APPENDIX "C."

TRIGONOMETRICAL SURVEY OF VICTORIA.

Contributed by J. M. Reed, Esquire, I.S.O., Surveyor-General of Victoria.

The earliest recorded survey of this character was commenced on 8th October, 1839, when under the authority of His Excellency Sir George Gipps, Governor of New South Wales, and the direction of Sir Thomas L. Mitchell, Surveyor-General of New South Wales, Mr. Charles James Tyers, from an initial point on Batman's Hill, Melbourne, observed a chain of triangles extending eastward to the vicinity of the boundary between New South Wales and South Australia. Fourteen stations were established, and two astronomically determined bases were used, viz., Mt. Eckersley to Mount Sturgeon, N. 49° 52′ 10″ E., 49·628 miles, and Cape Sir William Grant to Mount Eckersley N. 2° 26′ 30″ E., 21·652 miles. A point near Portland Bay was defined by a deep trench in the form of a broad arrow, and filled with broken limestone, and as it was from this point that Mr. Wade subsequently made his measurements to fix the starting point of the boundary line between the States (the 141st meridian), which has recently been the subject of litigation before the High Court, and is now engaging the attention of the Privy Council, this survey mark is certainly of historic interest.

The equipment provided for this survey was an 8-in. sextant with artificial horizon, a 3½-in. theodolite, pocket sextant, prismatic compass, and a circumferenter. This work forms no part of what is regarded as the trigonometrical survey proper of Victoria.

Later developments necessitated the connecting of various detached surveys in the vicinity of the metropolis, and a trigonometrical survey of Melbourne and its environs was undertaken in 1852 by Mr. Clement Hodgkinson. A base line was carefully measured by means of tested pine rods, and a chain of small triangles was established, the work embracing an area of about 310,000 acres only.

On the appointment of Captain Andrew Clark, of the Royal Engineers, to the position of Surveyor-General in August, 1853, he originated the scheme of a proper systematic trigonometrical survey of the colony, and the services of a small company of sappers and miners with experience of the Ordnance Survey work were obtained from the Imperial Government. Sergeant T. Forbes, two corporals, and four sappers were, with the necessary labourers, intrusted with the work of clearing a large number of mountain tops and erecting stations thereon.

The actual Geodetic Survey of Victoria was commenced in 1858, but in its earlier stages consisted more of the definition of meridian and parallel (chordal) lines embracing squares of one-tenth of a degree than of triangulation. Mr. C. W. Ligar, Surveyor-General, advised this form of survey to meet the pressing need for settlement subdivision, and the lines so defined were adopted on the comparatively flat country as parish boundaries, within which the settlement surveys were effected under a system of contract. In July, 1858, Mr. R. L. J. Ellery, Government Astronomer, was appointed to the position of Superintendent of the Geodetic Survey, and the work was carried on under his direction up to the year 1872, when it was suspended, and only at irregular intervals since has any limited supplementary work been undertaken.

The staff in 1859 consisted of—Mr. R. L. J. Ellery, as Superintendent, Messrs. R. Petty, A. C. Allan, E. deVerdon, P. Chauncey, T. W. Pinniger, as Assistants, and Mr. P. Crennion, as computer.

The earliest work consisted of the running of the standard meridian of 145° E. longitude to latitude 37°, and the marking of the parallel of 37° 48′ to the meridian 144° E. This and other similar work occupied the staff up to 1860. An 18-in. altazimuth instrument, or a 12-in. theodolite was used for a series of observations of selected stars for azimuth. Points were established north and south of the observing station at from 5 to 20 miles distance by means of flag and heliotrope signals.

Between these primary points secondary ones were fixed from 1 to 2 miles apart, and further intersection points marking the degree and tenth of degree were defined by a marked stone sunk below the ground, and surmounted by a squared post with cast-iron cap.

The chordal latitude lines of one-tenth of a degree were run, the determination of the latitude of the initial point being effected by means of a series of astronomical observations and the length measurement by means of a chain of small triangles based on very accurately measured base lines of a length of from 1 to 2 miles. Specially good theodolites, 8 inches to 10 inches, were used for this triangulation. In all about 300 miles were surveyed and marked in the manner described.

As much of the land traversed by the meridian lines was not so much in demand for settlement as other distant areas, it was then decided that a more expeditious work in the form of a primary triangulation was essential, and with this the actual and reliable triangulation of Victoria was instituted. The preparatory work of clearing the mountain tops and erecting stations had already been commenced, and the measurement of the base line was undertaken in January, 1860. The line selected and which presented most favorable conditions was on the Werribee Plains. Its southern end was a point on the Melbourne to Geelong railway reserve, about 2 miles east of Werribee railway station, with a bearing 304° 36′ 31″, and length of 4·942 miles to a point in direct line with Green Hill on the western side of the Werribee River. The measured base was subsequently extended a further length of 5·651 miles by triangulation to Green Hill, its total length being 10·593 miles.

Each end of the measured base was defined by a solid mass of masonry built 5 feet into the ground, capped by a heavy stone with gun metal plug and platinum centre, on which the terminal dot was marked. A heavy protection stone was placed over the capstone, and this was surmounted by a timber pyramid with pinnacle accurately centered over the platinum point.

The apparatus used for the measurement of the line was as follows :—Three measuring bars 10 feet long and 1 inch square, with the ends turned round for about 4 inches in length, one end of each bar being finished quite flat and polished, while the other end was a polished segment of a sphere of 5 feet radius. The bars were furnished with thermometers, levels, and aligning vanes. In addition pine tripods or trestles with metal sockets on the top frames to receive a brass tripod were provided. These frames carried a brass "Camel" consisting of a heavy brass tripod fitted with levelling screws and a stout brass prism with screw attachment for raising and lowering the prism. This again supported a small slide rest with rollers and slow motion screw for accurate adjustment of the position of the bars.

It is not necessary here to describe the details of the work of measuring. The length determined was 4·942 miles, and a portion of the line 2·11 miles long was re-measured, showing a difference of 0·308 inches, equal to about 0·15 inches per mile.

Measured base, 26,091·82 feet	=	4·942 miles.
Re-measured portion, 11,174·29 feet	=	2·11 miles.
Base elongated by triangulation to Green Hill terminal, 29,839·83 feet	=	5·651 miles.
Total length, 55,931·65 feet	=	10·593 miles.

True azimuth of base observed from southern end 304° 36′ 31″. Upwards of 2,000 observations were made in the process of determining the length of the base line.

The expansion of the base to points on the primary triangulation was obtained without difficulty. Station (now Flinders) Peak and Mount Macedon being reached in the second series of expansion triangles. On the extension of the triangulation westward to Mount Gambier and Mount Schank, in South Australia, it was intended to measure a very suitable line as a base of verification, but this work was not carried out.

In the survey, 209 primary stations were established and observed, involving 35,575 observations, or an average of 170 at each station. These stations are shown on the sketch map together with 267 secondary ones, and in addition, many points, which are not shown, were marked by posts and cairns of stones, and used in conjunction with the standard lines to establish connexions with detached surveys.

The types of trigonometrical stations vary, but for the most part consist of stone pyramids to the number of 110, each being described as a conical pile of stone from 4 to 18 feet in height, and surmounted by a pole placed exactly over the centre stone, which is either buried or cut in the rock and marked thus ⅄. Poles with supporting frames and boarded pyramids are numerous, and in some cases masonry and cement bases have been built, above which are timber structures. The observed sides of many of the triangles have a length of from 50 to 70 miles.

The tabular record of observations shows the observed angle, the sum, spherical excess and error, the reciprocal of weight, apportionment of error, seconds of corrected angle, the seconds of angle for computation, and the calculated distance. Angles of elevation and depression were observed, and the heights from sea-level thus determined.

The instruments used were an 18-in. altazimuth with micrometer reading to 1 second, a 13-in. (Ertel) theodolite with two micrometers reading to 1 second, two 12-in. (Ertel) with micrometers reading to 4 and 10 seconds respectively, a 10-in. altazimuth, 8-in. Swiss theodolite, and others of smaller size.

In the year 1870 it became necessary to mark the boundary line between Victoria and New South Wales, and for the purpose the trigonometrical survey was pushed on into New South Wales, and stations were established on Mount Pilot and Mount Kosciusko, and at Cape Howe. On the determination of the true positions of the stations the azimuth of a line from The Pilot to Cape Howe was computed. The work of running this line was undertaken by Messrs. A. Black and A. C. Allan, with the result that the actual error in the direction of the line at the Cape Howe terminal was only 16·8 inches. This evidenced the accuracy of the work performed, and also of the elements of the figure of the earth given by Colonel Clarke in his tables, which were used throughout the trigonometrical survey. At a later date the New South Wales survey was linked on to that of Victoria, and the following tabulated statement of the latitude and longitude of four stations shows the results independently obtained by the operations of the two States. Such results must be regarded as indisputable proof of the accuracy and value of the work performed by the officers intrusted with such an important duty, a work executed under most difficult conditions and reflecting the highest credit on those who accomplished it.

GEODETIC POSITIONS OF TRIGONOMETRICAL STATIONS COMMON TO THE TRIANGULATIONS OF NEW SOUTH WALES AND VICTORIA.

Station.	Latitude S.		Longitude E.	
	New South Wales.	Victoria.	New South Wales.	Victoria.
Mount Pilot	36° 45′ 21·504″	36° 45′ 21·748″	148° 12′ 26·348″	148° 12′ 19·003″
Mount Tingi Ringa ..	36° 59′ 59·385″	36° 59′ 59·510″	148° 40′ 42·404″	148° 40′ 34·837″
Mount Delegete	37° 6′ 52·2″	37° 6′ 52·190″	148° 53′ 56·4″	148° 53′ 48·602″
Mount Buckle	37° 21′ 28·3″	37° 21′ 28·125″	149° 35′ 37·0″	149° 35′ 28·651″

New South Wales longitude referred to Sydney Observatory, value of which is 151° 12′ 23·100″ (see *Nautical Almanac*, 1898, and onwards).

Victoria's longitude referred to Melbourne Observatory, value adopted since 1883 up to the present, 144° 58′ 30·0″.

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Surveyor-General's Office,
Melbourne, 20th July, 1912.