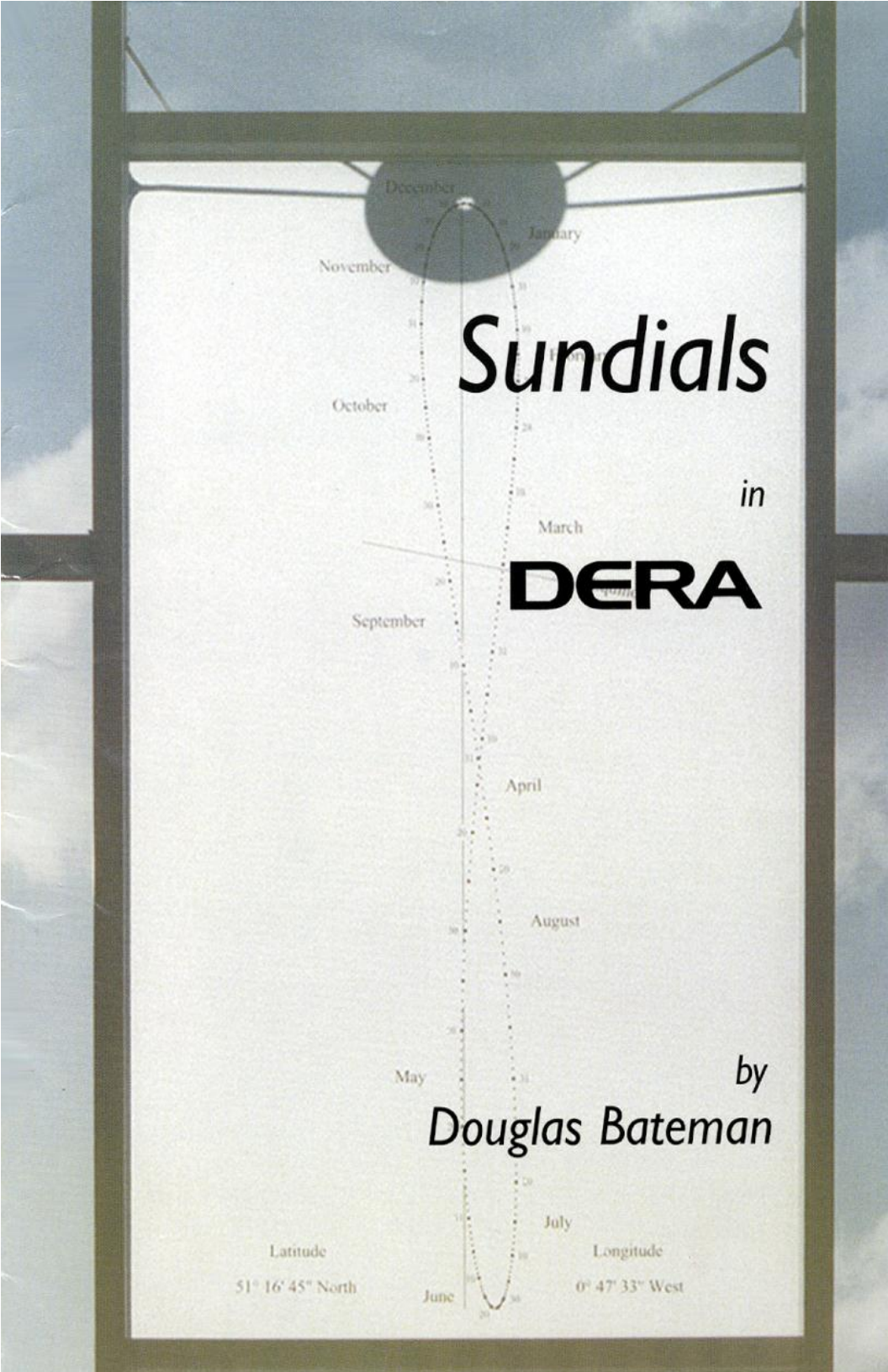

Sundials

in

DERA

by

Douglas Bateman

Latitude
51° 16' 45" North

Longitude
0° 47' 33" West

The main entrance to the DERA headquarters building, called the Cody Building, with the historic Cody's Tree. The tree (or rather this metal replica) commemorates the first sustained aeroplane flight in Great Britain on 16 October 1908.

The special noon dial, which prompted the publicity of this booklet, is in the glass curtain wall on the south side and can be seen after walking past the reception desk.

This booklet describes the very rare form of sundial, called a meridian or noon dial, installed in the glass curtain wall of the headquarters building of the Defence Research and Evaluation Agency (DERA) at Farnborough. Although the central theme of the booklet is the planning, theory and construction of the noon dial, it is placed in the context of sundials generally, and details are given of two other dials that have associations with DERA. In fact, by way of an introduction to sundials, the horizontal dial at Fort Halstead and a memorial dial at Farnborough are described first.

However, it also necessary to put the noon dial in the context of the new building programme at Farnborough and the formation of DERA, and to mention an unexpected connection with some of the work at DERA - the control of solar panels on artificial satellites.

The Formation of DERA

With the formation of the Defence Research Agency (DRA) in 1991 - based on the amalgamation of the Royal Aerospace Establishment, the Royal Signals and Radar Establishment, the Royal Armaments Research and Development Establishment, and Admiralty Research Establishment - there was a pressing need to rationalise the accommodation. The greatest priority was at Farnborough itself and the decision was made to build a new £70M complex on the site of the old Concorde test facility on the north west area of the airfield. During 1994-95 the then DRA became larger by embracing other government defence establishments, notably the aircraft testing establishment at Boscombe Down, the Chemical Defence Establishment at Porton Down, and operational analysis and trials organisations. To reflect the overall gain in testing capability, the larger organisation was renamed the Defence Evaluation and Research Agency (DERA) in April 1995.

The new development at Farnborough was designed to give much improved working conditions for all staff such as open plan offices, linked buildings, a pleasant outlook, good parking and energy-efficient construction. Altogether, it was to provide an attractive environment consistent with the international status of the Agency and the calibre of its scientific and engineering staff. Figure 1 shows the finished site, one year after first occupancy.

At the planning stage in 1994, staff were invited to make suggestions for the new buildings, and it was at this time the imaginative idea for a very unusual type of

sundial was put forward. Such a sundial gives a link with academic institutions: indeed, without being too modest, it is on a par with more traditional dials on colleges in Oxford and Cambridge. The suggestion was accepted, and it is clear that the somewhat enigmatic noon dial, with its detailed engraving on glass and stainless steel structure, is a functional scientific instrument and conveys the research and development ethos of observation, analysis and application.

Figure 1: Aerial view of the new buildings, 1997. The noon sundial is on the Cody Building, (with white curved roof, right of centre) in the dark rectangle in the middle of the white 'wall' facing the circular piazza.

Satellites and Solar Panels

The link between artificial satellites and sundials may appear tenuous, but both rely on the sun and a proper knowledge of the solar system. Sundials, generally, show local apparent time rather than mean time (both of which are defined later). To put it simply, and rather obviously, the sundial is responding to the position of the sun as it is, and if the sun is at its highest, it is due south (to those of us in the northern hemisphere) and it is noon - the middle of the day.

To gain maximum power from the solar panels on a satellite, they too, need to take account of the sun 'as it is', and the on-board controls work to keep the panels pointing towards the sun, or at least angled to get as much of the sun's energy as possible.

If we take, for example, the geostationary military communications satellites, Skynet, the antennae must point towards the earth at all times. The orbit of the

Showing the Date

Dials of this type generally make do with marking the months as in Figure 9, with one exception being a very fine dial in Parma, Italy, dated 1829. On the noon dial the date is marked every 3 days on an adjacent border, with a thin line linking the analemma and border - see Figure 11. The dial is rather confusing to read, but it must be remembered that a dial of this type acts rather like a modern almanac, and the information is there for all to see.

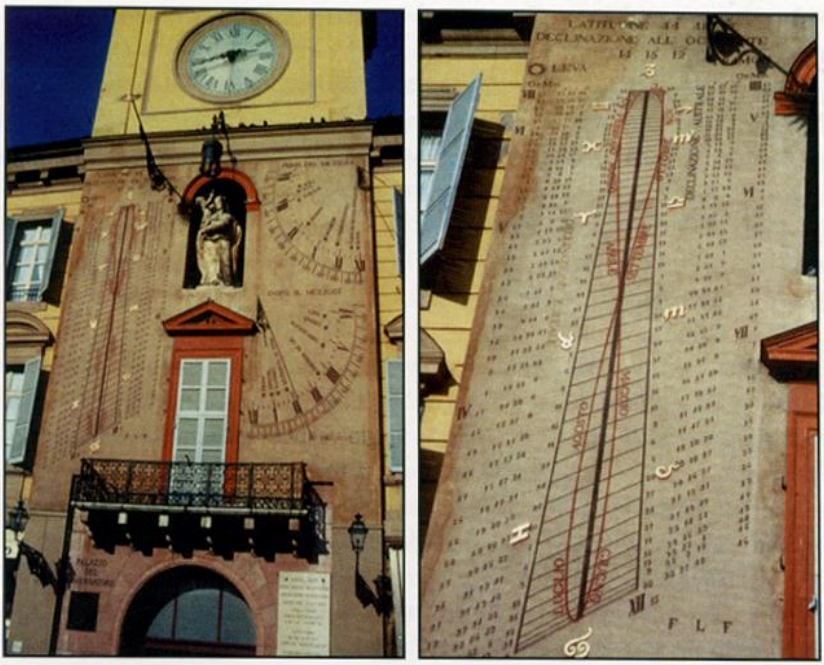

Figure 11: A superb combination of clock, noon dial with analemma, and a more traditional vertical dial on the Governor's Palace, Parma, Italy. The vertical dial has been cleverly 'split' to make best use of the vertical space, and shows noon in other cities around the world. The noon dial shows, from the left to the centre: time of sunrise (hour and minute), the declination of the sun, the date (at 3 day intervals), the month, the analemma in red (for mean time), and the central line is for local apparent noon. On the far right is the time of sunset. Note the gilded signs of the zodiac.

It was clear from the mock-up of the prospective DERA dial that a line for the analemma, which is traditional, could have the dates marked by 'tick marks'. However, this looked like a map-representation of a railway line! A series of dots was tried, with a larger dot at every 5 days. This looked very good, and helped to convey the scientific precision appropriate for the location. The only other design detail in the use of dots was where to start the numbering from. A calendar always gives the first day of the month, but if "1" was emphasised there would only be 4 dots to the "5" with 5 dots thereafter. A more regular spacing

is achieved by marking the ends of each month. Although this leads to 7 months with 6 small dots (and one of 3) at the end of each month, the effect is of regular spacing for the emphasised days along the analemma. It only then remained to mark the months and number dates at 10, 20, 30 (or 31 and a 28).

In keeping with a deliberately austere design, the only extra information is the equinox line and the latitude and longitude. Although the dial is not 'signed' a separate plaque gives the designer's name and a short description of the dial.

The artwork was delivered to a specialist sub-contractor in the field of glass etching, engraving and design, known as T&W Ide, and located in east London. Indeed, their advice was taken on the etching of the whole sheet to give the 'frosted' glass appearance, and the shot blasting of the lettering and final gold leaf treatment. Figure 12 shows work being done at an intermediate stage. Although the gold appearance of the analemma and lettering appears dark when viewing the dial from inside the building against the light of the sun, from outside the gold appears bright, and looks good on a winter's evening from the inside with the local spotlighting.

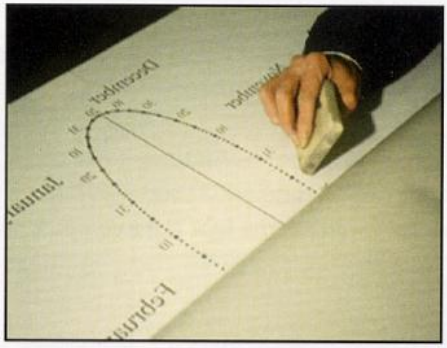

Figure 12: Work on the glass panel - on the left the stencil is being applied before shot blasting; on the right the gold leaf is being given a protective lacquer.

Gnomon Design

Meridian or noon dials are normally constructed on a wall and the designer makes the gnomon as a circular disc with a circular aperture. Decoration is almost invariably as an outer rim of the 'sun's rays' and often gilded. The outer shadow of the decoration is quite attractive and the overall shape varies during the seasons with the elevation of the sun. On the other hand, for a dial that is designed to be viewed from *inside* the building, I considered that a 'decorated' gnomon would be very fussy. I opted for a disc (which the architect agreed with), but with an unusual refinement. A circular disc, normal to the sun, will cast an elliptical shadow on a vertical wall. However, the situation can be reversed by having an elliptical shape to cast a circular shadow on a vertical surface.

The proportions of the ellipse were calculated for the elevation of the sun at the equinox (51.28°) with the further minor complication that the glass curtain wall for the dial does not face due south, but is declining 13.5° to the west. The circular shadow may be 'restored' by rotating the ellipse clockwise (as viewed from the sun) by 21.0°. A model proved the point, and showed that the angles were surprisingly critical. I am indebted to a retired scientist from the former RSRE Malvern, Dr P M Woodward, for the mathematical proof of this translation.

The end result is that the shadow of the ellipse, and the elliptic aperture, cast circular shadows twice a year at each equinox.

Structurally, the gnomon is made from stainless steel tube and flat sheet. In keeping with the functional design, the only decoration as such was to score the sun-facing surface of the ellipse so that it catches the light like a compact disc.

The Completed Dial

The window containing the finished analemma, vertical line and lettering was installed by the contractors in August 1996 in the curtain wall of Cody Building. A colleague and I fitted the gnomon structure on 7 August 1996.

At the outset, leaflets were prepared and suitable display pockets were positioned in the entrance hall. The dial is very successful as a suitably technical and functional object. The rarity of such a dial is such that many are curious (and often baffled). The leaflets are taken by staff and visitors at a fairly consistent rate of 8 a day.

New arrivals have the dial included in the induction tour, and when the whole site is shown to visitors with an interest in the architecture of the buildings, the

dial is invariably mentioned. Indeed, the architects have paid a compliment to the dial by 'framing' it with the automatic venetian blinds that descend over the main areas of the curtain wall on a sunny day. Figures 13 to 16 show various views of the dial in place.

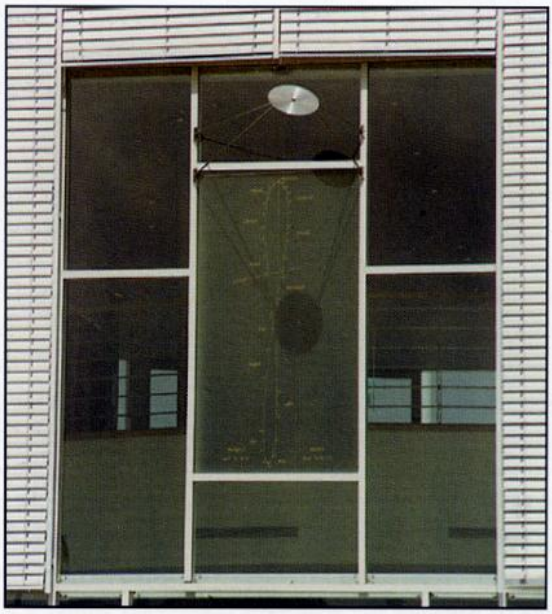

Figure 13: A view of the dial from the outside, which shows the finish on the gnomon disc and the gold lettering. A balcony at first floor level can be seen through the windows.

Figure 14: The dial as seen from the concourse below the balcony. The photograph was taken at the time of the equinox.

Conclusion

The traditional horizontal dial at Fort Halstead and the memorial dial from the old RAE do have a place in DERA and its formation, but the dials have turned out to be transitory. The horizontal dial came from Waltham Abbey in 1991 and is due to be returned when the historical site has been restored. The Busk Memorial dial was set up in 1914 and removed to safe storage in 1999. To have been on site for 85 years is hardly transitory by modern standards, but one always hopes that a sundial will be as permanent as possible.

Will the noon dial be in place for this length of time? Although the design life of the buildings is 25 years, experience shows that good buildings stay in place well beyond the specified figures.. If the buildings are eventually changed or demolished, then one may hope that the dial be preserved or incorporated in any new construction.

To summarise the noon dial, it gives three separate but related pieces of information - the local apparent noon, the meantime noon, and the date. The delineation of the dial on frosted glass, specifically for viewing inside the building is novel, and has the additional feature of the gnomon casting a perfectly circular shadow at each equinox. The dial has proved to be very successful in that it has met all the design criteria of appearance and accuracy. The latter is such that the time of the spot of sunlight crossing the analemma is generally within ± 7 seconds, and this is mainly dictated by a natural variation of the sun's position during the leap year cycle. By telling the date, the dial can also be called a calendar dial.

The question is occasionally asked "What has a sundial to do with Farnborough and its traditions?" The answer is - nothing to do with aviation, but in the context of a scientific or learned community, it is an instrument that represents the principles of observation, analysis, and application. In this respect the dial has a place on a par with the traditional sundials in our foremost academic institutions. The dial already features in a popular commercial book on sundials - for example in the book on sundials by C Daniel. The dial is in a prominent place in the main entrance to the DERA complex and attracts the attention and admiration of many people, both from inside and outside the Cody Building. It is hoped that staff and visitors will continue to enjoy the dial for many years to come.

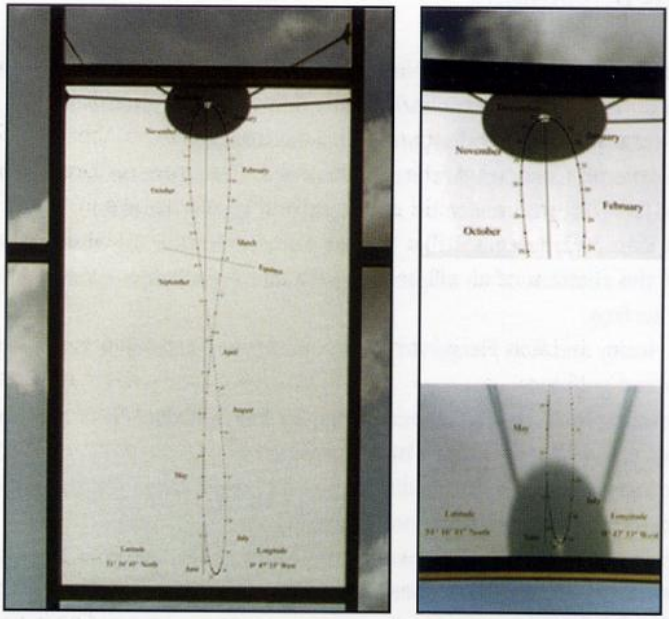

Figure 15: Views of the dial at the winter solstice (left) and the summer solstice (bottom).

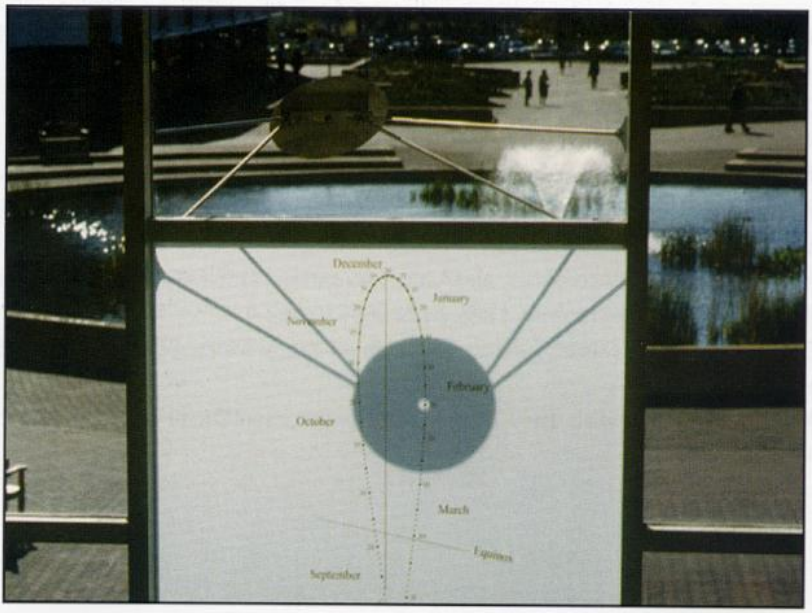

Figure 16: Another view of the dial from the first floor balcony. The date is the 20th of February at 12.00 noon precisely.

Acknowledgements

Peter Briggs, Weapons Sector (Navigation), for providing the GPS co-ordinates, and Chris Kelleher, Communication and Information Systems Sector (Skynet satellite team), for independent analemma calculations.
John Weatherill, Contract Architect, Shepherd Construction Limited, and Ray Spillman, T&W Ide, for advice on structural and glazing aspects.
Dr P M Woodward (ex-RSRE) - private communication for the mathematical proof of the rotation of an ellipse to give a circular shadow on an inclined and rotated surface.
Darren Healey and Ron Fitzgerald for comments and assistance on the mock up, artwork and gnomon.
The photographs in Figure 12 were taken by Ray Spillman, T&W Ide, and those in Figures 4, 9, 10, and 15 were by the author.
The photographs of the Parma dial (Figure 11) were taken for the author by a well known Italian diallist, Giovanni Paltrinieri.
Norman Paul and George Hooper (ex-Waltham abbey and Fort Halstead staff) for information on the dial at Fort Halstead, and Jill Wilson, dial-maker historian, British Sundial Society.

Bibliography

Robin Clive, Fort Halstead - a celebration of the first 100 years, DERA, Fort Halstead, 1997.
D A Bateman, The Noon Sundial on the Cody Building, Farnborough, Technical Report, DERA/WSS/WS1/TR990610/1.0, November 1999.
Alan A Mills, Noon Marks and the Projection of the Analemma, with some new versions of these old instruments, Bulletin of the British Sundial Society, Vol 11(ii), 62-69, June 1999.
H R Mills, Positional Astronomy and Astro-Navigation Made Easy. Stanley Thornes (Publishers) Ltd, Cheltenham, 1978. ISBN 085950 062 4.
Christopher St J H Daniel, Sundials, Shire Album 176, Shire Publications Ltd, 1996 edition.
Albert E Waugh, Sundials, Their Theory and Construction, Dover Publications Inc, New York, 1973.