# INSTRUCTIONS FOR SETTLEMENT SURVEYORS ON DEMESNE LANDS OF THE CROWN.

## PREFACE.

THE general survey of this colony in the meantime comprehends two distinct branches only, viz. Geographical and Settlement, or, in other words, standard and sectional; and it may be anticipated that this will be the case till the advancement of wealth and increase of scientific institutions permit of pure geodetic problems being undertaken and investigated by the department. Operations confined to Geographical and Settlement.

The Geographical Branch will be based on astronomical and electric telegraph observations, combined with major triangulation, or—time and the calls of the settlers not permitting this—with meridional circuit; these again will govern minor triangulation. Minor triangulation, being executed on the principles of plane trigonometry, is not included in the Geographical but in the Settlement Branch; it however, thus stands as a link or key between the two main processes. And it must be remarked that though neither the meridional circuit nor major trigonometrical surveys are sufficiently refined to independently solve pure globe-form problems, yet as geographical values of their points or trigonometrical stations are determined on the surface of the earth with the assistance of geodetic formulæ and data supplied by great or primary triangulation executed elsewhere, these points or trigonometrical stations are called geodesical. Geodesical data determined by great triangulation made use of, but not independently observed.

These instructions are confined to settlement or section survey, so do not touch on the ruling processes.

## MINOR TRIANGULATION.

The surveyor requires to be specially provided with a 5-inch theodolite, logarithm tables, standard chains, and thermometer. The surveys extend over an area of 14 miles square,* called survey districts, and which are apportioned on the maps of the standard survey of the colony. Instruments. Survey districts.

In triangulating a survey district or a portion thereof, choose a level piece of ground centrical or most convenient for the measurement of a base. The line should be chipped and otherwise prepared, and should be of about two miles in length. Before commencing the measurement of the base, lay down on the ground a chain's length by your standard chain—adjusted to 62° Fahrenheit—for reference. Try your chain on this at the commencement and ending of actual measurements. During measurements observe temperatures (the co-efficient to be used may be ·000007 for each degree) for correction of expansions and contractions of chain, which have to be applied in calculations. Hold chain when in use with an equal tension, and mark the ends on flat-boards spiked into the ground. These flat-boards should have a hollow filled with lead, for receiving the end marks made by a sharp instrument. Three boards are used, the hinder being always carried forward. Measure the base thus: forward and back again, and take the mean. Angles of inclination should be observed for reduction to true level. Base line.

Should a major triangulation cover the area to be surveyed, no measured base will be necessary, but the distances of minor trigonometrical stations will be obtained by "breaking down" the larger triangles. Where base need not be measured.

* Unless where other areas are already in use.

True bearing, how obtained.

Fix your trigonometrical stations at $2\frac{1}{2}$-mile distances, more or less, and in order to extend the true meridian from the geographical into the settlement survey, proceed to one of the geodesical or major trigonometrical stations, and set your instrument on the bearing given in the standard maps. This done, if you have an Everest theodolite, take from thence three sets of observations to each minor trigonometrical station in view; the vernier A of instrument being placed at Zero, 120 and 240 degrees of the horizontal limb respectively—thus you have nine readings; but if you have a plain theodolite, take four sets of observations, the vernier A of instrument being placed at Zero, 90, 180 and 270 degrees respectively—thus you have eight readings. This done, proceed to the next minor trigonometrical station, observing the bearings in like manner, so as to complete the three angles of each triangle. Select your points so as to have well-conditioned triangles—no angle being less than 30°, unless under very exceptional circumstances. Avoid crossing triangles, or one bearing over another bearing, so that each triangle may appear on the maps distinct from others.

Calculation of triangles, and reduction.

The differences of the means of bearings will give the value of the angles of each triangle; sum these up, and note the correction, one-third of which + or − for calculation will have to be applied to each angle. Also in each side the mean of the opposite bearings will have to be taken. The logarithms should be taken out to seven places, and the angles to seconds. This being completed, and so all the sides and angles being known, calculate all your stations on the meridian and perpendicular of the initial station of the survey district with the same accuracy, and prepare a table of these. This table serves to construct the skeleton maps by standard scale and beam compass from the above data, which, being mathematically calculated, is greatly more correct than mechanical construction by "building" with scale and protractor.

Confine operations to actual necessities.

If you require to measure a base, carry on your minor triangulation from it to the sectional survey you wish to cover; but if you base your work on major triangulation already executed, carry your triangles from thence in the most direct course to such section survey in hand, and execute no more work than is necessary for checking the chain measurements of this.

Degree of error.

With average care the degree of error in minor triangulation need not exceed 2 links to the mile, so the extreme error allowable is 4 links to the mile, and the summation of angles of a triangle 30″ and 60″, respectively. All work having error in excess of this will require revisal.

Topography.

Combined with your operations, carry on a topographical survey, showing the disposition of natural features and their names, also tracks, ridges, rocks, streams, forests, remarkable objects, natural and artificial, &c.; and construct a map of the same. Observe altitudes of prominent objects, based on the elevations given in the standard maps, and note them in this map. A surveyor of experience, and with a good eye, may generally make a very serviceable sketch-map from his trig. stations, and by theodolite alone, by taking the bearings, cross-bearings, and tangents, with estimated distances of objects; but, if the country be intricate, he will plant his theodolite in intervening positions where necessary, or use prismatic compass on stand when the theodolite cannot be had recourse to.

Trigonometrical stations.

Minor trigonometrical stations should be constructed in the following manner: Gas-pipes, 2 inches internal diameter, are cut to $2\frac{1}{2}$ feet lengths; these are inserted into cast metal plates with sockets, secured by an iron pin. (See Appendix IV.) The

* Where there is not room for laying flat, folios to be placed upright. A specimen will be sent on application.

tube or pipe thus constructed is sunk in the hole prepared for it to a depth of 2 feet 3 inches, with the metal plate downwards. The hole is then re-filled, and the loose soil firmly beaten down. Round this a circular ditch, 20 feet diameter, 1 foot deep, and 18 inches wide, is dug. When in use the trigonometrical tube has a pole carrying a black-and-white flag inserted into it. It is not desirable to build trigonometrical mounds, but in low positions these may be necessary, and of which the surveyor will exercise his own judgment. If mounds be built, they are better to be of stone than of earth or sods. But in peculiar positions and natures of soil the above will require to be modified as specially directed.

Trigonometrical stations are to be indicated in maps by two small concentric pink circles.

Recourse to traverse circuit.

Provided the country to be surveyed is so covered with forest that no minor triangulation can be carried out, then traverse circuit must be had recourse to, which effects the objects of minor triangulation, but necessarily less accurately. Traverse circuit consists in taking a departure from a geodesical major or minor trigonometrical station, and, by careful chain and angular measurements surrounding the block about to be sectionized, returning to the same station again. The ground selected for the traverse should be as level as is possible to obtain; the lines should be cut under the direction of a theodolite, and, if possible, be not less than 10 chains in length.

In forwarding a map of a complete district the surveyor will require to append tables (on foolscap paper) of bearings and distances, angles of triangles, altitudes of stations, and reductions on the meridian and perpendicular; also the mean results of measurements of base line.

## BLOCK AND SECTION SURVEYS.

Instruments.

The surveyor requires to be specially provided with a 5-inch theodolite, chain, beam compass, and Ordnance protractor.

Setting off a block.

No magnetic bearings are admissible, unless under very special circumstances, in minor detail work, and this very sparingly. Flat or undulating country should be laid off in rectangular sections, but in rugged and hilly country the "lay" of the ridges and valleys must modify the disposal and form of these. It is desirable to have all the boundaries on the meridian and perpendicular; but when the general features of the country run obliquely to these, especially in rough districts, the boundaries must be arranged accordingly. The less diversity of bearings the better for the avoidance of errors and multiplication of office work. When necessary, road lines may cross sections diagonally. The boundaries of the block should be cut or pared, and no survey block should exceed on any account in length or breadth the distance of 280 chains ($3\frac{1}{2}$ miles), however much less, or of whatever form they may be. Circuit traverse round a block, being necessarily pared and cut, effects this purpose of itself. If the boundaries of the area to be sectionized exceed $3\frac{1}{2}$ miles, it will be necessary to divide it into two or more survey blocks, which separate blocks can be reduced into one plan for exhibition to the public.

Size of block.

Mode of conducting traverse survey.

In traversing, proceed to the nearest trigonometrical station and base your work on it, setting the zero of the theodolite to true meridian by means of the given bearing to an adjacent trig. station. Unclamp the upper plate, and turn it from left to right until the signal of the forward station is bisected; clamp, and

then record reading of vernier in field book. Then unclamp, and keep turning upper plate in same direction, or towards the right, until the back station is again bisected. A reference to the vernier will show whether the lower plate has remained unmoved. If so, proceed to the next station, and so forth, until you close with another trigonometrical station. Observe angles of elevation and depression, and reduce to horizontal value. (See Appendix I., and of which tables will be printed on cards.) The road lines should be thus traversed in the first place,—the surveyor when on a trig. station having taken careful readings to many of the traverse or subsidiary points, so as to check his positions as he proceeds,—boundaries of sections in the same manner necessary to be measured, in the second place.

Calculate traverse reductions.

In the evenings the surveyor should invariably calculate, mathematically, all his bearings and distances on the meridian and perpendicular, so that no daily actual measurements get in advance of this mode of check to his operations. Enter reductions into form shown in Appendix III., to be forwarded with the map.

Unless where otherwise specially ordered, main road lines should be pegged to a breadth of 1 chain, occupation or by-roads to a $\frac{1}{2}$ chain, main roads 3 to 4 miles apart, by-roads $\frac{3}{4}$ to $1\frac{1}{2}$ miles apart. The opposite angles should be pegged by setting off half the included angle and calculated distance. (See Appendix II., and of which tables will be printed on cards.)

Prior surveys to be investigated.

Having designed and laid off the skeleton of the work by survey and calculation of road traverses, do this also for the exterior boundaries of your block, and at this time investigate all adjacent and included prior claims and their boundaries, for which object copies of the original plans will be furnished you from the head offices. Survey those claims as held by established or indicated marks on the ground, showing the same by dotted lines if the boundaries disagree with your own measurements of what they ought to be. Boundaries as they ought to be will be marked on the plan by continuous lines. If owners of prior claims cannot be found, and if all the marks of their claims are obliterated, then it will be competent for the surveyor to re-establish the boundaries by his own actual survey.

Pegs, how made and placed.

All pegs should be sawn or dressed totara, kowhai (goay), blue gum, kauri, or matai (black pine), 3 inches by 2 inches, in scantling 2 feet long, put $1\frac{1}{2}$ foot into the ground, the hole having first been driven by an iron jumper, and a piece of china-ware thrown in. The front pegs of sections must have the numbers of the sections and the letter R branded on them; road traverse pegs will have the letter R and the broad arrow, ranging pegs the broad arrow only. In forest country, at convenient distances, trees on the traverse lines should be blazed, having the linkage marked on the face. Conspicuous trees should also be branded, and their distances and bearings from section corners noted in field-book. Sections in open country must be pegged front and back as well as at every corner, and have ranging pegs placed 3 chains distance from the front ones with the lines pared up to them. In forest, back pegs need not be inserted, but fronts of sections must have, besides the corner pegs, two ranging ones at $\frac{1}{2}$-chain and 3-chain distances. Town sections should be pegged at every corner, unless under forest; where under forest, then back pegs need not be inserted.

Mapping.

In mapping, first set off your meridian and perpendicular on the initial station of your survey,—which must be a trig. station,—by beam compass from the calculated traverse table already prepared; then set off all the skeleton boundaries

and traverses by the same instrument, or by scale and parallel ruler. Ordnance protractor may be used in detail plotting.

Draw measured lines in pink, calculated lines in black, with figures in pink and black respectively. Draw observed bearings in blue, and calculated bearings in black. For minor detail prismatic compass work (which should, if possible, be avoided), use green. Pegs should be marked by a small pink circle in every case.

Having drawn your road lines and boundaries on your map, then design the disposition of sections, adhering as much as possible to the cardinal points for sake of simplicity and the avoidance of error. Disposition of sections.

All pegs in open country should have trenches dug in the following manner: —6 feet long, 9 inches wide, and 9 inches deep at adjacent section frontages, thus—  At traverse boundaries thus—  Pegs to be trenched.



At corners of isolated (spotting) sections thus— 

The distances of the section pegs in the traverse lines already surveyed are to be measured on the ground and noted in the map, and should the section peg be on the opposite side of a road, the calculated distance should be given from adjacent pegs on same side also.

Note accurately all crossings of creeks and tracks in public use; also, make such notes as will give a sketch of the topographical features. Topographical features.

Draw a black marginal line round your map. Show road line and boundary ends of adjacent survey blocks. Draw a scale 12 inches in length; also an inscription in upright letters denoting block and district, name of surveyor, date of survey. Colour water in Prussian blue, roads in sienna, bush in green. Finishing details of maps.

The error attached to traverse survey necessarily varies with the nature of the ground, and, as it is essential for the security of settlers in rural blocks that it should not accumulate above 10 links, it will be advisable to have recourse to triangulation subsidiary to minor, where the country is so rough as to prevent correct chaining. On an average, surveyors can chain a mile within an error of 2 or 4 links; thus a limit of error in traverse has to be assigned, and here it is so at 8 links to the mile. Should the error in closing exceed this limit, the work must be revised. So also, governed by minor triangulation, traverses should close by bearing with an error not exceeding 2 or 3 minutes of arc. In town sections, the number and proximity of marks secure the purchasers. Limit error assigned.

Reserve 100 links frontage to all navigable rivers. Reserve also centres of bushes in sparsely timbered country, stone quarries, gravel and sand pits for road-making, where conveniently situated for trunk and district lines. Reserves.

As the land laws in various parts of the colony require a system of settlement before survey can be carried on, the same principles and practice of survey that have been denoted above may be adhered to, only there are greater difficulties and responsibilities cast on the officers of the department. The objects of advance or pioneer free-selectors may be admitted to certainly consist in a repayment of their enterprise by superior advantages beyond the reach of the general public. To curtail these advantages is in no way the duty of the surveyor, so long as public privileges are not unfairly interfered with. The surveyor of spotting claims must therefore have a care of legitimate public or prescriptive rights—such as in town, village, and ferry sites, roads, water-ways, water-races on gold fields or elsewhere Isolated or spotting surveys.

&c., &c.; and in so doing he may sometimes be opposed by personal pressure; but he is expected to be superior to this. His professional responsibilities are also greater than in block survey, as he is not subject to the same close supervision. The work is also not capable of such satisfactory check, while the inducements to evade toil and trouble are many.

Mode of survey.

In surveying a spotting or isolated claim, the surveyor must proceed to the nearest geodesical or trigonometrical station and connect his section work by minor triangulation, and he will prepare a plan of the section and its connections on special sheets provided for that purpose. But if the claim be near to a trig. station he may connect by traverse.

Case of no geodesical station.

If no geodesical or trigonometrical station be available for connection, it will be the duty of the surveyor to report the circumstance to the head of his department before executing the survey; and in cases where a broken country is covered with forest, preventing minor triangulation or approved traverse circuit, special directions will be given for the survey and sectionizing under such conditions of the locality.

Broken forest country.

Returns.

In regard to monthly returns of block and section work completed, cost, and expenditure, special orders will be issued.

Contract surveys.

Where contract surveys are ordered, the written contract will embrace necessary special conditions.

Field-books.

Field-books to be kept in ink, and when filled up to be returned to the head office. It is to be understood that all field-books and maps, whether of the official or the contract surveyor, are the property of Government. Field-books should be dated for each survey, and their contents indexed.

Repairs to trigonometrical stations.

Report if not able to repair all trigonometrical stations that are seen to be dilapidated.

## OFFICE RECORD.

Record of maps.

Not less important than the field survey is the preservation of records. If the cost of surveys since the commencement of the colonization of New Zealand could be correctly summed up, it would be found to represent an immense amount. Several offices in the colony now have maps whose construction has cost from £100,000 to £200,000 sterling. Surely the preservation of these in good order is a serious duty. It is therefore essential that records be kept in a fire-proof safe, and which being necessarily of limited dimensions, the mode of doing so demands compactness and economy of space.

Facts considered.

In directing this duty, the following fact in regard to maps is attended to—namely, that sheets of paper of moderate size kept flat remain, after twenty or thirty years' use, in good condition, which is not the case with sheets rolled up, subject to be continuously unfolded. Hence, in initiating a general system of map record, the above is the primary consideration.

Size of folios.

As the working plans are the most valuable,—the originals of which when once destroyed never being entirely replaceable of equal value as evidence,—the first care of the surveyor should be to these. Thus working plans, whether of meridional circuits, major triangulations, minor triangulations, or block surveys, should be drawn on antiquarian paper, cut to 30 inches square. These are laid flat, in folios 33 inches square, which again slide into level shelves 34 inches square, constructed in a closed press, set up in the fire-proof safes attached to the Survey Offices. In this manner all the primarily important maps are compact

secured in a small space. The working plans of isolated sections are also kept in folios 18 inches by 16 inches. All these plans should remain unmounted. The compiled or index plans, however, being unavoidably of large size (56 inches square),* are mounted, and kept in rolls; but these if destroyed are replaceable, containing as they do no original work. The tops and bottoms of those maps should have thin laths adhered to them, and extra-fastened with copper tacks. This prevents the paper breaking and creasing.

The following are the scales to be used in surveys:— Scales.

*Working Plans.*

| | | | | |
|---|---|---|---|---|
| Town section ... | ... | 2 chains or $\frac{1}{40}$ | mile | to an inch. |
| Rural „ ... | ... | 10 „ | $\frac{1}{8}$ „ | „ |
| Minor triangulations | ... | 40 „ | $\frac{1}{2}$ „ | „ |
| Topographical | ... | 40 „ | $\frac{1}{2}$ „ | „ |
| Meridional circuit | ... | 320 „ | 4 „ | „ |
| Major triangulations | ... | 320 „ | 4 „ | „ |
| Reconnaissance | ... | 160 „ | 2 „ | „ |
| Index maps ... | ... | 80 „ | 1 „ | „ |

*Copied or Compiled Plans.*

| | | | |
|---|---|---|---|
| Town or village selection maps | ... | 5 or 10 | chains to an inch. |
| „ „ Crown grant record maps | | 2 „ | „ |
| Rural selection maps (after survey)... | | 10 „ | „ |
| „ „ „ (before survey) | | 40 „ | „ |
| Crown grant record maps (rural) | ... | 20 „ | „ |
| Territorial maps | ... | ... 4 or 8 | miles „ |

*Extreme Areas contained in Plans.* Areas.

| | | | | |
|---|---|---|---|---|
| Working plans of Town sections | ... | $\frac{7}{10}$ | miles | square. |
| „ Rural „ | ... | ~~3¼~~ | miles | „ |
| „ Minor triangulations | ... | ~~13†~~ | „ | „ |
| „ Topographical | ... | ~~13†~~ | „ | „ |
| „ Reconnaissance | ... | 112 | „ | „ |
| „ Major triangulations | ... | 112 | „ | „ |
| „ Meridional circuit | ... | 112 | „ | „ |

3 1/8

12 1/2

12 1/2

The above are suitable for keeping in the fire-proof safes.

Wall maps may be of any size and scale. As the computations form a very important part of the practical work of the office, computation books should be of one size, so as to fit the shelves in the safe. The size should be a little above the ordinary foolscap, and the books should be numbered, paged, and the contents indexed, for easy reference.

## QUALIFICATIONS FOR ENTRY INTO AND PROMOTION IN THE SURVEY DEPARTMENT.

The candidate for an apprenticeship must exhibit a certificate of his having passed the Junior Examination under "The Civil Service Act, 1866," and Regulations dated 15th June, 1876, *New Zealand Gazette*, No. 34. Besides the above, a satisfactory departmental inquiry as to good eyesight for observing, a healthy constitution, a legible hand, and taste for drawing are necessary to qualify.

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* Unless where already in use of other dimensions. † Unless where other areas are already in use.

During apprenticeship (which extends over three years—one in office, two in the field) the Senior Examination of the Civil Service Act and Regulations above quoted must be passed, otherwise no future engagement nor promotion is guaranteed. If this be passed, it will also be necessary to undergo a departmental inquiry as to knowledge of the use and adjustment of the theodolite, and aptness in map-drawing. A certificate of good conduct and competence from a Crown Lands Surveyor must also be shown. These requirements being complied with qualify for promotion into the grade of actual or section surveyor.

In order to obtain employment in the geographical or standard branch, a knowledge of spherical trigonometry and algebra will be necessary; the use and adjustment of sextant, alt-azimuth, and transit instruments; also of practical astronomy, particularly in reference to latitude, longitude, and true meridian.

## CONTRACT SURVEY.

As it is probable that a considerable portion of the general operations, particularly in regard to triangulation and block survey (but not spotting or isolated sections), will be executed by contract, in dealing with this the following principles will be recommended to the authorities for approval:—

Professional responsibility.

1. A surveyor when he contracts cannot be allowed to divest himself of professional responsibility, because the greater part of his work, being hidden from view and spread over large areas, cannot be fully inspected. Thus a contractor for surveys occupies quite a different position from a contractor for mechanical, engineering, or architectural work, over which inspection is done without difficulty.

Qualification.

2. No surveyor can be considered qualified to be a contractor unless he has had five years' experience in an approved system.

Limit of contractors.

3. Thus, to recommend to the authorities for acceptance the tenders of all classes of surveyors, good, bad, and indifferent, would be subversive of the interests of land purchasers, by risking inferior and inaccurate work.

List of qualified.

4. Hence, in the first place, this department will carefully prepare a list (for office use only) of all surveyors in the colony known to be qualified, and who will be asked to act.

Recommendation on first tender.

5. Others, not included in this list, before tendering for survey contracts, will require to apply to a Chief Surveyor; and if such officer feel himself justified in attesting to, under the above conditions of experience, his personal knowledge of the competency, and his confidence in the integrity, of the surveyor, a certificate to this effect should accompany his first tender.

*Revision of Surveys of Lands already Alienated from the Crown.*

Special instructions will be drawn up for the carrying out of these.

# APPENDICES REFERRED TO.

## APPENDIX I.

TABLE OF LINKS TO BE DEDUCTED FROM EACH CHAIN OF 100 LINKS IN MEASURING SLOPING GROUND.

| Angle. | Links. | Angle. | Links. | Angle. | Links. | Angle. | Links. | Angle. | Links. | Angle. | Links. | Angle. | Links. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ° ′ | | ° ′ | | ° ′ | | ° ′ | | ° ′ | | ° ′ | | ° ′ | |
| 1 9 | ·02 | 16 28 | 4·1 | 23 48 | 8·5 | 29 26 | 12·9 | 34 13 | 17·3 | 38 23 | 21·6 | 42 11 | 25·9 |
| 1 38 | ·04 | 16 40 | 4·2 | 23 57 | 8·6 | 29 33 | 13·0 | 34 19 | 17·4 | 38 28 | 21·7 | 42 16 | 26·0 |
| 2 0 | ·06 | 16 52 | 4·3 | 24 5 | 8·7 | 29 40 | 13·1 | 34 25 | 17·5 | 38 34 | 21·8 | 42 21 | 26·1 |
| 2 18 | ·08 | 17 4 | 4·4 | 24 13 | 8·8 | 29 47 | 13·2 | 34 31 | 17·6 | 38 39 | 21·9 | 42 27 | 26·2 |
| 2 34 | ·1 | 17 16 | 4·5 | 24 22 | 8·9 | 29 54 | 13·3 | 34 37 | 17·7 | 38 45 | 22·0 | 42 31 | 26·3 |
| 3 38 | ·2 | 17 27 | 4·6 | 24 30 | 9·0 | 30 0 | 13·4 | 34 43 | 17·8 | 38 50 | 22·1 | 42 37 | 26·4 |
| 4 27 | ·3 | 17 39 | 4·7 | 24 38 | 9·1 | 30 7 | 13·5 | 34 49 | 17·9 | 38 56 | 22·2 | 42 42 | 26·5 |
| 5 8 | ·4 | 17 50 | 4·8 | 24 46 | 9·2 | 30 14 | 13·6 | 34 55 | 18·0 | 39 1 | 22·3 | 42 47 | 26·6 |
| 5 44 | ·5 | 18 1 | 4·9 | 24 55 | 9·3 | 30 21 | 13·7 | 35 1 | 18·1 | 39 7 | 22·4 | 42 52 | 26·7 |
| 6 17 | ·6 | 18 12 | 5·0 | 25 3 | 9·4 | 30 28 | 13·8 | 35 7 | 18·2 | 39 12 | 22·5 | 42 57 | 26·8 |
| 6 47 | ·7 | 18 23 | 5·1 | 25 11 | 9·5 | 30 35 | 13·9 | 35 13 | 18·3 | 39 18 | 22·6 | 43 2 | 26·9 |
| 7 16 | ·8 | 18 34 | 5·2 | 25 19 | 9·6 | 30 41 | 14·0 | 35 19 | 18·4 | 39 23 | 22·7 | 43 7 | 27·0 |
| 7 42 | ·9 | 18 45 | 5·3 | 25 27 | 9·7 | 30 48 | 14·1 | 35 25 | 18·5 | 39 28 | 22·8 | 43 12 | 27·1 |
| 8 7 | 1·0 | 18 55 | 5·4 | 25 35 | 9·8 | 30 55 | 14·2 | 35 31 | 18·6 | 39 34 | 22·9 | 43 17 | 27·2 |
| 8 31 | 1·1 | 19 6 | 5·5 | 25 43 | 9·9 | 31 1 | 14·3 | 35 37 | 18·7 | 39 39 | 23·0 | 43 22 | 27·3 |
| 8 54 | 1·2 | 19 16 | 5·6 | 25 51 | 10·0 | 31 8 | 14·4 | 35 43 | 18·8 | 39 44 | 23·1 | 43 27 | 27·4 |
| 9 15 | 1·3 | 19 27 | 5·7 | 25 59 | 10·1 | 31 15 | 14·5 | 35 49 | 18·9 | 39 50 | 23·2 | 43 32 | 27·5 |
| 9 36 | 1·4 | 19 37 | 5·8 | 26 7 | 10·2 | 31 21 | 14·6 | 35 55 | 19·0 | 39 55 | 23·3 | 43 37 | 27·6 |
| 9 57 | 1·5 | 19 47 | 5·9 | 26 14 | 10·3 | 31 28 | 14·7 | 36 0 | 19·1 | 40 0 | 23·4 | 43 42 | 27·7 |
| 10 16 | 1·6 | 19 57 | 6·0 | 26 22 | 10·4 | 31 35 | 14·8 | 36 6 | 19·2 | 40 6 | 23·5 | 43 47 | 27·8 |
| 10 35 | 1·7 | 20 7 | 6·1 | 26 30 | 10·5 | 31 41 | 14·9 | 36 12 | 19·3 | 40 11 | 23·6 | 43 52 | 27·9 |
| 10 54 | 1·8 | 20 17 | 6·2 | 26 37 | 10·6 | 31 48 | 15·0 | 36 18 | 19·4 | 40 17 | 23·7 | 43 57 | 28·0 |
| 11 12 | 1·9 | 20 27 | 6·3 | 26 45 | 10·7 | 31 54 | 15·1 | 36 24 | 19·5 | 40 22 | 23·8 | 44 2 | 28·1 |
| 11 29 | 2·0 | 20 37 | 6·4 | 26 53 | 10·8 | 32 1 | 15·2 | 36 30 | 19·6 | 40 28 | 23·9 | 44 7 | 28·2 |
| 11 46 | 2·1 | 20 47 | 6·5 | 27 0 | 10·9 | 32 7 | 15·3 | 36 35 | 19·7 | 40 33 | 24·0 | 44 12 | 28·3 |
| 12 3 | 2·2 | 20 56 | 6·6 | 27 8 | 11·0 | 32 14 | 15·4 | 36 41 | 19·8 | 40 38 | 24·1 | 44 17 | 28·4 |
| 12 19 | 2·3 | 21 6 | 6·7 | 27 15 | 11·1 | 32 20 | 15·5 | 36 47 | 19·9 | 40 43 | 24·2 | 44 22 | 28·5 |
| 12 35 | 2·4 | 21 16 | 6·8 | 27 23 | 11·2 | 32 26 | 15·6 | 36 53 | 20·0 | 40 48 | 24·3 | 44 27 | 28·6 |
| 12 51 | 2·5 | 21 25 | 6·9 | 27 30 | 11·3 | 32 33 | 15·7 | 36 58 | 20·1 | 40 54 | 24·4 | 44 32 | 28·7 |
| 13 6 | 2·6 | 21 34 | 7·0 | 27 38 | 11·4 | 32 39 | 15·8 | 37 4 | 20·2 | 40 59 | 24·5 | 44 36 | 28·8 |
| 13 21 | 2·7 | 21 44 | 7·1 | 27 45 | 11·5 | 32 46 | 15·9 | 37 10 | 20·3 | 41 4 | 24·6 | 44 41 | 28·9 |
| 13 36 | 2·8 | 21 53 | 7·2 | 27 53 | 11·6 | 32 52 | 16·0 | 37 15 | 20·4 | 41 9 | 24·7 | 44 46 | 29·0 |
| 13 50 | 2·9 | 22 2 | 7·3 | 28 0 | 11·7 | 32 58 | 16·1 | 37 21 | 20·5 | 41 15 | 24·8 | 44 51 | 29·1 |
| 14 5 | 3·0 | 22 11 | 7·4 | 28 7 | 11·8 | 33 4 | 16·2 | 37 27 | 20·6 | 41 19 | 24·9 | 44 56 | 29·2 |
| 14 19 | 3·1 | 22 20 | 7·5 | 28 14 | 11·9 | 33 11 | 16·3 | 37 32 | 20·7 | 41 25 | 25·0 | 45 1 | 29·3 |
| 14 33 | 3·2 | 22 29 | 7·6 | 28 22 | 12·0 | 33 17 | 16·4 | 37 38 | 20·8 | 41 30 | 25·1 | 45 6 | 29·4 |
| 14 46 | 3·3 | 22 38 | 7·7 | 28 29 | 12·1 | 33 23 | 16·5 | 37 44 | 20·9 | 41 35 | 25·2 | 45 10 | 29·5 |
| 14 59 | 3·4 | 22 47 | 7·8 | 28 36 | 12·2 | 33 30 | 16·6 | 37 49 | 21·0 | 41 41 | 25·3 | 45 16 | 29·6 |
| 15 13 | 3·5 | 22 56 | 7·9 | 28 43 | 12·3 | 33 36 | 16·7 | 37 55 | 21·1 | 41 46 | 25·4 | 45 20 | 29·7 |
| 15 26 | 3·6 | 23 5 | 8·0 | 28 50 | 12·4 | 33 42 | 16·8 | 38 0 | 21·2 | 41 51 | 25·5 | 45 25 | 29·8 |
| 15 39 | 3·7 | 23 14 | 8·1 | 28 58 | 12·5 | 33 48 | 16·9 | 38 6 | 21·3 | 41 56 | 25·6 | 45 30 | 29·9 |
| 15 51 | 3·8 | 23 22 | 8·2 | 29 5 | 12·6 | 33 55 | 17·0 | 38 12 | 21·4 | 42 1 | 25·7 | 45 35 | 30·0 |
| 16 4 | 3·9 | 23 31 | 8·3 | 29 12 | 12·7 | 34 0 | 17·1 | 38 17 | 21·5 | 42 6 | 25·8 | | |
| 16 16 | 4·0 | 23 39 | 8·4 | 29 19 | 12·8 | 34 7 | 17·2 | | | | | | |

# APPENDIX II.

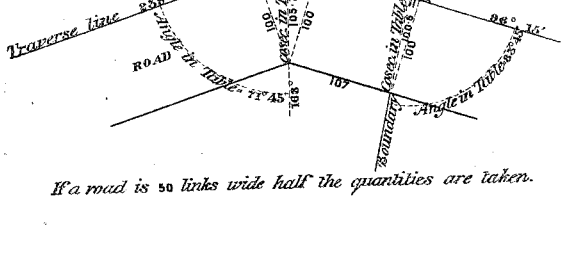
## Table for Setting out the Opposite Angles of a Road.

Natural Cosecants and Cotangents to Radius 100, the greatest difference being ·6.

| Angle. | Cosec. | Cotan. | Angle. | Cosec. | Cotan. | Angle. | Cosec. | Cotan. | Angles. | Cosec. | Cotan. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ° ′ | | | ° ′ | | | ° ′ | | | ° ′ | | |
| 45 0 | 141·4 | 100·0 | 51 40 | 127·5 | 79·1 | 62 24 | 112·8 | 52·3 | 76 0 | 103·1 | 24·9 |
| 6 | 141·2 | 99·7 | 50 | 127·2 | 78·6 | 36 | 112·6 | 51·8 | 15 | 103·0 | 24·5 |
| 12 | 140·9 | 99·3 | 52 0 | 126·9 | 78·1 | 48 | 112·4 | 51·4 | 30 | 102·8 | 24·0 |
| 18 | 140·7 | 99·0 | 10 | 126·6 | 77·7 | 63 0 | 112·2 | 50.9 | 45 | 102·7 | 23·5 |
| 24 | 140·4 | 98·6 | 20 | 126·3 | 77·2 | 12 | 112·0 | 50·5 | 77 0 | 102·6 | 23·1 |
| 30 | 140·2 | 98·3 | 30 | 126·0 | 76·7 | 24 | 111·8 | 50·1 | 15 | 102·5 | 22·6 |
| 36 | 140·0 | 97·9 | 40 | 125·8 | 76·3 | 36 | 111·6 | 49·6 | 30 | 102·4 | 22·2 |
| 42 | 139·7 | 97·6 | 50 | 125·5 | 75·8 | 48 | 111·4 | 49·2 | 45 | 102·3 | 21·7 |
| 48 | 139·5 | 97·2 | 53 0 | 125·2 | 75·4 | 64 0 | 111·3 | 48·8 | 78 0 | 102·2 | 21·3 |
| 54 | 139·3 | 96·9 | 10 | 124·9 | 74·9 | 15 | 111·0 | 48·2 | 15 | 102·1 | 20·8 |
| 46 0 | 139·0 | 96·6 | 20 | 124·7 | 74·4 | 30 | 110·8 | 47·7 | 30 | 102·0 | 20·3 |
| 6 | 138·8 | 96·2 | 30 | 124·4 | 74·0 | 45 | 110·6 | 47·2 | 45 | 102·0 | 19·9 |
| 12 | 138·6 | 95·9 | 40 | 124·1 | 73·5 | 65 0 | 110·3 | 46·6 | 79 0 | 101·9 | 19·4 |
| 18 | 138·3 | 95·6 | 50 | 123·9 | 73·1 | 15 | 110·1 | 46·1 | 15 | 101·8 | 19·0 |
| 24 | 138·1 | 95·2 | 54 0 | 123·6 | 72·7 | 30 | 109·9 | 45·6 | 30 | 101·7 | 18·5 |
| 30 | 137·9 | 94·9 | 12 | 123·3 | 72·1 | 45 | 109·7 | 45·0 | 45 | 101·6 | 18·1 |
| 36 | 137·6 | 94·6 | 24 | 123·0 | 71·6 | 66 0 | 109·5 | 44·5 | 80 0 | 101·5 | 17·6 |
| 42 | 137·4 | 94·2 | 36 | 122·7 | 71·1 | 15 | 109·3 | 44·0 | 15 | 101·4 | 17·2 |
| 48 | 137·2 | 93·9 | 48 | 122·4 | 70·5 | 30 | 109·0 | 43·5 | 30 | 101·4 | 16·7 |
| 54 | 137·0 | 93·6 | 55 0 | 122·1 | 70·0 | 45 | 108·8 | 43·0 | 45 | 101·3 | 16·3 |
| 47 0 | 136·7 | 93·3 | 12 | 121·8 | 69·5 | 67 0 | 108·6 | 42·4 | 81 0 | 101·2 | 15·8 |
| 6 | 136·5 | 92·9 | 24 | 121·5 | 69·0 | 15 | 108·4 | 41·9 | 15 | 101·2 | 15·4 |
| 12 | 136·3 | 92·6 | 36 | 121·2 | 68·5 | 30 | 108·2 | 41·4 | 30 | 101·1 | 14·9 |
| 18 | 136·1 | 92·3 | 48 | 120·9 | 68·0 | 45 | 108·0 | 40·9 | 45 | 101·0 | 14·5 |
| 24 | 135·9 | 92·0 | 56 0 | 120·6 | 67·5 | 68 0 | 107·9 | 40·4 | 82 0 | 101·0 | 14·1 |
| 30 | 135·6 | 91·6 | 12 | 120·3 | 66·9 | 15 | 107·7 | 39·9 | 15 | 100·9 | 13·6 |
| 36 | 135·4 | 91·3 | 24 | 120·1 | 66·4 | 30 | 107·5 | 39·4 | 30 | 100·9 | 13·2 |
| 42 | 135·2 | 91·0 | 36 | 119·8 | 65·9 | 45 | 107·3 | 38·9 | 45 | 100·8 | 12·7 |
| 48 | 135·0 | 90·7 | 48 | 119·5 | 65·4 | 69 0 | 107·1 | 38·4 | 83 0 | 100·8 | 12·3 |
| 54 | 134·8 | 90·4 | 57 0 | 119·2 | 64·9 | 15 | 106·9 | 37·9 | 15 | 100·7 | 11·8 |
| 48 0 | 134·6 | 90·0 | 12 | 119·0 | 64·4 | 30 | 106·8 | 37·4 | 30 | 100·6 | 11·4 |
| 6 | 134·4 | 89·7 | 24 | 118·7 | 64·0 | 45 | 106·6 | 36·9 | 45 | 100·6 | 11·0 |
| 12 | 134·1 | 89·4 | 36 | 118·4 | 63·5 | 70 0 | 106·4 | 36·4 | 84 0 | 100·6 | 10·5 |
| 18 | 133·9 | 89·1 | 48 | 118·2 | 63·0 | 15 | 106·3 | 35·9 | 15 | 100·5 | 10·1 |
| 24 | 133·7 | 88·8 | 58 0 | 117·9 | 62·5 | 30 | 106·1 | 35·4 | 30 | 100·5 | 9·6 |
| 30 | 133·5 | 88·5 | 12 | 117·7 | 62·0 | 45 | 105·9 | 34·9 | 45 | 100·4 | 9·2 |
| 36 | 133·3 | 88·2 | 24 | 117·4 | 61·5 | 71 0 | 105·8 | 34·4 | 85 0 | 100·4 | 8·7 |
| 42 | 133·1 | 87·9 | 36 | 117·2 | 61·0 | 15 | 105·6 | 33·9 | 15 | 100·3 | 8·3 |
| 48 | 132·9 | 87·5 | 48 | 116·9 | 60·6 | 30 | 105·4 | 33·5 | 30 | 100·3 | 7·9 |
| 54 | 132·7 | 87·2 | 59 0 | 116·7 | 60·1 | 45 | 105·3 | 33·0 | 45 | 100·3 | 7·4 |
| 49 0 | 132·5 | 86·9 | 12 | 116·4 | 59·6 | 72 0 | 105·1 | 32·5 | 86 0 | 100·2 | 7·0 |
| 10 | 132·2 | 86·4 | 24 | 116·2 | 59·1 | 15 | 105·0 | 32·0 | 15 | 100·2 | 6·6 |
| 20 | 131·8 | 85·9 | 36 | 115·9 | 58·7 | 30 | 104·9 | 31·5 | 30 | 100·2 | 6·1 |
| 30 | 131·5 | 85·4 | 48 | 115·7 | 58·2 | 45 | 104·7 | 31·1 | 45 | 100·2 | 5·7 |
| 40 | 131·2 | 84·9 | 60 0 | 115·5 | 57·7 | 73 0 | 104·6 | 30·6 | 87 0 | 100·1 | 5·2 |
| 50 | 130·9 | 84·4 | 12 | 115·2 | 57·3 | 15 | 104·4 | 30·1 | 15 | 100·1 | 4·8 |
| 50 0 | 130·5 | 83·9 | 24 | 115·0 | 56·8 | 30 | 104·3 | 29·6 | 30 | 100·1 | 4·4 |
| 10 | 130·2 | 83·4 | 36 | 114·8 | 56·3 | 45 | 104·2 | 29·1 | 45 | 100·1 | 3·9 |
| 20 | 129·9 | 82·9 | 48 | 114·6 | 55·9 | 74 0 | 104·0 | 28·7 | 88 0 | 100·1 | 3·5 |
| 30 | 129·6 | 82·4 | 61 0 | 114·3 | 55·4 | 15 | 103·9 | 28·2 | 15 | 100·0 | 3·1 |
| 40 | 129·3 | 81·9 | 12 | 114·1 | 55·0 | 30 | 103·8 | 27·7 | 30 | 100·0 | 2·6 |
| 50 | 129·0 | 81·5 | 24 | 113·9 | 54·5 | 45 | 103·6 | 27·3 | 45 | 100·0 | 2·2 |
| 51 0 | 128·7 | 81·0 | 36 | 113·7 | 54·1 | 75 0 | 103·5 | 26·8 | 89 0 | 100·0 | 1·7 |
| 10 | 128·4 | 80·5 | 48 | 113·5 | 53·6 | 15 | 103·4 | 26·3 | 15 | 100·0 | 1·3 |
| 20 | 128·1 | 80·0 | 62 0 | 113·3 | 53·2 | 30 | 103·3 | 25·9 | 30 | 100·0 | ·9 |
| 30 | 127·8 | 79·5 | 12 | 113·0 | 52·7 | 45 | 103·2 | 25·4 | 45 | 100·0 | ·4 |

The Cosecant and Cotangent of the angle nearest to half the angle bisected to be taken.

*EXAMPLE.*

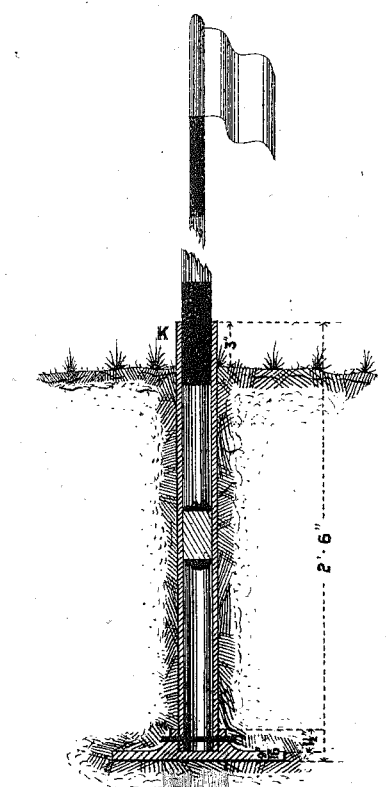


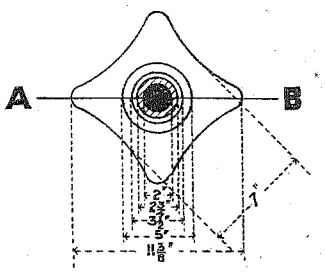

*If a road is* 50 *links wide half the quantities are taken.*

...Traverse of ...Marked ... District, Block V Section 22

| Page of Field Book | *Surveyor's No. of Peg or Trig Stn | Cardinal Direction | True Bearing ° | ' | " | Measured Distance Links | Traverses of each Distance: On Meridian N Links | On Meridian S Links | On Perpendicular E Links | On Perpendicular W Links | Total Traverses from Trig ( V ): On Meridian N Links | On Meridian S Links | On Perpendicular E Links | On Perpendicular W Links | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N E | 336 | 40 | 10 | 4[illegible] | | | | | | | | | |
| | | N W | 310 | 5 | | 272[illegible] | | | | | | | | | |
| | | S W | 226 | 3 | | 1[illegible] | | | | | | | | | |
| | | S W | 62 | 15 | | 4[illegible] | | | | | | | | | |

*Note that Surveyor's numbers should be sawn on back of pegs in Roman figures, & distinct from branded Section numbers in front or side of pegs



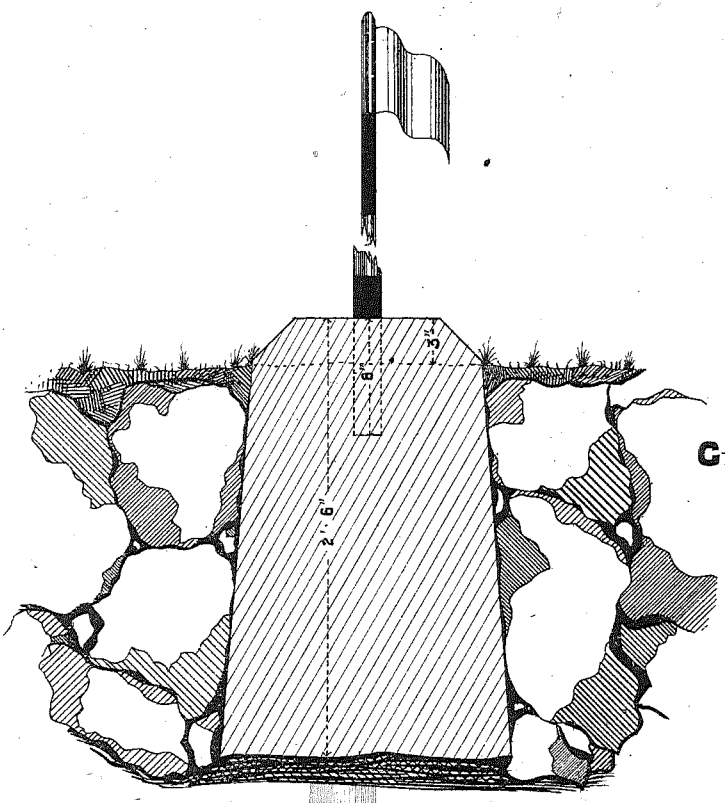



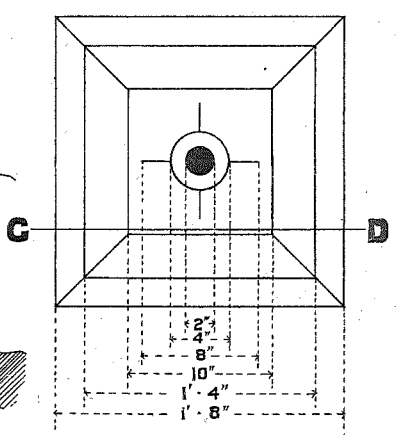

PLAN

SECTION THROUGH A.B.

# TRIG. STATION

weight complete 20lbs.




PLAN

SECTION THROUGH C.D.

# GEODESICAL STATION

—Scale—


Note. To be of Stone if procurable, if not, to be of Portland Cement; if neither be available, a minor Trig. Station Pipe may be used.

# APPENDIX V.

TABLE SHOWING ACRES IN SQUARE MILES.

| Square Miles | Acres. | Square Miles. | Acres. | Square Miles. | Acres. | Square Miles. | Acres. | Square Miles. | Acres. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 640 | 21 | 13,440 | 41 | 26,240 | 61 | 39,040 | 81 | 51,840 |
| 2 | 1,280 | 22 | 14,080 | 42 | 26,880 | 62 | 39,680 | 82 | 52,480 |
| 3 | 1,920 | 23 | 14,720 | 43 | 27,520 | 63 | 40,320 | 83 | 53,120 |
| 4 | 2,560 | 24 | 15,360 | 44 | 28,160 | 64 | 40,960 | 84 | 53,760 |
| 5 | 3,200 | 25 | 16,000 | 45 | 28,800 | 65 | 41,600 | 85 | 54,400 |
| 6 | 3,840 | 26 | 16,640 | 46 | 29,440 | 66 | 42,240 | 86 | 55,040 |
| 7 | 4,480 | 27 | 17,280 | 47 | 30,080 | 67 | 42,880 | 87 | 55,680 |
| 8 | 5,120 | 28 | 17,920 | 48 | 30,720 | 68 | 43,520 | 88 | 56,320 |
| 9 | 5,760 | 29 | 18,560 | 49 | 31,360 | 69 | 44,160 | 89 | 56,960 |
| 10 | 6,400 | 30 | 19,200 | 50 | 32,000 | 70 | 44,800 | 90 | 57,600 |
| 11 | 7,040 | 31 | 19,840 | 51 | 32,640 | 71 | 45,440 | 91 | 58,240 |
| 12 | 7,680 | 32 | 20,480 | 52 | 33,280 | 72 | 46,080 | 92 | 58,880 |
| 13 | 8,320 | 33 | 21,120 | 53 | 33,920 | 73 | 46,720 | 93 | 59,520 |
| 14 | 8,960 | 34 | 21,760 | 54 | 34,560 | 74 | 47,360 | 94 | 60,160 |
| 15 | 9,600 | 35 | 22,400 | 55 | 35,200 | 75 | 48,000 | 95 | 60,800 |
| 16 | 10,240 | 36 | 23,040 | 56 | 35,840 | 76 | 48,640 | 96 | 61,440 |
| 17 | 10,880 | 37 | 23,680 | 57 | 36,480 | 77 | 49,280 | 97 | 62,080 |
| 18 | 11,520 | 38 | 24,320 | 58 | 37,120 | 78 | 49,920 | 98 | 62,720 |
| 19 | 12,160 | 39 | 24,960 | 59 | 37,760 | 79 | 50,560 | 99 | 63,360 |
| 20 | 12,800 | 40 | 25,600 | 60 | 38,400 | 80 | 51,200 | 100 | 64,000 |

640 Acres=1 Square Mile.

LONG MEASURE.

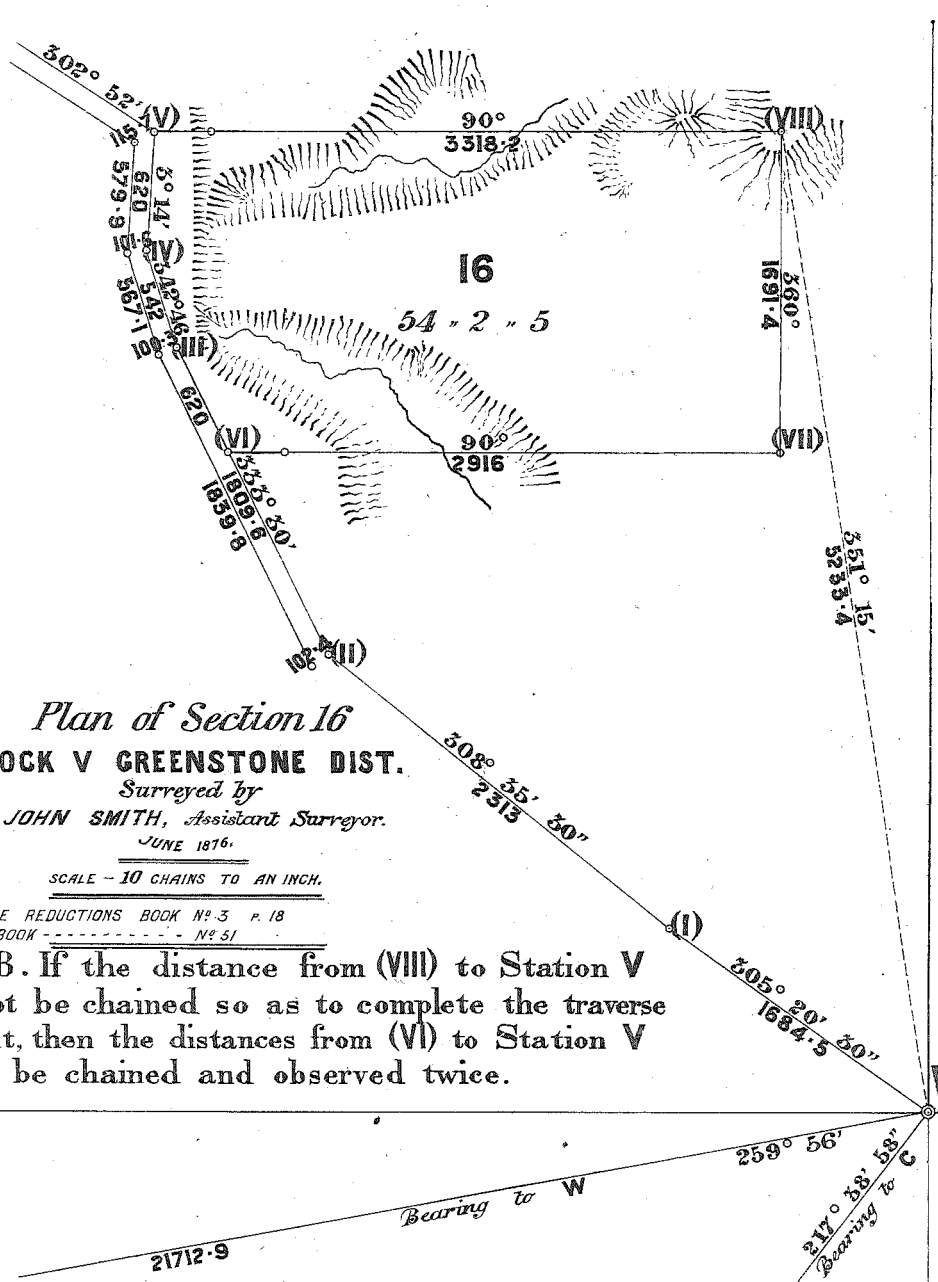
| Inches. | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7·92 | 1 Link. | | | | | | |
| 12 | 1·51 | 1 Foot. | | | | | |
| 36 | 4·54 | 3 | 1 Yard | | | | |
| 198 | 25 | 16 | 5·5 | 1 pole | | | |
| 722 | 100 | 66 | 22 | 4 | 1 ch. | | |
| 7,920 | 1,000 | 660 | 220 | 40 | 10 | 1 fur. | |
| 63,360 | 8,000 | 5,280 | 1,760 | 320 | 80 | 8 | 1 mile |

SQUARE MEASURE.

| Sq. inches. | | | | | | |
|---|---|---|---|---|---|---|
| 62·7264 | 1 sq. link. | | | | | |
| 144 | 2·29 | 1 sq. ft. | | | | |
| 1,296 | 20·66 | 9 | 1 sq. yd. | | | |
| 39,204 | 625 | 272·25 | 30·25 | 1 sq. pole | | |
| 1,568,160 | 25,000 | 10,890 | 1,210 | 40 | 1 sq. rood | |
| 6,272,640 | 100,000 | 43,560 | 4,840 | 160 | 4 | 1 sq. ac. |

# Appendix VI

## SPECIMEN OF SURVEY OF ISOLATED SECTION.




*Plan of Section 16*

**BLOCK V GREENSTONE DIST.**

*Surveyed by*

*JOHN SMITH, Assistant Surveyor.*

*JUNE 1876.*

*SCALE – 10 CHAINS TO AN INCH.*

*TRAVERSE REDUCTIONS BOOK No 3 P. 18*
*FIELD BOOK ---------- No 51*

**N.B. If the distance from (VIII) to Station V cannot be chained so as to complete the traverse circuit, then the distances from (VI) to Station V must be chained and observed twice.**

*Traverses of Road &c marked Greenstone District, Block V Section 16*

| Page of Field Book | Surveyor's No of Peg or Trig No | Cardinal Direction | True Bearing ° | ' | " | Measured Distance | Traverses of each Distance. On Meridian N | On Meridian S | On Perpendicular E | On Perpendicular W | Total Traverses from Trig (V) On Meridian N | On Meridian S | On Perpendicular E | On Perpendicular W | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Links | Links | Links | Links | Links | Links | Links | Links | Links | |
| 8 | I | NW | 305 | 20 | 30 | 1684·5 | 374·4 | | | 1370·4 | 374·4 | | | 1370·4 | |
| | II | " | 308 | 35 | 30 | 2313 | 1442·7 | | | 1807·9 | 2417·1 | | | 3178·3 | |
| | III | " | 333 | 30 | | 1809·6 | 1619·4 | | | 807·4 | 4036·5 | | | 3985·7 | |
| | IV | " | 342 | 46 | | 542 | 517·6 | | | 160·5 | 4554·1 | | | 4146·2 | |
| | V | NE | 3 | 14 | | 620 | 619 | | 34·9 | | 5173·1 | | | 4181·1 | |
| | III | | | | | | | | | | 4036·5 | | | 3985·7 | |
| | VI | SE | 153 | 30 | | 620 | | 554·8 | 276·6 | | 3481·7 | | | 3708·7 | |
| | VII | E | 90 | 0 | | 2916 | | | 2916 | | 3481·7 | | | 792·7 | |
| | VIII | N | 0 | 0 | | 1691·4 | 1691·4 | | | | 5173·1 | | | 792·7 | |
| Trig | V | SE | 171 | 15 | | 5233·4 | | 5172·3 | 796·1 | | ·8 | | | 1 | |

*(½ size)*

*Note that Surveyor's numbers should be sawn on back of pegs in Roman figures, & distinct from branded Section numbers in front or side of pegs.*