

A Short History of the Trigonometrical Survey of New South Wales

A paper presented to the N.S.W. Lands Department Staff Surveyors' Conference, 1967, by J. B. McLean, M.I.S. Aust.

This year, 1967, commemorates 100 years of trigonometrical survey on a statewide basis.

For nearly a century, efforts had been made to extend a trigonometrical survey of New South Wales. In April, 1855, the Governor, Sir William Denison, stated that he was desirous of establishing an Observatory for the purpose of connecting it with the Trigonometrical Survey of the country. A few years later the Sydney Observatory was established at the site of Fort Phillip, or what was then known as Windmill Hill.

At a meeting on the 6th February, 1867, convened to take steps for the measurement of base line for triangulation, attended by the Government Astronomer, Surveyor-General and Deputy Surveyor-General, it was agreed "that surveyors in the most important localities be requested to report on what appears to be the most favourable positions for the Base Line—such line to be from 7 to 8 miles of uninterrupted level. . . ." The responsibility for observations, measurement and reductions to be carried out by the Government Astronomer. It was considered desirable for the Government Astronomer (George R. Smalley) to examine the geodetic operations in Victoria—"at the usual travelling allowance, 30s. per diem".

One reply was received from "Camp, Two Mile Flat, Mudgee" by Surveyor Edward Fisher—of a suitable site—on Bylong Creek—a base length of approximately 3 miles.

1828 Surveys of a trigonometrical nature had been carried out as early as 1828 by Thomas Florance on the coastal area between Bowens Island, Jervis Bay and Moruya, also later in 1828 Florance triangulated the shores of Sydney Harbour from two bases, one at North Head, the other in the vicinity of the Botanical Gardens.

In this period Surveyor Dixon was engaged in the Counties of Camden, Argyle and King where he observed rounds of angles from certain peaks from which the 1st Class Stations of the present survey were later erected. In 1829 Dixon employed a method of triangulation when crossing the Murrumbidgee River.

During this period, Sir Thomas (then Major) Mitchell was appointed Deputy Surveyor-General and found that the complaint had become general, that settlement was being retarded as farms could not be granted because of a lack of description of the localities. Surveyor-General Oxley had determined not to allow anyone to attempt anything approaching a general survey on a trigonometrical basis. Governor Darling, however, recognized the advantages of such a survey and instructions were issued in early 1828 for Mitchell and three others to devote their attention to the performance of a trigonometrical survey.

1833 At this point I would like to digress and refer to an article appearing in the *New South Wales Magazine*—August, 1833. The article referred to the importance of a proper system of survey to enable the “satisfactory accomplishment of three distinct items of primary importance: viz., the location of grants, the division of territory, and the construction of permanent public works, roads, bridges, canals, etc.” It went on to describe, in detail, the extent of Major Mitchell’s general survey on trigonometrical principles. The hills mentioned, and which now form part of our first-order triangulation network—Budawang, Currockbilly, County St Vincent, Cambewarra—near the mouth of the Shoalhaven River; on the west, Mt Macalister, Werong, Colong, Jenolan, Mt Hay, Mt Tomah—were observed in 1828.

In 1829, the operations were continued across the northern portion of the colony when the Surveyor-General was instructed to lay out the Great Road northward. The first step being to clear the summit of Warrawolong (near Morisset) “which was broad and covered with enormous trees” (Mitchell reported here that—“the hills had, with great labour, to be cleared of timber, which was done by prisoners in chains”), then to observe a series of triangles Broken Back, Wambo to the north, Coricudgy, Pomany, Monundilla, Yengo, Oxley’s Pic, Mt MacArthur, Murulla, Mt Royal with intersections on Bird Island, Bungaree Norah and other prominent points on the coast which were of value for a subsequent coastal survey by Assistant Surveyor Mathew.



Figure 1. Mitchell's Theodolite

Surveys continued in 1830—to mark the Bathurst Road—fixing Mt York, Mt Victoria, Honeysuckle Hill, the Canobolas, also Conterubal and Mt Arthur. Mitchell reported that the Sydney Lighthouse was visible from Honeysuckle Hill (now known as Mt Lambie) near Rydal,

a distance of approximately 75 miles. In 1831, a check was made on the plains off the Liverpool Plains to give a comparison with the work as deduced from the Lake George Base (measured by Mitchell—about 1 mile long), the difference being only a few yards. The survey was extended from the Liverpool Ranges to the Lindesay Range by which means the difference in longitude between these interior parts and Sydney was obtained.

Of interest to officers of our present Trigonometrical Division are the comments on observations from Jellore and Warrawolong—"yet so clear is the Australian atmosphere that on ten successive days, from Warrawolong, Jellore was clearly visible as was also Warrawolong from Jellore, Sydney Lighthouse being visible with a glass from Jellore". Mt Hay was visible from all three "placing all these stations in the utmost importance for trig. survey and enabling the survey to be connected to the observatory".

In conclusion, the writer made the following reflection—"it is to be regretted that the public should know so little of the arduous labours of the surveyors. . . theirs has not been a flowery path by inland streams or over open plains—on the contrary, it has been necessary to measure the most rugged and broken ranges and to penetrate the wildest ravines—a kind of work which it has never yet been possible to accomplish without undergoing much privation and fatigue".

1835 This work resulted in the publication of the "Map of the Nineteen Counties" in three sheets. Nine hundred plans entered into the formation of the map, drawn to a scale of 8 inches to a degree, covering an area of 38,000 square miles. The principal points used in commencing this survey were Jellore to the south, Warrawolong to the north, and Mount Hay to the west of Sydney. These three peaks formed a triangle, the longest side, that between Jellore and Warrawolong, being 102 miles.

Three base lines were measured, two in the vicinity of Botany Bay and one at the north end of Lake George, not far distant from the initial base of the present survey. The Botany Bay bases were used to obtain, by triangulation, the distance between Sydney Lighthouse and a small hill on the south side of Botany Bay. The survey was then extended over the area covered by the three sheet map. Independently of these measurements, it also appears that the distance between Warrawolong and Jellore was obtained from astronomical observations determining the difference in latitude of the two hills and the bearing between them. The base at Lake George was 1 mile in length and measured with two tent poles of English deal, about 2 inches in diameter, one 10 feet 2 inches and the other 9 feet 11 inches long. It hasn't been possible to determine how this base was incorporated into Mitchell's survey although he described it as a base of verification

Mitchell's mode of operation was to observe single rounds of angles with a seven-inch theodolite, from favourable positions, the distant objects being generally the summits of hills. Some of the hills were afterwards visited and their summits cleared with the exception of a single tree to serve as an object for future observations. This put Mitchell's survey more in the form of a reconnaissance survey, but it was the first attempt to effect a survey of a trigonometrical nature on an extensive scale.

1854 For want of an accurate detail map of Sydney, the City Commissioners authorized a trig. survey of the city which was effected with a fair degree of accuracy. A base of 3,250 feet measured eight or nine times with a 100-foot chain and afterwards with 20-foot rods, tested before and after each day's work, was laid down at Waterloo Swamp, 5 miles from Sydney, whilst another base of 13,192 feet, measured with rods provided with adjusting screws at the ends, was located at Paddington. The bases and trig. marks of this survey have long since disappeared.

1855 The Commissioners appointed to enquire into the Surveyor-General's Department recommended—"Points to serve as trig. stations should be selected and permanently, as well as conspicuously marked A base line should be measured, every practical precaution being taken to ensure correctness"

From this base a system of triangulation might gradually be extended. Observations should be reduced and the necessary corrections applied, according to the most approved methods—other base lines also being measured to test the accuracy of the triangulation as it extends."

No trig. work followed either the recommendations of the Commissioners or the establishment of the Sydney Observatory although Lieutenant-Colonel Barney, Mitchell's successor, reported in 1856 that the time had arrived when preparation should be made for commencing a general trig. survey, and submitted a report on the subject of selection of a base line.

1859 The District Surveyor at Albury, Mr P. F. Adams, initiated a triangulation to facilitate the construction of accurate County maps of his district. Mr P. F. Adams' Albury triangulation includes several stations which were later remarked, and included in the State triangulation; e.g., Black Range, which appears to be the oldest trig. still in its original position. Adams' Base Line, about 48 chains, accords very well with the later triangulation, better than 1:300,000.

1865 The first attempt to commence a purely trigonometrical survey was made in July, 1865, when Deputy Surveyor-General P. F. Adams submitted a report on the necessity for initiating the survey. The report stressed the point that publication of the many maps required for administration purposes was not attempted owing to the defective data from which they were prepared. The most perfect safeguard against a recurrence of these faults would be found in the general triangulation of the State.

1869 In a progress report from the Government Astronomer (Mr Smalley) to the Principal Under Secretary tabled in the Legislative Council, 4th June, 1869, Mr Smalley reported that Lake George had been unanimously chosen as a site for the first base. The comprehensive report set out the suitability of the base profile, and survey equipment. The instruments, borrowed from the Royal Astronomical Society, a Fuller theodolite and a smaller instrument by Ertel had the misfortune to be saturated when the ship transporting them from England, the *John Duthrie* caught fire and was scuttled in Port Jackson. Charges for repairs, carried out by Troughton & Simms were £55 4s. 8d., with the Treasury "requested to pay the Colonial Astronomer the said sum for repairs, upon production of the necessary vouchers, etc."

1870 The Lake George Base measurements were made with wooden rods 10 feet in length. The first two positions for the baseline had to be abandoned due to the unexpected changes in the level of the lake, and a third position, chosen by Mr P. F. Adams' was measured between 2nd January, 1873 and the 31st January, 1874, weather causing some delays. Mr A. C. Betts (and L. A. Vessey) carried out the base measurements.

1872 Surveyor Woolrych made field measurements with a steel tape chain, made of well-tempered crinoline wire about 1/4 inch wide. "The middle of it, or 50 links from each end, was marked by a four-penny piece, each link was marked by a rivet of copper wire and every tenth link by one of the copper discs of rivets, in common use for mending harness. These were rivetted to the chain, and had from one to four punch marks to indicate the distances."

Mr Woolrych had so much success with such a tape that he completed the alignment survey of Randwick. An improved tape was made and several more made by surveyors until instrument makers took over to meet the demand. Surveyor Woolrych's letter to the Surveyor-General appears to be the first recorded instance of the use of a steel band for survey measurements.

1874 Officers of the Trigonometrical Survey co-operated with the Government Astronomer in observations of the Transit of Venus in that year. The observations at Woodford, by Mr L. A. Vessey, who had taken part in the Lake George Base measurement, were particularly successful.

1875-1878 The triangulation was first extended west (by J. B. S. Chard) and north-west (by W. J. Conder). The former measured a check base at Bullenbung near Wagga, apparently by steel tape, but this appears afterwards to have been abandoned. Conder's triangulation extended round by Boorowa and Cowra to the vicinity of Bathurst and then turned east towards Richmond. The direct chain from Lake George to Richmond apparently gave some difficulty (several stations were abandoned), and was not completed until 1881.

1879 A baseline was measured at Newcastle with a steel riband by D. S. Twynam in anticipation of the general trig. survey reaching that place. The object of the measurement was to ascertain whether the use of a steel band, with necessary corrections, would afford results sufficient to warrant its further and extended use for that purpose. Three steel bands were used 66, 100 and 200 feet. Mt Twynam's report sets out, in detail, the field methods employed and the various problems encountered.

1880 A base of verification, for the Lake George Base was measured at Richmond. This base, about 7 miles long, was measured with wooden rods for the first measurement and steel rods for the second.

The comparison between wooden (pine) and steel was -0.05515 feet. The combined errors of measurement of the bases and the intervening triangulation produced an apparent discrepancy of $1\frac{3}{4}$ inches in the length of the Lake George Base. The base measurements were controlled by comparison of the rods with a steel bar, 10 feet in

length prepared in 1859 by the Ordnance Department in England and standardized by Colonel Clarke who refers to it as 014 (Ordnance Intermediate No. 4).

During the next 36 years, until work was suspended because of war conditions and economic reasons, approximately $\frac{1}{3}$ of the State was covered with 2,700 stations marked and piled and the positions of 2,100 determined. Heights were ascertained for 1,500 stations, the datum being high water spring tide at Fort Denison, being 2.93 feet above Mean Sea Level.



Figure 2. Eighteen-inch Troughton & Simms "Altazimuth" theodolite

Observations of a high order for horizontal angles of the primary network were made with two 18 inch altazimuth instruments by Troughton & Simms. These had a 3-inch object glass and filar micrometer eyepiece with eyepiece motion to view any part of the field. . . . 10-inch Troughton & Simms theodolites were employed to read vertical angles at 1st Class Stations and both horizontal and vertical observations at 2nd Class Stations. A Repsold 10-inch universal instrument of a similar pattern to that used in South Africa was purchased about 1904 to supplement the older types.

1874-1890 Between the years and during lulls in ordinary triangulation astronomical observations at 40 stations throughout New South Wales were complete, partly to facilitate the compilation of a more accurate map of the colony and also in anticipation of further triangulation extensions in the trigonometrical survey. Of these stations, 11 were

within the triangulation system and 29 beyond its scope. Longitude observations were derived from difference in time with Sydney Observatory.

1916 The triangulation had been extended to Bourke about 300 miles north-west of Lake George and although a base (at Bourke) had been selected and connected to the system, no measurement had been made.

1918 At a Royal Commission to inquire into the Public Service of New South Wales, it was explained that field surveys had been temporarily curtailed to allow Computing Branch an opportunity of bringing the work up to date—calculations were approximately three years in arrears.

The period between the two wars was one of comparative inactivity in triangulation by the State Authorities.

1927 The Bourke Base was measured by the Lands Department in 1927. Use was made of four invar bands, 24 metres in length and for conversion of metres to feet, Benoit and Chaney's 1896 value, 1 metre = 3.28084275 feet, was adopted. Six bands had been received in 1911, after standardisation at the National Physical Laboratory, England, but before measurement, 2 of these were returned for restandardization. The length of this base, situated on flat terrain, was in excess of $19\frac{1}{2}$ miles. Comparisons from Lake George to Bourke Base taken partly through single triangles gave an unadjusted difference of 4.92 feet or $1/21,000$, between the measured and the computed length of the Bourke Base. In view of the discrepancy, but mainly for the purpose of establishing a 1st Order chain throughout an area extending north-east to the main chain near Tamworth, a base was laid down, measured, and base net observed at Condobolin by Lands Department surveyors in 1945. A new computation from Lake George gave a misclose on the Condobolin Base of $1/32,000$ and from Condobolin on the Bourke Base of $1/29,600$.

In 1927 the Richmond Base was remeasured with invar bands. A comparison between the two measurements showed 0.2709 feet between 1880 and 1927.

It is of interest at this point to recall the personnel engaged for the Base Line measurements at Richmond and Bourke in 1927 and a later remeasurement of Richmond in 1944.

The 1927 measurements were carried out by Mr Fred C. Carr, with "two other professional officers"—Mr H. C. Messer who had been a computer in the old Trig. Branch, and Mr A. W. Bonner, "at the time an experienced and specially qualified Field Assistant", in addition three experienced fieldhands. The Surveyor-General and Director of Trigonometrical Survey in 1927 was Mr H. B. Mathews who participated in the field measurements at Richmond. The Richmond Base measurements were intended partly for training personnel in the use of new equipment brought into the country for the Bourke Base Line and partly for the comparison with Conder's value.

The same personnel measured the Bourke Base. In 1944 the re-measurement of the Richmond Base was carried out, under the supervision of Mr Fred Carr and included Mr C. E. Elphinstone, Mr A. S.

Hutchinson, Mr G. W. Anderson—Staff Surveyors; L. Hall—Registered Surveyor; K. Scott, F. Vickress—Field Assistants; and H. Stapleton—Fieldhand.

1936 A reconnaissance was made for the purpose of linking the triangulation of Victoria, New South Wales and Queensland and to that end, the triangulation chain was designed with favourably conditioned figures and located mainly along the coast and northern tablelands. Bases were located and measured during 1939-1940 at Benambra (Victoria), Somerton (New South Wales) and Jondaryn (Queensland). No observations were necessary over that part covered by the Trig. Survey of New South Wales, as it was found sufficient information was available to close the figures selected to the desired degree of accuracy. Army surveyors carried out all the field work necessary to connect the Victorian system near the State border and to design and observe a chain northerly, from a line Balkan—Cockrow (Muswellbrook district) into Queensland.

The work of the Australian Army Survey Corps cannot be too highly commended, as during these years when State mapping activities were at a standstill, its members had modernized triangulation methods, both field and office; had laid the foundation for future operations and provided a system of co-ordination which could be developed over the State from one geodetic origin.

1946 The report of the Government Mapping Investigating Committee in 1946 ushered a new era in mapping in New South Wales, and one of its recommendations was that "the Trigonometrical Survey be accelerated and continued without abatement", the survey to be effected by a new organization within the Lands Department, the Central Mapping Authority, controlled by the Surveyor General in his capacity as Director of Mapping.

Since that date primary triangulation extension and measurement within the trig. network has been made from Condobolin Base, north-east to Somerton Base—1957-58, Cockrow—Euther 1959, Wambelong—Mt Foster—Bourke network 1960, and in 1965 an extension from Cobar, south-west to a point on the Ivanhoe/Wilcannia road, 45 miles north from Ivanhoe, for the purpose of providing a terminal for an extensive tellurometer traverse.

1958 The introduction of the Tellurometer, an electronic distance measuring device, provided an opportunity to effect check measurements throughout the triangulation network, the results of which were used in the overall geodetic adjustment of Australia, carried out by the Department of National Mapping in 1966.

To a great extent, the future requirements of the trigonometrical survey of New South Wales will depend on the mapping programme. In western districts, and the Riverina, where topography has limited the triangulation, a form of traverse utilizing Wild T2 theodolites, and 9 feet tall tripods with signalling lamps, to give traverse legs up to 4 miles, and tellurometer measurement, has given results sufficient for standard topographic map accuracy. A newer model of the tellurometer promises to provide greater distance precision.

In conclusion, I would express my appreciation for the advice and assistance of Mr J. Hutchison, Computing Division, who had many valuable old papers carefully compiled, and Mr R. Bayliss for his assistance with the older instruments.

As a matter of interest, I have listed the various papers used for references.

1828—*Progress of Roads and Public Works.*

1833—*New South Wales Magazine—On Trig. Survey of N.S.W.*

1867—Letter Surveyor/General's Office—regarding steps for measurement of base line.

1870-71—Report Surveyor/General to Under/Secretary for Lands—Base Line for triangulation.

1883—Memo from Surveyor Woolrych to Surveyor/General—use of steel band.

1879—Memo from District Surveyor Twynam to Surveyor General—Newcastle Base Line.

1894—*The Surveyor*, March 7th, a sketch of the progress of Trig. Survey Division by Mr W. C. Campbell.

1898—T. F. Furber—*The Trig. Survey of New South Wales with mention of similar surveys in other Australian Colonies.*

1892—*Observations of Transit of Venus, 9-12-1870, made at stations in N.S.W.*—Govt Printer, 1892.

1914—T. F. Furber—*Geodetic Surveying in New South Wales, and some results.*

1924—A. H. Chesterman—*Trigonometrical Survey of New South Wales.*

1944—*Remeasurement of the Richmond Base Line 1927, 1944—*Reports 3-3-1944 and 21-6-1944—Senior Surveyor Fred C. Carr.

1946—Report of Government Mapping Investigating Committee.

1947—Lands Department Litho 47-984—A Brief Review of the Trig. Survey and the Mapping Activities in the State of New South Wales.