788	36	0·04042	21	0·09814	11	0·12193	2	17
44	9·40373	161	9·76497	64	9·94007	36	0·04170	21	0·09880	10	0·12207	2	16
45	9·41337	157	9·76884	64	9·94224	36	0·04298	21	0·09945	10	0·12220	2	15
46	9·42219	153	9·77266	63	9·94439	35	0·04424	20	0·10009	10	0·12232	1	14
47	9·43200	150	9·77644	62	9·94653	35	0·04548	20	0·10072	10	0·12243	1	13
48	9·44101	147	9·78018	61	9·91864	35	0·04672	20	0·10134	10	0·12253	1	12
49	9·44983	144	9·78388	61	9·95074	34	0·04795	20	0·10195	10	0·12263	1	11
50	9·45847	141	9·78754	60	9·95281	34	0·04916	20	0·10255	10	0·12270	1	10
51	9·46693	138	9·79116	59	9·95487	34	0·05036	19	0·10314	9	0·12279	1	9
52	9·47522	135	9·79474	59	9·95691	33	0·05155	19	0·10373	9	0·12286	1	8
53	9·48335	133	9·79828	58	9·95894	33	0·05273	19	0·10430	9	0·12293	1	7
54	9·49132	130	9·80179	57	9·96094	33	0·05390	19	0·10486	9	0·12298	1	6
55	9·49913	128	9·80526	57	9·96293	33	0·05505	19	0·10542	9	0·12303	0	5
56	9·50681	125	9·80870	56	9·96490	32	0·05620	18	0·10597	9	0·12306	0	4
57	9·51434	123	9·81210	56	9·96685	32	0·05733	18	0·10651	8	0·12309	0	3
58	9·52173	121	9·81547	55	9·96879	32	0·05845	18	0·10704	8	0·12311	0	2
59	9·52899	119	9·81880	55	9·97071	31	0·05956	18	0·10756	8	0·12312	0	1
60	9·53613		9·82210		9·97261		0·06066		0·10807		0·12313		0

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ARGUMENT, Hour angle of Polaris, and distance in Latitude, northward, from 49th 88° 40′ 20″, or $p=1°$

t.	M in Decimals of a Degree.	Differences for 1m. and 10s.		Differences for 1 Tp. and 1 Section.	M in Decimals of a Degree.	Differences for 1m. and 10s.		Differences for 1 Tp. and 1 Section.	M in Decimals of a Degree.	Differences for 1m. and 10s.		Differences for 1 Tp. and 1 Section.
H. H. M.	0 Tp.	1m.			10 Tps.	1m.			20 Tps.	1m.		
0 or 12 0	0°·0000				0°·0000				0°·0000			
10	0024				0025				0026			
20	0047				0049				0052			
— 30	0070	·00023	10s.	1 Tp.	0073	·00024	10s.	1 Tp.	0077	·00025	10s.	1 Tp.
40	0092				0097				0102			
50	0114				0120				0126			
H. H. M.												
1 or 13 0	0135				0142				0149			
10	0155				0162				0171			
20	0174	·00017		·00009	0182	·00018		·00010	0191	·00019		·00010
— 30	0191		·00003		0200		·00003		0211		·00003	
40	0207				0217				0228			
50	0221				0232				0244			
H. H. M.												
2 or 14 0	0234				0245				0258			
10	0245	·00007		·00012	0256	·00007		·00014	0270	·00007		·00014
20	0253		·00001		0266		·00007		0280		·00001	
— 30	0261				0273				0288			
40	0266				0279				0294			
50	0269				0282				0296			
H. H. M.												
3 or 15 0	0270				0283				0298			
10	0269				0282				0296			
20	0266	·00005		·00012	0279	·00006		·00014	0294	·00006		·00014
— 30	0261		·00001		0273		·00001		0288		·00001	
40	0253				0266				0280			
50	0245				0256				0270			
H. H. M.												
4 or 16 0	0234				0245				0258			
10	0221				0232				0244			
20	0207	·00016		·00009	0217	·00017		·00011	0228	·00017		·00011
— 30	0191		·00003		0200		·00003		0211		·00003	
40	0174				0182				0191			
50	0155				0162				0171			
H. H. M.												
5 or 17 0	0135				0142				0149			
10	0114				0120				0126			
20	0092	·00023		·00004	0097	·00025		·00004	0102	·00025		·00004
— 30	0070		·00004		0073		·00004		0077		·00004	
40	0047				0049				0052			
50	0024				0025				0026			
60	0°·0000				0°·0000				0°·0000			

For $dp \pm 0°·01$, $dM = \pm ·015\ M°$.

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nort[illegible]rd, from 49th

88° 40′ 20″, or $p = 1°$

TABLE No. IV.

Parallel, in Townships and Sections. Values of M calculated for Declination 19′ 40″ = 1°·3278.

M in Decimals of a Degree.	Differences for 1m. and 10s.		Differences for 1 Tp. and 1 Section.		M in Decimals of a Degree.	Differences for 1m. and 10s.		Differences for 1 Tp. and 1 Section.		M in Decimals of a Degree.	Differences for 1m. and 10s.		Differences for 1 Tp. and 1 Section.		t.
30 Tps.	1m.	10s.	1 Tp.	1 Sec.	40 Tps.	1m.	10s.	1 Tp.	1 Sec.	50 Tps.	1m.	10s.	1 Tp.	1 Sec.	M. H. H.
0°·0000					0°·0000					0°·0000			.....	.....	0 6 or 18
0027	·00026	·00004	00004	·00001	0029	·00028	·00005	·00004	·00001	0030	·00030	·00005	....	.....	10
0054					0059					0060			.....	....	20
0081					0085					0090			.....	.....	30 +
0107					0113					0119			.....	.....	40
0132					0139					0147			.....	.....	50
															M. H. H.
0156					0165					0174			.....	.....	0 7 or 19
0179	·00020	·00003	·00012	·00002	0189	00021	·00004	·00012	·00002	0199	·00022	·00004	.....	.....	10
0201					0212					0224			.....	.....	20
0221					0233					0246			.....	.....	30 +
0240					0253					0267			.....	.....	40
0256					0270					0285			.....	.....	50
															M. H. H.
0271	·00008	·00001	·00016	·00003	0286	·00008	·00001	·00017	·00003	0302	·00009	·00002	.....	.....	0 8 or 20
0283					0299					0315			.....	.....	10
0294					0310					0327			.....	.....	20
0302					0318					0336			.....	.....	30 +
0308					0325					0343			.....	.....	40
0312					0329					0347			.....	.....	50
															M. H. H.
0313	·00006	·00001	·00016	·00003	0330	·00006	·00001	·00018	·00003	0348	·00007	·00001	.....	.....	0 9 or 21
0312					0329					0347			.....	.....	10
0308					0325					0343			.....	.....	20
0302					0318					0336			.....	.....	30 +
0294					0310					0327			.....	.....	40
0283					0299					0315			.....	.....	50
															M. H. H.
0271	·00012	·00002	·00012	·00002	0286	·00019	·00003	·00013	·00002	0302	·00021	·00004	.....	.....	0 10 or 22
0256					0270					0285			.....	.....	10
0240					0253					0267			.....	.....	20
0221					0233					0246			.....	.....	30 +
0201					0212					0224			.....	.....	40
0179					0189					0199			.....	.....	50
															M. H. H.
0156	·00026	·00004	·00004	·00001	0165	·00028	·00005	·00005	·00001	0174	·00029	·00005	.....	.....	0 11 or 23
0132					0139					0147			.....	.....	10
0107					0113					0119			.....	.....	20
0081					0085					0090			.....	.....	30 +
0054					0057					0060			.....	.....	40
0027					0029					0030			.....	.....	50
0°·0000					0°·0000					0° 0000			.....	.....	60

For $dp \pm 0°·01$, $dM = \pm ·015\ M_o$.

AZIMUTH TABLE V.

ARGUMENT, Hour angle of Polaris, and distance in Latitude, Northward, from 49th Parallel in Townships. Values of N in decimals of a degree, for P = °1·3278.

t.	0 TP.	10 TPS.	20 TPS.	30 TPS.	40 TPS.	50 TPS.	*t.*	j N for d p of °0·1.
H. H.	N °	N °	N °	N °	N °	N °	H. H.	°
—0 or 12	0·0000	0 0000	0·0000	0·0000	0·0000	0 0000	+12 or 24	0·00000
1 or 11	0·0004	0·0004	0·0005	0·0005	0·0006	0·0006	13 or 23	0·00013
2 or 10	0·0006	0·0007	0·0007	0·0008	0·0008	0·0009	14 or 22	0·00018
3 or 9	0·0005	0·0005	0·0005	0·0006	0·0006	0·0006	15 or 21	0·00013
—4 or 8	0·0001	0·0001	0·0001	0·0001	0·0001	0·0001	+16 or 20	0·00002
+5 or 7	0·0003	0·0003	0·0004	0·0004	0·0004	0·0005	—17 or 19	0·00010
+6	0·0005	0 0005	0·0006	0·0006	0·0007	0·0007	—18	0·00014

Northward, from 49th
, for P = °1·3278.

	t.	j N for d p of °0·1.
	H. H.	°
0	+12 or 24	0·00000
6	13 or 23	0·00013
9	14 or 22	0·00018
6	15 or 21	0·00013
1	+16 or 20	0·00002
5	—17 or 19	0·00010
7	—18	0·00014

AZIMUTH TABLE VI.

Apparent places, Polaris for 1880.

Day.	January.		February.		March.		April.	
	AR ° ′ ″	δ	*AR* ° ′ ″	δ	*AR* ° ′ ″	δ	*AR* ° ′ ″	δ
1	1 14 57	1·3233	1 14 29	1·3233	1 14 08	1·3247	1 13 59	1·3247
11	0 0 48	31	0 0 20	36	0 0 03	56	0 0 59	81
21	0 0 39	31	0 0 13	42	0 0 00	64	1 14 01	89
31	0 0 30	33	0 0 07	47	0 13 59	72	0 0 06	97

Day.	May.		June.		July.		August.	
	AR ° ′ ″	δ	*AR* ° ′ ″	δ	*AR* ° ′ ″	δ	*AR* ° ′ ″	δ
1	1 14 06	1·3297	1 14 26	1·3314	1 14 54	1·3319	1 15 24	1·3308
11	0 0 11	·3306	0 0 35	17	0 15 04	17	0 0 32	03
21	0 0 18	11	0 0 45	19	0 0 14	14	0 0 40	·3297
31	0 0 26	14	0 0 54	19	0 0 23	11	0 0 47	·3289

Day.	September.		October.		November.		December.	
	AR ° ′ ″	δ	*AR* ° ′ ″	δ	*AR* ° ′ ″	δ	*AR* ° ′ ″	δ
1	1 15 47	1·3286	1 16 01	1·3258	1 16 02	1·3228	1 15 50	1·3200
11	0 0 53	78	0 0 03	47	0 0 0	17	0 0 43	192
21	0 0 58	69	0 0 04	36	0 15 56	06	0 0 36	186
31	1 16 01	58	0 0 02	28	0 0 50	00	0 0 28	183

AZIMUTH

APPARENT Places of Stars for the Year 1850. For the

Star's Name.	Magnitude.	15th April.		15th May.		15th June.	
		AR H. M. S.	δ °	*AR* S.	δ	*AR* S	δ
α Andromedae	2	0 02 11·7	+28·4285	12·4	·4286	13·5	·4297
γ Pegasi	3·2	0 07 04·1	+14·5174	04·8	·5180	05·7	·5194
β Andromedae	2·3	1 03 01·5	+34·9854	02·1	·9847	03·1	·9852
θ' Ceti	3	1 18 02·1	− 8·8011	02·6	·7996	03·4	·7977
β Arietis	3·2	1 48 01·4	+20·2224	01·8	·2225	02·6	·2232
α Arietis	2	2 00 25·3	+22·8959	25·7	·8958	26·5	·8964
α Ceti	2·3	2 56 01·1	+ 3·6189	01·3	·6196	01·9	·6209
α Persei	2	3 15 46·3	+49·4352	46·5	·4337	47·3	·4327
ε Eridani	3	3 27 17·2	− 9·8655	17·3	·8642	17·7	·8624
δ Persei	3	3 34 23·8	+4 4048	23·9	·4034	24·6	·4024
η Tauri	3	3 40 22·0	+23·7343	22·1	·7340	22·7	·7342
z Persei	3	3 46 36·4	+31·5277	36·4	·5270	37·0	·5268
γ Eridani	3	3 52 26·4	−13·8509	26·4	·8495	26·8	·8475
α Tauri	1	4 29 03·2	+16·2677	03·1	·2677	03·5	·2681
ι Aurigae	3	4 49 12·0	+32·9765	11·9	·9758	12·3	·9752
α Aurigae	1	5 07 51·0	+45·8767	50·8	·8756	51·1	·8744
β Orionis	1	5 08 47·2	− 8·3427	47 0	·3418	47·2	·3404
γ Orionis	2	5 18 42·9	+ 6·2390	42·7	·2394	42·9	·2401
ξ Orionis	2	5 30 08·6	− 1·2809	08·4	·2803	08·5	·2792
α Orionis	1	5 48 41·8	+ 7·3827	41 6	·3830	41·7	·3835
μ Geminorum	3	6 15 43·7	+22·5740	43·4	·5739	43·5	·5737
γ Geminorum	2·3	6 30 48·4	+16·5000	48·1	·5001	48·2	·5002
α Canis Majoris	1	6 39 52·8	−16·5565	52·4	·5558	52·3	·5554
α Geminorum	2·1	7 26 58·4	+32·1505	58·0	·1503	57·9	·1498
α Canis Minoris	1	7 33 03·1	+ 5·5287	02·7	·5290	02·6	·5295
β Geminorum	1·2	7 37 60·5	+28·3146	60·1	·3146	59·9	·3142
ε Hydrae	3·4	8 40 27·5	+ 6·8552	27·1	·8555	26·9	·8560
α Hydrae	2	9 21 43·7	− 8·1440	43·3	·1438	43·0	·1431
ε Leonis	3	9 39 05·1	+24·3239	04·6	·3244	04·3	·3245
α Leonis	1·2	10 02 01·5	+12 5497	01·2	·5502	00·8	·5506

AZIMUTH

ıe Year 1880. For the

h May.		15th June.	
	δ	AR s	δ
	·4286	13·5	·4297
	·5180	05·7	·5194
	·9847	03·1	·9852
	·7996	03·4	·7977
	·2225	02·6	·2232
	·8958	26·5	·8964
	·6196	01·9	·6209
	·4337	47·3	·4327
	·8642	17·7	·8624
	·4034	24·6	·4024
	·7340	22·7	·7342
	·5270	37·0	·5268
	[illegible]	26·8	·8475
	·2677	03·5	·2681
	·9758	12·3	·9752
	·8756	51·1	·8744
	·3418	47·2	·3404
	·2394	42·9	·2401
	·2803	08·5	·2792
	·3830	41·7	·3835
	·5739	43·5	·5737
	·5001	48·2	·5002
	·5558	52·3	·5554
	·1503	57·9	·1498
	·5290	02·6	·5295
	·3146	59·9	·3142
	·8555	26·9	·8560
	·1438	43·0	·1431
	·3244	04·3	·3245
	·5502	00·8	·5506

TABLE VII.

upper Transit in Longitude 102° West of Greenwich.

15th July.		15th August.		15th September.		15th October.		15th November.		15th December.	
AR s.	δ	AR s.	δ	AR s.		AR s.	δ	AR s.	δ	AR s.	δ
14·5	·4314	15·3	·4336	15·8	·4356	15·9	·4371	15·7	·4381	15·4	·4382
06·7	·5212	07·5	.5230	08·0	·5245	08·1	·5253	07·9	·5256	07·6	·5254
04·2	·9865	05·2	·9884	05·9	·9904	06·2	·9922	06·2	·9935	06·0	·9940
04·3	·7961	05·2	·7949	05·8	·7944	06·2	·7948	06·2	·7956	06·0	·7965
03·6	·2245	14·6	·2263	05·3	·2275	05·8	·2285	05·9	·2291	05·8	·2292
27·5	·8976	28·4	·8990	29·3	·9005	29·7	·9016	30·0	·9023	29·9	·9017
02·8	·6223	03·7	·6235	04·5	·6243	05·1	·6245	05·5	·6240	05·5	·6234
48·5	·4326	49·9	·4333	51·1	·4346	52·1	·4363	52·7	·4381	52·9	·4368
18·5	·8607	19·4	·8594	20·3	·8589	20·9	·8593	21·3	·8604	21·4	·8617
25·7	·4022	27·1	·4028	28·3	·4039	29·3	·4054	30·0	·4070	30·2	·4084
23·5	·7348	24·5	·7357	25·5	·7366	26·3	·7373	26·8	·7378	27·1	·7380
37·9	·5271	39·0	·5278	40·0	·5287	40·9	·5297	41·5	·5305	41·7	·5312
27·6	·8458	28·5	·8444	29·4	·8439	30·1	·8145	30·6	·8458	30·7	·8473
04·3	·2688	05·2	·2695	06·1	·2702	07·0	·2704	07·6	·2704	08·0	·2701
13·1	·9751	14·1	·9753	15·2	·9757	16·2	·9763	17·0	·9769	17·4	·9774
52·0	·8735	53·1	·8732	54·4	·8733	55·6	·8739	56·6	·8749	57·2	·8760
47·8	·3388	48·6	·3375	49·4	·3369	50·3	·3373	51·0	·3385	51·4	·3400
43·5	·2410	44·3	·2419	45·2	·2424	46·0	·2422	46·8	·2416	47·2	·2407
09·0	·2780	09·8	·2769	10·7	·2764	11·6	·2767	12·3	·2776	12·8	·2789
42·2	·3844	43·0	·3851	43·9	·3855	44·8	·3853	45·6	·3845	46·1	·3836
44·0	·5737	44·7	·5737	45·7	·5727	46·6	·5735	47·6	·5731	48·3	·5728
48·6	·5004	49·3	·5006	50·1	·5006	51·1	·5003	52·0	·4997	52·7	·4990
52·6	·5528	53·2	·5512	54·0	·5505	54·9	·5508	55·7	·5522	56·4	·5543
58·1	·1492	58·7	·1484	59·6	·1476	60·6	·1469	61·7	·1462	62·6	·1460
02·8	·5301	03·3	·5306	04·0	·5307	04·9	·5302	05·8	·5290	06·6	·5277
60·1	·3138	60·7	·3132	61·5	·3125	62·5	·3117	63·5	·3109	64·4	·3104
26·9	·8564	27·2	·8567	27·8	·8566	28·5	·8559	29·5	·8547	30·4	·8532
42·9	·1422	43·1	·1413	43·5	·1407	44·2	·1410	45·1	·1421	46·1	·1439
04·2	·3243	04·3	·3236	04·8	·3225	05·5	·3212	06·4	·3196	07·5	·3183
00·7	·5508	00·7	·5597	01·1	·5502	01·7	·5492	02·6	·5477	03·6	·5461

AZIMUTH TABLE.

APPARENT Places of Stars for the Year 1880. For the Upper

Star's Name.	Mag-nitude.	15th April.		15th May.		15th June.	
		AR H. M. S.	δ °	*AR* S.	δ	*AR* S.	δ
τ Leonis	2	10 13 24·1	+20·4152	23·7	·4457	23·4	·4461
δ Leonis	2·3	11 07 46·6	+21·1774	46·3	·1782	45 9	·1787
β Leonis	3	11 42 59·3	+15·2386	59·1	·2394	58·8	·2401
γ Virginis	3	12 35 37·9	— 0·7967	37·8	·7964	37·5	·7959
12 Canum Venat	3	12 50 28·2	+38·9628	28 0	·9645	27·6	·9658
α Virginis	1	13 18 55·5	—10·5397	55 6	·5398	55·4	·5395
π Bootis	3	13 48 61 4	+18·9950	61·5	·9963	61·4	·9975
α Bootis	1	14 10 14·4	+19 8029	14·5	·8042	14·4	·8055
ε Bootis	2·3	14 39 47·9	+27·5759	48·1	·5776	48·0	·5793
μ Bootis	2	15 19 60 5	+37·7935	60·8	·7957	60·7	·7979
α Coronae	2	15 29 39·4	+27·1145	39 7	·1162	39·8	·1181
β Herculis	2·3	16 25 06·4	+21·7475	06·9	·7491	07·1	·7510
α Herculis	Variable	17 09 13·1	+14·5243	13·7	·5257	14 1	·5275
α Ophinchi	2	17 29 24·3	+12·6449	25·0	·6463	25·4	·6480
η Serpentis	3	18 15 08·4	— 2·9303	09 2	·9294	09·8	·9283
α Lyrae	1	18 32 54·3	+38·6681	55·2	·6699	55 8	·6724
z Aquilae	3	18 59 55·6	+13·6837	56·4	·6850	57·1	·6869
α Aquilae	1·2	19 44 57·5	+ 8·5509	58·4	·5522	59·2	·5539
θ Aquilae	3	20 05 08·6	— 1·1770	09·5	·1759	10·3	·1744
α Cygni	2·1	20 37 21·3	+44·8487	22·4	·8497	23·4	·8519
z Cygni	3	21 07 50·8	+29·7334	51·7	·7343	52·7	·7363
β Aquarii	3	21 25 15·9	— 6 0971	16 8	·0958	17·8	·0942
ε Pegasi	2·3	21 38 18·8	+ 9·3254	19·7	·3265	20·6	·3283
α Aquarii	3	21 59 38·4	— 0·9013	39 3	·9000	40·2	·8984
π Pegasi	3	22 37 23·4	+29·5933	24·3	·5937	25·3	·5952
β Pegasi	2·3	22 57 58·1	+27·4318	59 0	·4323	60·0	·4337
α Pegasi	2	22 58 47·9	+14·5605	48·7	·5613	49·7	·5629

AZIMUTH TABLE.

188[redacted] For the Upper

VII—*Concluded.*

Transit in Longitude 102° West of Greenwich.—*Concluded.*

1st May.		15th June.		15th July.		15th August.		15th September.		15th October.		15th November.		15th December.	
δ		*AR* s.	δ	*AR* s.		*AR* s.		*AR* s.	δ	*AR* s.	δ	*AR* s.	δ	*AR* s.	δ
	·4457	23·4	·4461	23·2	·4460	23·2	·4456	23·6	·4446	24·2	·4433	25·1	·4416	26·1	·4410
	·1782	45 9	·1787	45·6	·1788	45·5	·1784	45·6	·1774	46·1	·1759	46 9	·1740	47·9	·1722
	·2394	58 8	·2401	58 4	·2404	58·3	·2402	58·3	·2395	58·6	·2383	59·3	·2365	60·3	·2346
	·7964	37·5	·7959	37·2	·7954	37·0	·7950	36·8	·7949	37·0	·7944	37·6	·7965	38·4	·7981
	·9645	27·6	·9658	27·1	·9662	26·6	·9655	26·3	·9640	26·3	·9617	26·9	·9590	27·9	·9567
	·5398	55·4	·5395	55·1	·5391	54 8	·5385	54 6	·5380	54·6	·5380	55·1	·5385	55·9	·5398
	·9963	61·4	·9975	61·0	·9983	60 6	·9984	60·3	·9979	60·2	·9966	60·5	·9946	61·3	·9924
	·8042	14·4	·8055	14·0	·8061	13·6	·8066	13·2	·8060	13·0	·8047	13·3	·8026	14·0	·8004
	·5776	48·0	·5793	47·7	·5804	47·2	·5808	46 7	·5802	46·4	·5787	46·5	·5765	47·1	·5740
	·7957	60·7	·7979	60·4	·7994	59 7	·8000	59·1	·7994	58·6	·7979	58·5	·7955	59·0	·7927
	·1162	39·8	·1181	39·5	·1195	39·0	·1202	38·4	·1200	38·0	·1188	38 0	·1167	38·4	·1143
	·7491	07·1	·7510	07·0	·7526	06 6	·7535	06·1	·7537	05·6	·7538	05·4	·7514	05·6	·7493
	·5257	14 1	·5275	14·1	·5290	13·8	·5301	13·3	·5305	12·8	·5302	12·5	·5290	12 7	·5273
	·6463	25·4	·6480	25 5	·6495	25 3	·6507	24·7	·6511	24·2	·6509	23·9	·6499	24·0	·6483
	·92[redacted]	09·8	·9283	10·0	·9273	09·9	·9265	09 5	·9262	09·0	·9265	08·6	·9267	08·6	·9274
	·6699	55 8	·6724	56·0	·6747	55·7	·6772	55·1	·6784	54·3	·6784	53·7	·6773	53·5	·6752
	·6850	57·1	·6869	57·4	·6887	57·4	·6902	57·0	·6911	56·4	·6912	56·0	·6906	55·8	·6893
	·5522	59 2	·5539	59·6	·5556	59·7	·5571	59·4	·5580	58·9	·5582	58·5	·5578	58·3	·5569
	·1759	10·3	·1744	10·9	·1730	11·0	·1720	10·8	·1714	10·3	·1713	09 9	·1716	09·7	·1722
	·8497	23·4	·8519	24·1	·8547	24·2	·8575	23 8	·8598	23·1	·8610	22 4	·8610	21·8	·8599
	·7343	52·7	·7363	53·4	·7387	53·7	·7412	53 6	·7431	53·1	·7442	52·5	·7443	52·1	·7434
	·0958	17·8	·0942	18·5	·0929	18 9	·0919	18·9	·0915	18·6	·0916	18·1	·0919	17·8	·0924
	·3265	20 6	·3283	21·4	·3302	21·8	·3319	21·8	·3330	21·5	·3335	21·0	·3334	20·7	·3328
	·9000	40·2	·8984	41·0	·8968	41·5	·8955	41·6	·89 9	41·4	·8947	41·0	·8950	40·6	·8955
	·5937	25·3	·5952	26·2	·5974	26 8	·5998	27·0	·6019	26 8	·6034	26·4	·6041	26·0	·6037
	·4323	60·0	·4337	60 9	·4357	61·6	·4280	61 9	·4401	61·7	·4415	61·4	·4422	61·0	·4420
	·5613	49·7	·5629	50·5	·5648	51·2	·5668	51·4	·5632	51·3	·5690	51·0	·5693	50 7	·5699

EXPLANATION OF THE GEODETIC TABLES.

The elements of the figures of the earth on which these 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 489 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 is required, to first interpolate N sin 1″ for the latitude, and then to multiply the result by the cosine of that latitude.

For P sin 1″ = N. sin 1″ × cos ϕ.

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 angle subtended by this deflection angle at a distance of one chain. By means of it the deflection angle may be turned off without any reading of the angle on the instrument. Thus, suppose we are running on the 6th Base and come to a township corner. The instrument say, is 15 chs. back (east) from the corner, and a picket is planted forward on the chord produced at a distance of say 10 chs. beyond the corner. Then, to lay off the angle—take from the table for the 6th Base the deflection offset 1·4930 inches. Then plant the back-picket 1·4930 × 15 = 22·4 inches to the south of the instrument station. Carry the instrument forward and set it up over a point 1·4930 × 10 = 14·9 inches north of the foresight, and produce the line forward from the backsight.

In the column headed "Longitude for one range" is given the number of seconds of time to be applied to a chronometer to correct it for the longtitude gained in going west from one corner of the township to the other. In other words, if a watch or chronometer be carried westward across a township it will be that number of seconds faster, if it has no gaining or losing rate of its own.

TABLE IV.

This table gives for correction lines the chord azimuths, deflection and deflection offsets for running the chords along the *south* side of the road allowance. To run the *north* side it is necessary to apply the correction given in Table VI.

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 longtitude 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 is a correction which must be applied to every half-mile on the correction line in order to distribute the convergence or divergence of meridans equally all along the line. For the township line midway between the base and correction line, this correction must be divided by two.

TABLE V.

Gives chains in decimals of a township for convenience of computation of azimuth, &c.

TABLE VI.

Gives quantities required for running along the north side of the road on correction lines, and also the "correction to width of the road on account of curvature." On account of the curvature of the earth, the road allowance along a correction line is of unequal width. If the south side of the road is being run; if it is required to plant a township corner on the north side, the quantity taken from the table is *subtractive* from the width (1·50 chs.) of the road allowance. If the north side is being run, to plant a township corner on the south side, the correction must be added to the width of the road.

TABLE VII.

The township side being a chord of the circle of latitude, it lies north of the parallel at all points except the township corners. Hence, the true latitude of any intermediate post on the chord is equal to the tabulated latitude of the base or correction line, plus the quantity given in the table.

This table is to be used in tying in and correcting a line at an Astronomical Station.

W. F. K.

GEODETIC TABLE No. 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	9·9849 92	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
53 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				

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GEODETIC TABLE No. II.

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

No. of Township.	Number of Line.	Latitude.	Log. N sin. 1″.	Log. P sin. 1″.	Log. R sin. 1″.	Longitude covered by 489 Chains of westing.
		° ′ ″				′ ″
0	1st Base	49 00 00·00	0·1875572	0·0045001	0·1862852	8 03·959
2	Correction	10 36 86	5618	0·0029573	2989	05·681
4	2nd Base	21 13·70	5662	0·0014047	3122	07·421
6	Correction	31 50·52	5707	9·9998425	3256	09·177
8	3rd Base	42 27·33	5751	9·9982704	3391	10·951
10	3rd Correction	49 53 04·12	0·1875797	9·9966886	0·1863527	8 12·743
12	4th Base	50 03 40 89	5842	9·9950968	3662	14·552
14	Correction	14 17 64	5887	9·9934951	3797	16·379
16	5th Base	24 54·37	5932	9·9918831	3931	18·225
18	Correction	35 31·08	5976	9·9902611	4064	20·089
20	6th Base	50 46 07·77	0·1876021	9·9886289	0 1864198	8 21·972
22	Correction	56 44·44	6065	9·9869863	4331	23 875
24	7th Base	51 07 21·09	6110	9 9853334	4466	25·796
26	Correction	17 57·72	6154	9·9836700	4599	27·737
28	8th Base	28 34·33	6199	9·9819961	4733	29·698
30	8th Correction	51 39 10·92	0·1876243	9·9803116	0·1864867	8 31·678
32	9th Base	49 47·49	6287	9 9786163	4998	33·680
34	Correction	52 00 24·04	6332	9·9769104	5131	35·701
36	10th Base	11 00·57	6376	9·9751934	5264	37·744
38	Correction	21 37·08	6420	9·9734657	5395	39·808
40	11th Base	52 32 13·57	0·1876464	9·9717267	0·1865529	8 41·894
42	Correction	42 50 04	6508	9·9699768	5661	44·001
44	12th Base	53 26·49	6552	9·9682156	5791	46·130
46	Correction	53 04 02 92	6595	9·9664429	5920	48·282
48	13th Base	14 39·33	6640	9·9646592	6055	50·456
50	13th Correction	53 25 15·73	0·1876683	9·9628636	0·1866185	8 52·654
52	14th Base	35 52·11	6727	9·9610566	6316	54·875
54	Correction	46 28·47	6771	9 9592380	6448	57·119
56	15th Base	57 04·81	6813	9·9574073	6576	59·388
58	Correction	54 07 41·13	6857	9·9555649	6706	9 01·681
60	16th Base	54 18 17·43	0·1876900	9·9537104	0·1866836	9 03·999
62	Correction	28 53·71	6943	9·9518440	6966	06·342
64	17th Base	39 29·97	6986	9·9499653	7094	08·711
66	Correction	50 06·21	7029	9 9480743	7224	11·105
68	18th Base	55 00 42·43	7071	9·9461708	7349	13·526
70	18th Correction	55 11 18·64	0·1877115	9·9442550	0·1867482	9 15·973
72	19th Base	21 54·83	7158	9·9423264	7609	18·447
74	Correction	32 31·00	7200	9·9403851	7736	20·949
76	20th Base	43 07·15	7242	9·9384308	7863	23·479
78	Correction	53 43·28	7284	9 9364638	7989	26·037
80	21st Base	56 04 19·39	0·1877326	9·9344835	0·1868115	9 28·624
82	Correction	14 55·48	7369	9 9324901	8243	31·240
84	22nd Base	25 31·55	7411	9·9304833	8370	33·886
86	Correction	36 07·61	7453	9 9284632	8194	36·561
88	23rd Base	46 43·65	7495	9 9264294	8618	39·268
90	23rd Correction	56 57 19·67	0·1877535	9·9243817	0·1868742	9 42 005
92	24th Base	57 07 55·67	7578	9 9223205	8869	44·774
94	Correction	18 31·65	7619	9 9202450	8993	47·575
96	25th Base	29 07·62	7661	9·9181557	9120	50·409
98	Correction	39 43·57	7702	9 9160520	9242	53·2.6

GEODETIC TABLE No. II.—*Continued.*

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

No. of Township.	Number of Line.	Latitude.	Log. N. sin. 1″.	Log. P. sin. 1″.	Log. R. sin. 1″.	Longitude covered by 489 Chains of westing.
		° ′ ″				′ ″
100	26th Base	57 50 19·50	0·1877743	9·9139339	0·1869366	9 56·176
102	Correction	58 00 55·41	7784	9 9118014	9489	59·111
104	27th Base	11 31·30	7825	9 9096541	9610	10 02·081
106	Correction	22 07·17	7865	9 9074921	9732	05·085
108	28th Base	32 43·03	7906	9 9053151	9854	08·126
110	28th Correction	58 43 18·87	0·1877947	9·9031229	0·1869976	10 11·204
112	29th Base	53 54·69	7987	9 9009156	0·1870096	14·318
114	Correction	59 04 30·49	8027	9 8986928	0217	17·470
116	30th Base	15 06·28	8067	9 8964544	0338	20·661
118	Correction	25 42·05	8107	9 8942003	0457	23·891
120	31st Base	59 36 17·80	0·1878147	9·8919303	0·1870577	10 27·160
122	Correction	46 53·53	8187	9 8896443	0696	30·470
124	32nd Base	57 29·25	8226	9 8873419	0813	33·821
126	Correction	60 08 04·95	8265	9·8850232	0931	37·214

GEODETIC TABLE No. III.

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

Number of Base Line.	Chord Azimuth.	Chord Azimuth.	Deflection.	Deflection.	Deflection Offset for 1 chain distance.	Longitude covered by 1 range.
	° ′ ″	°	′ ″	°	inches.	s
1	89 56 57·4	89·9493	6 05·2	0·1014	1·402	32·3
2	55·1	·9486	09·8	·1027	1·420	32·5
3	52·8	·9480	14·5	·1040	1·438	32·7
4	50·4	·9473	19·2	·1053	1·456	33·0
5	48·0	·9467	24.0	·1067	1·474	33·2
6	89 56 45·6	89·9460	6 28·8	0·1080	1·493	33·5
7	43·1	·9453	33·8	·1094	1·512	33·7
8	40·6	·9446	38·8	·1108	1·531	34·0
9	38·1	·9439	43·8	·1122	1·551	34·2
10	35·5	·9432	49·0	·1136	1·570	34·5
11	89 56 32·9	89·9425	6 54·3	0·1151	1·591	34·8
12	30·2	·9417	59·6	·1165	1·611	35·1
13	27·5	·9410	7 05·0	·1180	1.632	35·4
14	24·8	·9402	10·5	·1196	1·653	35·7
15	21·9	·9394	16·1	·1211	1·674	36·0
16	89 56 19·1	89·9386	7 21·8	0·1227	1·696	36·3
17	16·2	·9378	27·6	·1243	1·719	36·6
18	13·3	·9370	33·5	·1260	1·741	36·9
19	10·3	·9362	39·5	·1276	1·764	37·2
20	07·2	·9353	45·6	·1293	1·788	37·6
21	89 56 04·1	89·9345	7 51·8	0·1310	1·812	37·9
22	01·0	·9336	58·1	·1328	1·836	38·3
23	89 55 57·7	·9327	8 04·6	·1346	1·861	38·6
24	54·4	·9318	11·2	·1364	1·886	39·0
25	51·0	·9308	17·9	·1383	1·912	39·4
26	89 55 47·7	89·9299	8 24·7	0·1402	1·938	39·7
27	44·2	·9289	31·7	·1421	1·965	40·1
28	40·6	·9279	38·8	·1441	1·992	40·5
29	37·0	·9269	46·0	·1461	2·018	41·0
30	33·3	·9259	53·4	·1482	2·048	41·4
31	89 55 29·5	89·9249	9 01·0	0·1503	2·077	41·8
32	25·7	·9238	08.7	·1524	2·107	42·3

GEODETIC TABLE No. IV.

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

Number of Correction Line.	Chord Azimuth.	Chord Azimuth.	Deflection.	Deflection.	Deflection Offset for one chain distance.	Length of one Range on Correction Line		Jog.	Convergence or Divergence on half Section.
						North side of Road.	South side of Road.		
	° ′ ″	°	′ ″	°	in inches.	chains.	chains.	chains.	links.
1	89 56 56·9	89·9491	6 06·2	0·1017	1·406	490 7514	487·2659	3·4855	14·5
2	54·6	·9485	10·8	·1030	1·424	·7733	·2442	·5291	14·7
3	52·3	·9479	15·5	·1043	1·442	·7957	·2221	·5736	14·9
4	49·9	·9472	20·2	·1056	1·460	·8184	·2000	·6184	15·1
5	47·5	·9465	25·0	·1069	1·478	·8412	·1770	·6642	15·3
6	89 56 45·1	89 9459	6 29·8	0·1083	1 497	490·8646	487·1539	3·7107	15·5
7	42·7	·9452	34·7	·1096	1·516	·8884	·1307	·7577	15·7
8	40·2	·9445	39·7	·1110	1·535	·9126	·1071	·8055	15·9
9	37·6	·9438	44·8	·1124	1·554	·9369	·0828	·8541	16·1
10	35·0	·9430	50·0	·1139	1·574	·9620	·0585	·9035	16·3
11	89 56 32 4	89 9423	6 55·2	0 1153	1·594	490·9871	487·0336	3·9535	16·5
12	29·7	·9416	7 00·6	·1168	1·615	491·0124	·0080	4 0044	16 7
13	27·0	·9408	06·0	·1183	1·636	·0389	486·9824	·0565	16 9
14	24·3	·9401	11·5	·1199	1·657	·0656	·9566	·1090	17·1
15	21·5	·9393	17·1	·1214	1·678	·0926	·9299	.1627	17·3
16	89 56 18 6	89·9385	7 22·8	0·1230	1·700	491·1199	486·9030	4·2169	17·6
17	15·7	·9377	28·6	·1246	1·722	·1480	·8754	·2726	17·8
18	12 8	·9369	34·5	·1262	1·745	·1763	·8476	·3287	18 0
19	09·8	·9360	40·5	·1279	1·768	·2055	·8190	·3865	18·3
20	06·7	·9352	46 6	·1296	1·791	·2349	·7903	·4446	18·5
21	89 56 03·6	89·9343	7 52·8	0·1313	1·815	491·2648	486·7607	4·5041	18·8
22	00 5	·9335	59·1	·1331	1 840	·2954	·7307	·5647	19·0
23	89 55 57·2	·9325	8 05·6	·1349	1·864	·3265	·6998	·6267	19·3
24	54·0	·9317	12·1	·1367	1·890	·3584	·6688	·6896	19 5
25	50·6	·9307	18·8	·1385	1·915	·3908	·6373	·7535	19·8
26	89 55 47 2	89·9298	8 25·7	0·1405	1·942	491·4238	486·6047	4·8191	20·1
27	43·7	·9288	32·6	·1424	1 968	·4573	·5717	·8856	20·4
28	40·2	·9278	39·7	·1444	1·996	·4915	·5377	·9538	20·6
29	36·5	·9268	47·0	·1464	2·023	·5268	·5036	5·0232	20·9
30	32 8	·9258	54·4	·1484	2·052	·5625	·4684	·0941	21·2
31	89 55 29·1	89·9247	9 01·9	0·1505	2·081	491·5993	486·4327	5·1666	21·5
32	25·2	·9237	09·6	·1527	2·110	·6364	·3962	·2402	21·8

Correction Lines.

Range on Line	Jog.	Convergence or Divergence on half Section.
ıth side Road.		
chains.	chains.	links.
37·2659	3·4855	14·5
·2442	·5291	14·7
·2221	·5736	14·9
·2000	·6184	15·1
·1770	·6642	15·3
37·1539	3·7107	15·5
·1307	·7577	15·7
·1071	·8055	15·9
·0828	·8541	16·1
·0585	·9035	16·3
37·0336	3·9535	16·5
·0080	4·0044	16·7
36·9824	·0565	16·9
·9566	·1090	17·1
·9299	·1627	17·3
36·9030	4·2169	17·6
·8754	·2726	17·8
·8476	·3287	18·0
·8190	·3865	18·3
·7903	·4446	18·5
36·760	·5041	18·8
·7307	·5647	19·0
·6998	·6267	19·3
·6688	·6896	19·5
·6373	·7535	19·8
36·6047	4·8191	20·1
·5717	·8856	20·4
·5377	·9538	20·6
·5036	5·0232	20·9
·4684	·0941	21·2
36·4327	5·1666	21·5
·3962	·2402	21·8

GEODETIC TABLE No. V.

To reduce chains to decimals of a Township side (489 chains.)

Chains.	Equivalent Decimal of a Tp. side.	Chains.	Equivalent Decimal of a Tp. side.	Chains.	Equivalent Decimal of a Tp. side.
1	0·00204	10	0·02045	100	0·20450
2	0·00409	20	0·04090	200	0·40900
3	0·00613	30	0·06135	300	0·61350
4	0·00818	40	0·08180	400	0·81800
5	0·01022	50	0·10225		
6	0·01227	60	0·12270		
7	0·01431	70	0·14315		
8	0·01636	80	0·16360		
9	0·01840	90	0·18405		

GEODETIC TABLE No. VI.

Corrections to be applied to the tabular quantities in Table No when the north side of the road allowance on Correction Lines is run instead of the south; also correction to road allowance on account of curvature:

Number of Correction Line.	Correction to Chord Azimuth.	Correction to Deflection Offset (for one chain distance)	Correction to width of road allowance on account of curvature.									
			jog. =30 chs.	jog. =40 chs.	jog. =50 chs.	jog. =60 chs.	jog. =70 chs	jog. =80 chs.	jog. =90 chs.	jog. =100 chs.	jog. =110 chs.	jog. =120 chs.
	"	inches.	lks.	lks.	lks.	lks.	lks.	lks.	lks.	lks.	lks.	lks.
1st....	—1·3	+0·010	2·5	3·2	3·9	4·6	5·2	5·8	6·4	7·0	7·5	7·9
11th...	—1·7	+0·013	2·8	3·7	4·5	5·2	6·0	6·7	7·3	7·9	8·5	8·9
21st....	—2·2	+0·017	3·2	4·2	5·2	6·0	6·9	7·7	8·4	9·1	9·8	10·4
31st....	—2·9	+0·022	3·7	4·8	5·9	6·9	7·9	8·8	9·6	10·4	11·2	11·9

GEODETIC TABLE No. VII.

SHEWING the difference of latitude between Township corners and section and quarter-section posts on a Township chord. To be used in closing on Astronomical Stations.

Number of Line.	$d\phi$ For ½ sec. from corner.	$d\phi$ For 1 sec. from corner.	$d\phi$ For 1½ secs. from corner.	$d\phi$ For 2 secs. from corner.	$d\phi$ For 2½ secs. from corner.	$d\phi$ For 3 secs. from corner.
	"	"	"	"	"	"
1st Base	0·02 lks.	0·04 lks.	0·05 lks.	0·06 lks.	0·07 lks.	0·07 lks.
do	3·2 "	5·9 "	8·0 "	9·5 "	10·3 "	10·8 "
11th Base	0·02 lks.	0 04 lks.	0·06 lks,	0·07 lks.	0·08 lks.	0·08 lks.
do	3·6 "	6·7 "	9·1 "	10·8 "	11·8 "	12·1 "
21st Base	0·03 lks.	0·05 lks.	0·07 lks,	0·08 lks.	0·09 lks.	0·09 lks.
do	4·2 "	7·7 "	10·3 "	12 3 "	13·3 "	13·8 "
31st Base	0·03 lks.	0·06 lks.	0·08 lks.	0·09 lks.	0·10 lks.	0·11 lks.
do	4·8	8·8	12·0	14·4	15·6	16·2