

THE SURVEY OF THE SHRINE OF REMEMBRANCE

A Lecture, read by FRANK J. DOOLAN, M.V.I.S., to the Fourth Interstate Conference of Surveyors' Institutes of Australia, on Wednesday, 31st October, 1934.

Before dealing with the actual survey work prior to, and during the construction of Victoria's National War Memorial, it is necessary to traverse briefly the history of the selection of the site, made prior to inviting competitive designs.

There were, in all, 25 prospective sites submitted to an expert committee, of which the late Sir John Monash was chairman, and to whose judgment and foresight especially, the selected site bears witness.

The chosen site admirably exhibits the architectural merits of the Memorial in such a way as to make it the dominating feature of the surroundings and strikingly visible from the City itself. St. Kilda Road, the main arterial approach to the City from the south, already skirted the eminence on which it stands, so that from north and south the Shrine appears to stand astride that leafy boulevard. It is visible far and wide throughout the suburbs, and visible also from far at sea, comparable in prominence with the Statue of Liberty at New York. All shipping approaching the Port of Melbourne by the "west channel" of Port Phillip steer directly towards it. The River Yarra where it enters Victoria Dock is aligned on the Shrine, so that visitors from overseas must for all time be impressed by the outstanding landmark of Melbourne, gleaming white by night or by day. The detours of St. Kilda Road about the Shrine, gives space for wide lawns capable of accommodating hundreds of thousands of people on their slopes upon ceremonial occasions.

The Architects, Messrs. Hudson and Wardrop, have in their design taken full

advantage of the possibilities of the site; they have designed the Shrine on an axial plan comprehending its dominance of the approaches, and the magnificent vistas; the axis north and south conforms with the centre line of one of the principal streets of the City—Swanston Street. In addition, the western axial is in line with Banks Street, which leads direct to South Melbourne Town Hall, one of the oldest and most imposing municipal buildings in the environs of Melbourne.

When my firm undertook the surveys necessary to fix accurately the intersection of the three main axials, these were found by my partner, Mr. Chas. T. L. Goodchild, to form a small triangle which the size of the memorial renders immaterial. The intersection of the northern axis from Swanston Street with the western axis from Bank Street, South Melbourne, was adopted as dead centre of the Shrine. The next work was the grid survey of the site, with special reference to its relation to sea-level, and also to the surrounding roads.

A 50-foot grid was pegged over the site, and it was found that the crown of the hill was 82 feet above sea-level, and 50 feet above St. Kilda Road; the relation to sea-level was obtained by linking up with a Standard Box of the M.M.B.W. Survey.

This plan, showing the natural features of the site, was of course an essential preliminary to the preparation of the architect's working drawings. The setting out of the foundation stone of the Shrine followed, being undertaken out of its usual order to enable the ceremony of laying the stone to be

performed by Lord Somers, then Governor of Victoria, on Armistice Day in 1927. Prior to that date a flagpole, of the designed height of the edifice, carrying an Australian flag by day and a beacon at the top by night, had been erected on the centre of the site.

In his remarks to the large gathering which attended, Sir John Monash showed that it could barely be contained by the playing area of the Melbourne Cricket Ground, and would comfortably occupy a major city block.

Control Points

The construction of the foundations and approach steps ensued, and when the Inner Shrine Floor level was reached it was necessary to lay down a very accurate control by an elaborate system of permanent marks to enable the masons accurately to set out their work, and to enable each vital operation to be checked continuously by the Superintendent of Works, Mr. Edward Gunn, as the work proceeded.

The utmost refinement of accuracy in the design and the construction of this monument is essential to the conception itself, and the correction of optical illusion involved mathematical calculations to an almost unprecedented degree by the architects. The requirements of accuracy thus imposed upon the control survey may be imagined.

The true centre of the memorial was re-instated from our control points, and a square copper plug was grouted into the concrete, and the dead centre engraved with hair-lines in the copper. Round copper plugs were also let into the concrete floor on the four axial lines, and the true line was similarly engraved on these plugs. In addition, the axial lines were produced and marked on all approach steps, and where required on the surrounds, by knife-edge scratches on concrete patches, thus permanently marking on

the concrete foundations a complete horizontal control.

The vertical control was obtained by selecting certain smooth patches on the concrete superstructure and chiselling a cross on the definite points, which were then numbered, and carefully levelled. As it was possible to stand close to the staff and estimate in reading three places of decimals, and as two completely independent sets of levels were taken, it may be said that the main levels were everywhere accurate to within a hundredth of a foot.

Following the practice of the Greeks in some of their most famous buildings, Messrs. Hudson and Wardrop, the architects, adopted the principle of parabolic and hyperbolic curves in the design for the cambering of all the horizontal lines in the Shrine; and the method adopted in the construction was to have accurately machined cylindrical brass discs or dumps to act as full-sized ordinates from level straight lines. The desired curves could then be established and checked with the utmost accuracy. Many of the figured dimensions on the working detail plans were recorded to one-thousandth of an inch, and although it was realised by the architects that it was impossible to achieve such accuracy in actual construction, still the calculation itself demanded this so that all measurements could be made to close. That extreme accuracy, furthermore, was an incentive to good workmanship.

All the verticals of the Shrine have been designed to lean in two directions, so that the axes of the columns would meet if produced at the apex of an imaginary pyramid at a point 1.4 miles above the Shrine floor. The lean of each individual column was calculated separately, so that some of the outer columns lean 1.08 in., and other similar columns lean 0.16 in. in the same direction. There must have been an im-

mense amount of research and study necessary by the architects to enable them to show these minute details on their working plans; the work of the contractors, Messrs. Vaughan and Lodge, and the Superintendent of Works, Mr. Edward Gunn, was extraordinarily exact. The Shrine of Remembrance is now probably the most accurately constructed structure of the world.

Astronomical Feature

The astronomical feature of the design is that a shaft of direct sunlight should shine on the Rock of Remembrance at 11 a.m. on Armistice day; and when construction had reached the stage when form work for the concrete superstructure of the stepped dome was being erected, I was called upon to calculate and set out for the contractors the position, shape and size of apertures in both the inner and outer walls of the dome of the memorial.

At the request of Sir John Monash, the Government Astronomer, Dr. J. M. Baldwin, had determined the greatest range of variation through the years of both the declination and hour angle of the sun, and according to the results supplied to me, the sun's greatest variation in declination, or (for my purposes) in altitude was 36 minutes of arc, and that in hour angle, or azimuth, 15 seconds of time. The true altitude was 65 degrees 8.7 minutes, and true azimuth of the mean position of the sun 38 degrees 54.2 minutes east of north at the critical moment, so that the survey work mainly involved making the necessary calculations and the responsibility of instructing the contractors the precise positions of the necessary apertures in the concrete.

In conference with the architects it was decided that an opening of 3 in. diameter in the inner wall, thus projecting a circular patch of sunlight on the Rock of Remembrance about 9in.

diameter, would be the most suitable size and shape; and it is obvious that the centre of this aperture must necessarily be on the true mean position of the sun at the requisite moment. In order to set this out it was necessary to determine accurately the orientation of the axes of the Shrine; and this was done by a series of extra meridian solar observations taken at the Shrine in August, 1931. It might be thought that these observations would be sufficient check on one another to make the orientation safe, but this was not an ordinary job, and could not be determined finally by a process of trial and error, so the writer decided to tie up as a check with the co-ordinated system of the Melbourne Harbour Trust; and through the courtesy of their Chief Surveyor (Mr. J. E. Bradley) I was able to check the true bearing of the axis by computing from co-ordinates.

This feature depended entirely on correct orientation, and any failure of the ray of light to strike correctly would have been a fiasco too appalling to contemplate.

The aperture in the outer wall of the memorial presented difficulties, as, in addition to setting out the true mean direction of the centre of the sun, it was necessary also to determine the size, shape and orientation of an aperture in the substantial masonry; so that this aperture would include all the positions of the sun at the eleventh hour of Armistice Day, having regard to the considerable range of variation in both directions as supplied by Dr. Baldwin. The distance between the two apertures is 22 feet 9 inches, and it follows that if the sun is in a direct line of the Rock of Remembrance and the outer aperture, sufficient rays must penetrate through the inner aperture to project a beam of direct sunlight on the central Rock of Remembrance as required.

The cross section of the outer aperture at right angles to the line of the

shaft devolved into a figure with parallel sides and having as its ends semi-circles tangential to both parallels and of a radius to accord with the semi-diameter of the sun. Templates were cut to show these figures, and a theodolite was erected on a platform, so that the axis of the instrument was in the plane of the final position of the Rock of Remembrance in the centre of the Inner Shrine.

With a backsight on the Brewery Buildings at the northern end of Swanston Street, the true bearing of which was known by our solar observations, the mean position both for altitude and azimuth of the ray of sunlight was turned out and marked on the form work of the inner wall; and at a later date on the forming of the outer wall. The contractors were thus able to set out their forming to allow of the apertures being provided in both walls of the size and shape required.

I have spent some time on the description of this feature, as I feel that it is of general interest, and also because it presents a somewhat unusual practical problem for the practising surveyor, and emphasises the uses of astronomy in the practice of surveying.

The field work was done under some difficulties, notably that of setting out a line, using a diagonal eye-piece—with the sight threading through a multiple grille of scaffolding and planks—in an unfavourable light; and one confesses to having been oppressed at times by anxieties arising from the possibility of most momentous issues being affected by physical limitations so imposed.

It goes without saying that an independent check upon the whole of the survey work was essential; and this was effected by Mr. J. F. Knight, a licensed surveyor on my staff; but the ultimate test, even allowing for the full-

est measure of confidence in the progressive checking antecedent to completion could be nothing other than the result obtained on the Armistice Day of which I speak, in 1931, when the passage of the ray of light across the mortar board which took the place of the Rock of Remembrance in the unfinished building had elements of personal drama additional to the impressive spectacle itself. At this stage I believe that it may be of interest to explain how adjustments of the calendar compensate for the inequality of the solar and sidereal years.

Calendar Adjustments

Actually the path of the beam of sunlight across the Rock of Remembrance varies slightly from year to year; but so that it returns every year almost exactly to the path it traversed four years before. The fact that the last year of the century is not a leap year, unless the year number is divisible by 400, ensures further adjustment, so that the path will always, century after century, pass close to the centre of the Rock.

The position of the aperture has been computed so that the shaft of light is closest to the centre of the Rock at 11 a.m. Standard Time at present. This corresponds to a definite time before the sun crosses the meridian. The standard time at which the sun crosses the meridian changes very slowly, so that after 2,300 years it will cross almost two minutes later than it now does. Two thousand years later still it will cross at the same hour as at present, and then for several thousand years it will cross earlier and earlier, until it will cross some thirteen and a half minutes earlier than at present. There will thus be a slow swing in the time at which the shaft of light will pass closest to the centre of the Rock of Remembrance, from 11.2 a.m. at the latest to 10.46½ a.m. at the earliest.

I am entirely indebted to the Victorian Government Astronomer (Dr. J. M. Baldwin) for the computation of the position of the sun and its variation of position through the years, and he has also computed that for the next five thousand years, at any rate, the ray of sunlight will be closest to the centre of the Rock within two minutes of eleven o'clock, and that should satisfy mere mortals. The sun will also be in direct line of the centre of the apertures on its return after midsummer: on 3rd February, at approximately 11.30 a.m.

The outer aperture is covered by a bronze plate, which was considered necessary in order to keep the structure weatherproof. This precaution was preferred to the idea that the agency of man should be entirely eliminated, so that the beam would penetrate the structure and illuminate the words, "Greater Love Hath No Man," automatically at the anniversary of the signing of the Armistice year after year.

In the original premiated design it was intended that Bank Street, South Melbourne, a direct artery 99 feet in width, to the South Melbourne Town Hall, should be extended to St. Kilda Road by resuming the few properties between Wells Road and St. Kilda Road, which intervene to bar the connection; and this seems so fundamental to the future development of the system of axial vistas that it is a disappointment that this has not been decided upon. In addition, a reflecting pool in front of the northern terrace is included in the layout, and each Roman

cypress and Queensland Kauri tree in the double grove along the main approach has been dedicated to a unit of the A.I.F., and planted by its members. A flanking road leaves St. Kilda Road at the Marquis of Linlithgow's statue, passes between the Shrine and the Observatory and by the newly-erected MacRobertson Herbarium, runs through the lawns and trees recently planted and continues beside the Botanical Gardens into Anderson Street.

Away from the hubbub of commerce, the noisy wheels of busy transport, and the mundane routine of city life, the site is sufficiently close to the metropolis to necessitate but a short pilgrimage to reach the Shrine, but when the trees which surround it are fully grown the restful and sequestered atmosphere will be enhanced. Yet the Memorial is not near enough to the city's life and traffic to cause it to be taken for granted like the generality of monuments.

So beautiful and enduring a monument, situated close to the heart of the State and people, is the only satisfactory constant reminder of the days and deeds of the war and of the people who fought and worked and waited throughout.

The Theme is Remembrance!

It stands in a quietude in which those to whom the memories of the war are poignant may be silent, with the same solemn but expressive stillness as possesses the mighty gloom within. For all time may it always be—

"A Shrine of Remembrance."

Mirrors correct for Daylight Saving Time

The Shrine was carefully designed so that a natural ray of sunlight would fall on the word *love* on the Stone of Remembrance at 11am. For the next five thousand years the design would see that this event occurred within 2 minutes of 11am on 11 November.

Melbourne's adoption of *daylight saving time* in 1971/72, however, caused a problem as the ray would now illuminate the stone at midday. Two mirrors, one inclined and one horizontal as shown in the figure below, were installed to *bend* the ray of sunlight to achieve the desired light effect at 11am once more. The mirrors are set in their respective positions before the service each year.

