

APPENDIX "D."

QUEENSLAND TRIANGULATION.

Contributed by Allan A. Spowers, Esquire, Surveyor-General.

STANDARD OF LENGTH.

The standard from which the tapes used on the Queensland base were measured, is a steel bar, octagonal in section, about $1\frac{1}{2}$ inch in diameter, and when in use is kept floating in a trough of mercury, in which thermometers are plunged to obtain the temperature of the bar. The 6 ft. and 10 ft. lengths are marked by microscopic dots on platinum plugs inserted in the bar. It was compared with the New South Wales standard bar 014 in 1883, the certificate signed by the late Wm. J. Conder, then Superintendent of Trigonometrical Survey, setting forth its length to be 9.9998581 feet at 62° F. This was the value used in all Queensland operations.

It appears, however, that a comparison made in New South Wales, in 1879, gave a value of .000178 inch longer, and in 1895, further careful comparisons by the late Mr. D. M. Maitland, with the two New South Wales bars 014 and A2, showed a further shortening of .000206 inch since 1883.

Notwithstanding these differences, the value used for determining the lengths of the tapes was probably very nearly correct, as all comparisons of the tapes were made within a year of the date on which the bar itself was compared.

TAPES.

From this bar, the lengths of two tapes (A and B) of 100 feet each were carefully measured with the aid of micrometer microscopes and other apparatus, specially prepared for the purpose. These tapes are about half-an-inch wide and little more than 1/100 inch thick. The results of comparisons with the bar are as shown in Table A. The co-efficient used for expansion was .0000636 for 1° F. for 10 feet.

Mr. Maitland's conclusion that the Queensland bar had been slowly shortening in length during the period 1879-1895 seems to be borne out by the above results, and by other comparisons made subsequently, as the later the date of comparison, the longer has been the resulting length of the tape. This may be taken as some indication of the care with which the comparisons were made. Thus—

			Tape A.		Tape B.
1883	..	..	99.9980192	..	99.99973446
1884	..	..	.9980930	..	.9978976
1890	..	..	.9991710	..	.9992165

Further, tape "1890" was measured as 100.0003864 feet in 1890 by the Queensland bar. By New South Wales bar A2, in 1899, its length was 99.9995714, another indication that the value ascribed to the Queensland bar in 1883 was too high for it in 1890.

BASE LINE MEASUREMENT.

The base line is very nearly 7 miles long, and is situated mostly on open plain between Mount Irving and Mount Maria, on the summits of which are the terminal points. The former is about 216 feet, and the latter about 162 feet above the level of the plain. The tapes were used in wooden troughs and shaded by a board; a tension of 20 lbs. was applied by means of a spring balance, and five thermometers whose index errors had been determined by comparison with a standard thermometer were used along each 100 feet of tape. The troughs were supported upon pegs set on an even grade by means of a levelling instrument. A reduction to the horizontal was computed for each grade. The base was divided into ten sections, the six central ones averaging nearly a mile, and the other two at each end being nearly half a mile long. The terminal points of these sections were marked by stones sunk into the ground and set in concrete. Each stone had a metal plug, upon which a small mark was made denoting the terminal point of the section. Each subdivision of 100 feet was marked by a piece of sawn hardwood, 4 by 4 inches and 3 feet long, firmly driven into the ground. On the top of this peg a copper rivet was sunk to receive the mark for each length measured from the tapes. Two micrometer microscopes, of which one revolution of the micrometer screw was equal to .005 of an inch, were employed for reading fractional differences between the marks on the tapes and those on the rivets.

The total correction for slope was 31.123 feet, of which 19.732 feet were for the Mount Irving section, and 11.225 feet for that at the Mount Maria end. The average height of the base line being 1,298 feet, a correction of 2.2520 feet was applied to reduce the length to that at sea level.

The appended tabular statement B shows results of the measurement. The base was measured three times with each tape.

ANGULAR WORK.

Two 10-in. Everest pattern theodolites by Troughton and Simms, reading by micrometer microscopes to a second of arc, were the instruments chiefly used in the triangulation, a 12-inch altazimuth by the same makers having been used at a few of the stations.

From two to eight readings were made on each of eleven different parts of the graduated arc, the mean of the means in each position being adopted. The triangles were corrected by apportioning the difference between the observed and spherical values by weight according to the probable error of the observed readings.

The following are the closing errors of the 74 measured triangles:—

Closing error.					Number of Triangles.
0" to 1" .. .. .	..	..	..	..	29
1 to 2" .. .. .	..	..	..	..	29
2" to 3" .. .. .	..	..	..	..	11
Upwards of 3" .. .. .	..	..	..	..	5

The maximum error of close was 3.90", and the probable mean closing error m by General Ferrero's criterion, where $m = \left(\frac{\Sigma A^2}{3n}\right)^{\frac{1}{2}}$, n the number of triangles dealt with, and ΣA^2 the sum of the squares of the closing errors of the triangles was $\pm 0.95''$.

ASTRONOMICAL WORK.

The astronomical datum is the position of the station at Jimbour as determined by Capt. Morris, R.E., and Lieut. Darwin, when preparing to observe the transit of Venus in 1882, the longitude being deduced by the telegraphic exchange of time signals with Sydney.

The latitude and longitude of each station were deduced from this, based on the elements published by Colonel James in connexion with the Ordnance Survey of Great Britain in 1858. The azimuth datum was determined at Bloodwood (the apex of one of the triangles standing on the base line) by the meridian observation of stars with a 20-inch transit. The size of the triangles varies considerably, as may be seen by accompanying map, but the average length of the sides is probably about 25 miles.

The values of tapes A and B as obtained in 1890 were used in determining the length of a line about 1,924 feet long in the Brisbane Botanical Gardens, to serve as a base for a minor triangulation of the city. This was eventually extended to meet the line Eildon Hill—Mount Petrie, where a comparison of lengths and azimuths was made. In the Brisbane triangulation, the area covered has been considered as a plane (the triangles being small) excepting for the comparison of azimuths. One of the 10-inch instruments used on the former triangulation was employed on the Brisbane work, also a 6-inch theodolite by Messrs. Troughton and Simms, reading to 10". Three of the angles determined by this instrument enter into the calculations affecting the comparison of lengths, but none into the azimuth comparisons. The distance between Eildon Hill and Mount Petrie is about $9\frac{1}{2}$ miles, and the difference in length by the two systems of triangulation is 0.982 of a link, or about 0.83 of an inch per mile, but it is a significant fact that by using the same values for tapes A and B for the Brisbane base as were adopted on the Jondaryan base, the lengths of the line Eildon Hill—Petrie agree almost exactly. The difference in azimuth is 4.07".

The principal triangulation was discontinued in 1891.

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TABLE A.—DETERMINATION OF THE LENGTH OF TAPES A AND B USED IN MEASUREMENT OF BASE LINE.

100 Feet Approx.—Tape A.			100 Feet Approx.—Tape B.			Tension, 20 lbs.
Date of Measurement.	Temperature.	Length at 62 Deg. Fahrt.	Date of Measurement.	Temperature.	Length at 62 Deg. Fahrt.	
1883.			1883.			
Sept. 14	66.5	99.9977453	Sept. 14	67.9	99.9969864	
„ 15	66.0	99.9978127	„ 15	66.5	99.9970344	
Nov. 7	72.5	99.9983970	Nov. 8	72.0	99.9977527	
„ 7	73.0	99.9980835	„ 8	73.5	99.9974246	
„ 7	73.5	99.9980573	„ 8	73.5	99.9975248	
1884.			1884.			
May 16	61.0	99.9975325	May 16	63.0	99.9976441	
„ 17	61.0	99.9975197	„ 17	62.5	99.9978327	
Aug. 8	64.0	99.9982328	Aug. 7	64.0	99.9973815	
„ 8	64.5	99.9985049	„ 7	65.0	99.9980631	
„ 9	63.5	99.9986753	„ 9	64.5	99.9985667	
Adopted Mean		99.9980561	Adopted Mean		99.9976211	

TABLE B.—MEASUREMENT OF ENTIRE LENGTH OF BASE LINE (FROM SUMMIT OF MT. IRVING TO SUMMIT OF MT. MARIA).—TABULAR RESULTS
IN FEET.

—	—	Deg.	A1.	A2.	A3.	Mean A.	Difference of Means.	Mean B.	B1.	B2.	B3.
1884.											
Sept.—Oct. ..	Mt. Irving	70	2546·4099339	2546·4160688	2546·4153823	2546·4137949	0·0039618	2546·4098331	2546·4103215	2546·4096699	2546·4095079
Sept.	1	73	2499·9667170	2499·9666739	2499·9672573	2499·9668827	0·0088902	2499·9757729	2499·9759511	2499·9768418	2499·9745260
1883.											
Aug. 31—Sept. 7 ..	2	71	4700·1733328	4700·1717090	4700·1725780	4700·1725399	0·0014832	4700·1740231	4700·1774686	4700·1721419	4700·1724595
Sept. 9—Sept. 25 ..	3	78	4000·3494483	4000·3464889	4000·3468172	4000·3475850	0·0043652	4000·3519502	4000·3523487	4000·3506108	4000·3528908
Sept. 25—Oct. 2 ..	4	75	5000·2951300	5000·2961735	5000·2939590	5000·2950878	0·0015760	5000·2935118	5000·2956193	5000·2925837	5000·2923332
Oct. 2—Oct. 6 ..	5	74	4500·2447470	4500·2432462	4500·2420932	4500·2433621	0·0167685	4500·2265936	4500·2277747	4500·2267747	4500·2252314
Oct. 8—Oct. 11 ..	6	76	4500·3290552	4500·3325728	4500·3318397	4500·3311559	0·0030507	4500·3281052	4500·3275099	4500·3288525	4500·3279529
Oct. 12—Oct. 19 ..	7	79	5000·4716607	5000·4725609	5000·4745378	5000·4729201	0·0036514	5000·4692687	5000·4685280	5000·4709806	5000·4682975
Oct. 19—Oct. 22 ..	8	84	2000·0939146	2000·0957883	2000·0963933	2000·0953638	0·0001460	2000·0952178	2000·0951609	2000·0949132	2000·0955782
Oct. 22—Oct. 24 ..	9	89	2281·4195725	2281·4209571	2281·4229186	2281·4211496	0·0046472	2281·4257968	2281·4256613	2281·4260411	2281·4256882
			37029·7535120	37029·7622394	37029·7637764	37029·7598418	0·0097686	37029·7500732	37029·7563440	37029·7494102	37029·7444566

Mean 37029·7549575.