THE MARGARET STANIER MEMORIAL SUNDIAL
AN UNEQUAL-HOURS DIAL FOR NEWNHAM COLLEGE
Part 2. Evolution of the Design

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In Part 1, which was published in the September issue of the BSS Bulletin[1]*, Frank King gave an account of the gnomonic details of the gnomon-driven unequal-hours dial that was made as a memorial to Margaret Stanier in 2010. Here, in Part 2, Annika Larsson describes how she developed the design into the finished sundial.*

The Story So Far

In Part 1, it was shown that by carefully choosing the orientation of the gnomon, it is possible to make a gnomon-driven sundial that indicates unequal-hours to acceptable precision. The gnomon must be in the meridian plane and, in the latitude of Cambridge, should dip downwards towards the south by an angle of about 8.9°.

With this angle of dip the variability in the direction of the shadow at the ends of hours III and IX is minimal. The variability at the end of hour VI is zero and at the ends of most of the other hours it is acceptably small.

Fig. 1, reproduced from Part 1, shows, for a direct south-facing dial, the positions of the 13 hour-lines from sunrise to sunset inclusive. Associated with each hour-line is a grey region whose margins indicate the range of directions of the shadow at the unequal-hour indicated. Each hour-line is in the mean direction.

The greatest variability is at sunrise and sunset and, in the mean positions, the (unlabelled) sunrise and sunset hour-lines slope noticeably downwards. These sloping lines prompted considerable design thought.

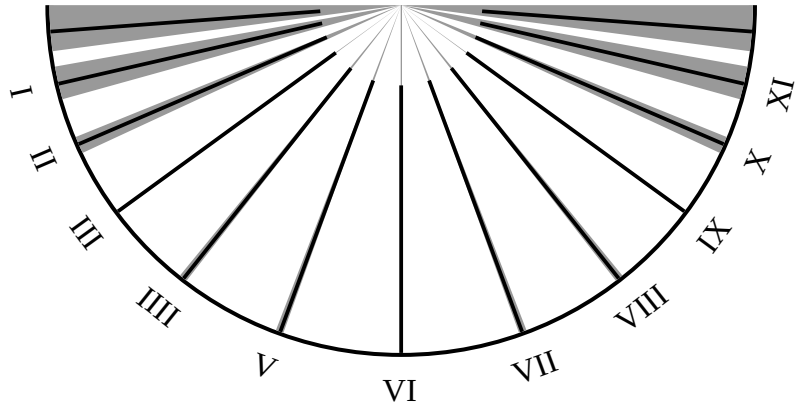

Fig. 1 — Embryonic Design

The procedure for determining the directions of the hour-lines also holds for declining and reclining dials. The Newnham College dial is vertical but declines about 3° west.

Early Thoughts

Having worked as a designer and stone-cutter on a number of Frank King sundial projects I was not too surprised when he got in touch with me just a few days after Newnham College suggested that a sundial might be an appropriate memorial to Margaret Stanier.

I gathered that an unequal-hours dial was a possibility but this was long before the gnomonic details were settled. Fig. 1 was some way into the future.

The principal early problem was persuading the Cambridge Planning Office to allow a sundial to be put up in the position that the College had chosen. The intended site is shown in Fig. 2.

Fig. 2 — The Intended Site

There is a panel of limestone blocks roughly 2 m square set into a recess in the wall of a college building. The panel is ornamented by a faux balcony and the balcony rail is supported at its centre by a horizontal bracket which is perpendicular to the stonework. The bracket cannot be seen but its shadow shows up as a short diagonal element running downwards to the right. This bracket could almost serve as a gnomon for a traditional design of unequal-hours dial.

The panel is close to direct south-facing and the space above the rail seemed a good site for a sundial. This space invites a rectangular dial but, to go some way towards echoing the circular shape of most mass dials, it was decided to round off the corners and design an elliptical dial. The proposed material was slate and the dial furniture would be cut and gilded.

The local planners argued for a dial cut directly into the stonework. This would have required a protracted period with scaffolding against the wall and associated security implications. It would also have greatly increased the cost. The College and I both thought it would be better to make the dial in a workshop.

Living in Sweden, I was happy to keep my distance during the long-drawn-out discussions with the planners and the first design was sketched by Frank King. This was requested

by the College so they could have something to discuss. The design is shown in Fig. 3 and it gives a hint of what dial furniture can look like when cut in slate and gilded. It also incorporates a possible inscription. The sun is plagiarised from the dial at Queens' College.

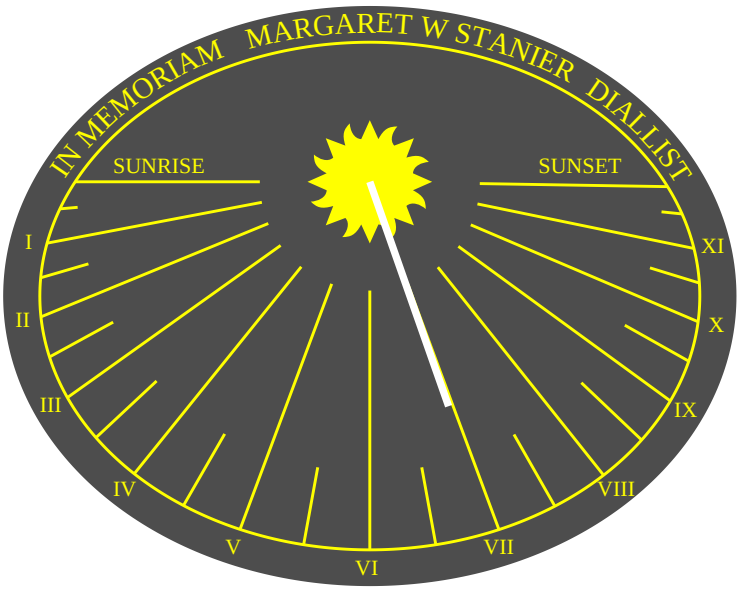

Fig. 3 — The First Design

The sunrise and sunset hour-lines are almost horizontal but this is the result of a gnomonic fudge. Instead of placing the hour-lines in the mean directions, each is placed in the position appropriate for a solar declination of $-2°$!

With a direct south-facing dial, the shadows at sunrise and sunset will be horizontal at an equinox whatever the orientation of the gnomon. The dial actually declines about 3° west and there would be no sunrise shadow at an equinox. Using a solar declination of $-2°$ just happens to result in both the sunrise and sunset hour-lines being approximately horizontal.

Drawing these hour-lines horizontal is misleading since this direction marks one extreme of the range of directions, as indicated by the upper margins of the sunrise and sunset grey regions in Fig. 1. At this stage, the variability had not been calculated.

The design includes half-hour lines. Their directions are determined in the same way as those of the hour-lines. Given that this is a declining dial, the hour-lines and half-hour lines are not quite symmetrically arranged about hour-line VI, but the asymmetries are barely noticeable.

The gnomon is white simply to ensure that it stands out against the background. It is shown in elevation lying along the sub-style. The direction of the sub-style indicates that the dial declines to the west but the sub-style angle is much greater than it would be with a polar-oriented gnomon. Given that the gnomon is only a few degrees off being perpendicular to the dial, the figure is implying that the gnomon is extraordinarily long!

The design has clear limitations both aesthetic and gnomonic and it was later modified to the form seen in Fig. 4. The Queens' Dial sun has been replaced by a circle which

represents the intended gnomon support seen in elevation. This is at the centre of a more flamboyant sun which has alternating wavy rays and spiky rays. These two forms of ray are sometimes said to represent heat and light respectively.

There are 11 sun-rays which, with the 13 hour-lines, makes a total of 24 radial elements. This total alludes to those mass dials that have 24 hour-lines at roughly 15° intervals.

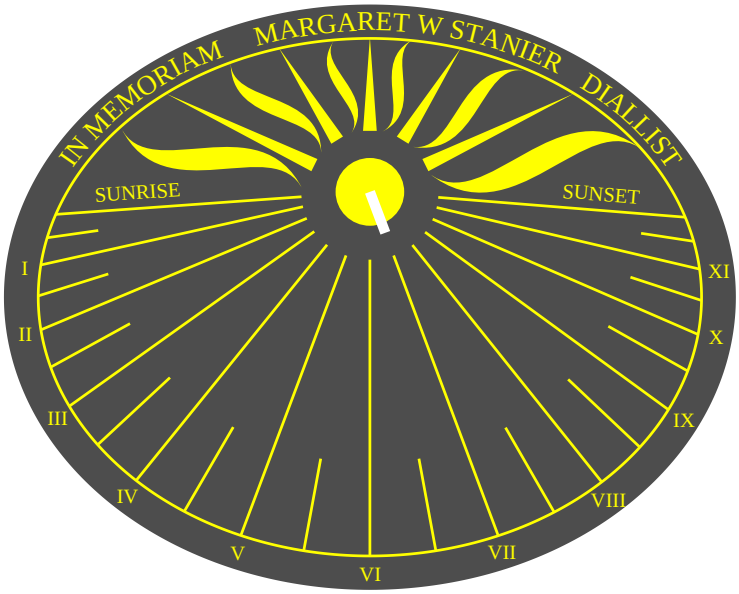

Fig. 4 — A Refinement

The gnomon seen in elevation is much shorter than in Fig. 3 and this corresponds to a more realistic length.

The principal gnomonic improvement in Fig. 4 is that the hour-lines and half-hour lines are now aligned with the mean directions of the shadows at the relevant times. The hour-lines more closely correspond to the directions in Fig. 1.

The sunrise and sunset hour-lines are sloping and although this is gnomonically honest it is rather unsettling. Even experienced diallists are unaccustomed to seeing sloping lines for sunrise and sunset.

Frank King discussed this matter with me and he asked whether I could think of an elegant way of indicating the grey regions for sunrise and sunset. Although the planning problems were still unresolved, I was unable to resist the temptation to produce a design of my own any longer.

My First Design

Fig. 5 shows my first attempt. It differs markedly from Figs 3 and 4. The two long wavy rays of the sun snake between the (implicit) margins of the sunrise and sunset grey regions and take the place of the hour-lines for those times. I removed the half-hour marks for half an hour after sunrise and half an hour before sunset. The other half-hour marks have been replaced by stylised flowers which grow in the morning and shrink in the afternoon.

Most of the rays of the sun have been turned into lettering which spells out SCIENTIST and DIALLIST with these words being separated by the two wavy rays for sunrise and sunset. The wavy rays are unlabelled but at their outer ends there are a cock's head and an owl which serve as metaphors for sunrise and sunset respectively.

Fig. 5 — A Fresh Start

The lettering that forms the sun is not wholly fanciful. Fig. 6 shows, on the left, detail of the limb of the sun taken from space with solar prominences appearing as a spike and as a loop. On the right of Fig. 6 there is detail of the letters LLI from DIALLIST as they appear when cut in slate and gilded.

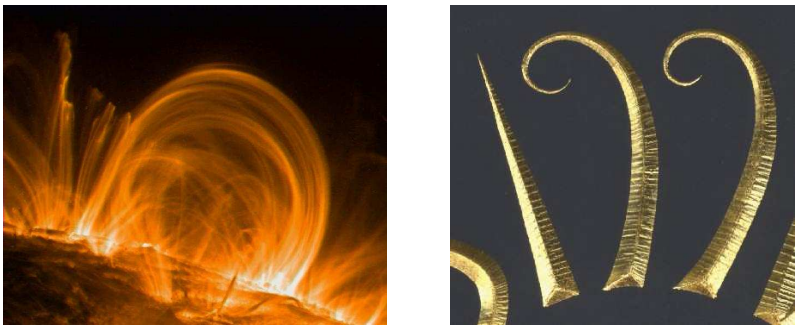

Fig. 6 — Details of two Suns

I chose to have a gilded chapter ring which doubles as an inscription band and I proposed to have ungilded raised lettering within it. The band includes the inscription MARGARET STANIER and the cock's head and the owl as well as the hour labels. I changed IV to IIII to balance the VIII on the afternoon side of the dial.

Given the normal viewpoint of the finished dial, the lettering in Figs 3 and 4 is much too small and it is significantly larger in Fig. 5.

While this proposal was being developed, the College was also giving thought to the design. The version in Fig. 5 was submitted for consideration but was not taken up. The College preferred the more conventional sun of Fig. 4 and they also asked to have the inscription at the bottom of the slate rather than at the top.

This presented something of a challenge. The hour labels clearly couldn't be moved to the top of the dial so, if there were to be any hour labels at all, they and the inscription would both have to be below the hour-lines.

The Starbucks Inspiration

At this time I was planning a brief visit to Cambridge and I was invited to lunch in Newnham College to discuss progress. On the day of this lunch, as a pre-meeting meeting, Frank King treated me to coffee at a Cambridge Starbucks and I had to report a total lack of progress. We pored over numerous sketches and we doodled on several table napkins but nothing really appealed to either of us.

Just as the deadline for leaving approached I had an idea. We hadn't exploited the fact that mass dials are very often inscribed in circles. I asked for a blank sheet of paper and a printout which showed the elliptical outline and the orientation of the hour-lines. I then walked over to the front window of Starbucks and used it as a tracing table. Five minutes later I came up with Fig. 7.

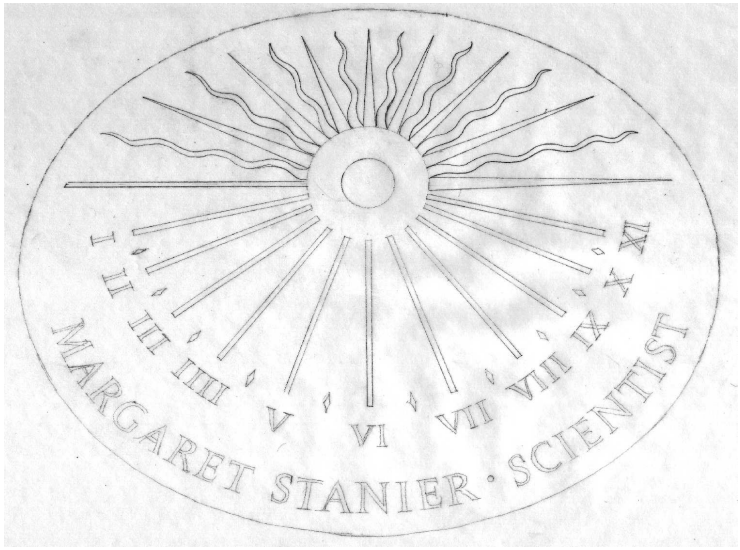

Fig. 7 — The Starbucks Sketch

This needed a good deal of refining but it would serve as something to show to the College. Stopping only to pause at a photo-copier, I rushed off to Newnham and enjoyed my lunch. The College liked the design and there was relief all round!

The Working Drawing

The planners still hadn't given their approval but there had been sufficient progress for me to feel confident that this sundial would see the light of day. On return to Sweden I prepared a long list of measurements which would be used to prepare a working drawing. This would be used for setting out the design on slate. The working drawing is shown in Fig. 8.

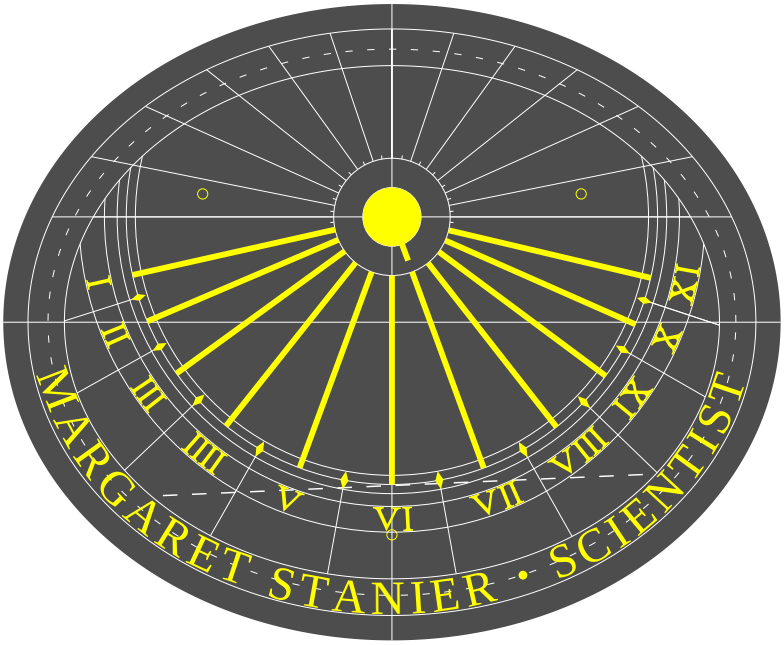

Fig. 8 — Guidelines to be transferred to the Slate

All the white lines are construction lines or guidelines. These are used for setting-out but do not feature in the finished dial. Two crucial reference lines are the major and minor axes; those who work on elliptical plaques call this pair of lines the Big Cross. Other guidelines include the top and bottom lines of the lettering for the inscription and for the hour labels.

The only true ellipse in the drawing is shown by the broken line which runs roughly along the centre-line of the inscription band. The top and bottom lines of the inscription and the rim of the slate itself are closed curves parallel to this ellipse so these curves are not quite ellipses.

There are numerous arcs of circles, all centred on the root of the gnomon. These include the bounding circles for the inner and outer ends of the hour-lines and the top and bottom lines of the hour labels.

There are 13 straight construction lines radiating from the root of the gnomon. These and the 11 hour-lines mean that there are 24 radiating lines altogether. The 13 radiating white lines mark the centre-lines of the rays of the sun which will be drawn on the slate.

There are rather fewer rays than on the Starbucks sketch and the two horizontal rays will be wavy rather than straight. These two rays will stand in place of the sunrise and sunset

hour-lines and their wavy appearance reflects the rather wayward behaviour of the sundial at sunrise and sunset!

The 13 radiating lines have quadratic spacing. Starting with the upward vertical, the spacings are 18.75°, 17.25°, 15.75°, 14.25°, 12.75° and 11.25°. These values total 90° and adjacent values differ by a constant 1.5°. The purpose of this progression is to ensure that the spaces between adjacent rays have approximately the same area.

The sloping broken line is the path traced by the shadow of the tip of the gnomon at an equinox. This line is clearly not at right-angles to the sub-style. The equinoctial line has the expected slope. It is the sub-style angle which is unusual.

There are some contrived details in this design which even the most assiduous diallist would probably miss. For example, the equinoctial line is tangential to the circle that bounds the outer ends of the hour-lines and the sub-style passes through the dot that separates STANIER from SCIENTIST.

Also, the half-hour diamonds vary in size. They grow slightly in the morning and then shrink in the afternoon, an echo of the ancient idea of the sun being born afresh each day and fading in the afternoon, a metaphor for life itself. This is a memorial sundial.

There are three mysterious yellow circles in the drawing, one almost hidden by the VI. These show the positions of the holes in the other side of the slate where metal dowels will eventually be glued for the purposes of attaching the dial to the wall.

Setting-out

The go-ahead finally came and, back in Cambridge, I was at last able to start work on the slate itself. This had been ordered from Ivett & Reed[2], a local supplier of stone. As delivered, the slate was 1067 mm × 868 mm and it was 35 mm thick. This was blue-grey Welsh slate, honed on one side with a light bevel round the rim. The slate was of memorial quality and almost completely free from iron pyrites (fool's gold) which goes a rusty colour when exposed to the elements.

My first task was to draw the Big Cross on the slate, which was not supplied with the major and minor axes neatly marked out. This is surprisingly difficult because conventional geometrical procedures are not as useful as theory would suggest. The standard practice is to draw an outline of the slate on tracing paper and then fold the paper in half both ways so that the two creases form a cross. This cross is transferred to the slate.

I then transferred the other construction lines in the working drawing to the slate before marking out the hour-lines, the rays of the sun, the lettering and other details of the design. Three representatives from Newnham College came round to check everything before I started cutting. Each letter was called out one at a time and checked.

Cutting

I decided to cut the rays of the sun first and Fig. 9 shows my working arrangements, using an easel set up in Frank King's spare bedroom.

Fig. 9 — Cutting the Rays of the Sun

Fig. 10 shows the cutting almost complete. There is just a final letter T outstanding. Notice that the sunrise wavy ray ends with an upward flick. It is time to get up. The sunset wavy ray ends with a downward flick. Notice also the three holes through the slate. The gnomon support is secured via three bolts whose heads run through a base-plate on the hidden side of the slate.

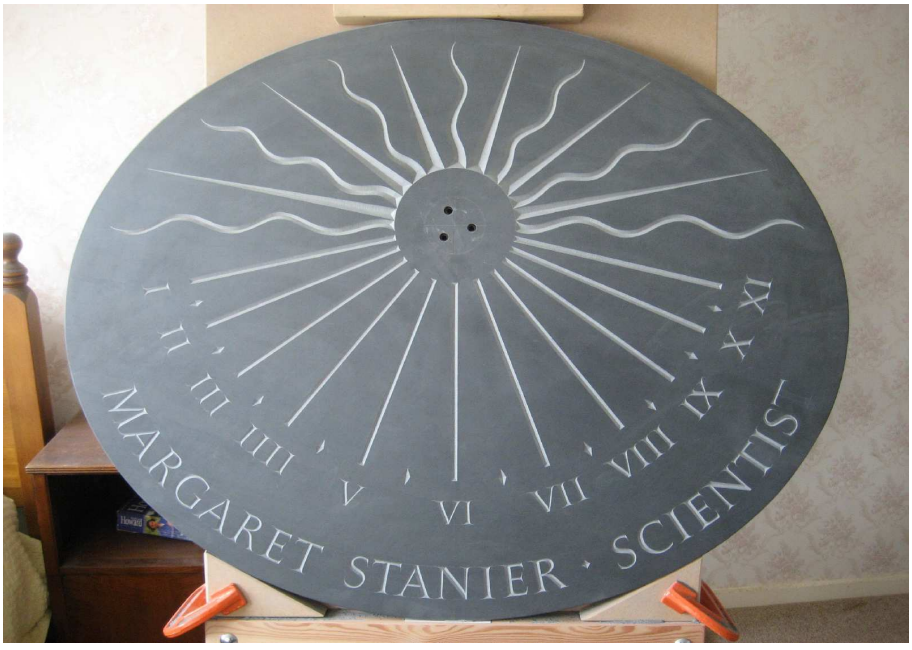

Fig. 10 — Cutting almost Complete

Lettering, and especially hand-cut lettering in stone, is a much-studied subject. The spacing of letters is of great importance and a seminal work on this topic was written by David Kindersley[3].

Lettering on sundials is particularly challenging. It makes sense to arrange the hour-line labels so that they are centred on the extensions of their hour-lines. Unfortunately, the quirks of Roman numerals and the irregular spacing of hour-lines can lead to strange effects. For example, there are large, but different-sized, gaps either side of the V and there are small gaps either side of the VIII.

Also, when first drawn out, the half-hour diamonds either side of the VIII appeared almost as quotation marks and subtle adjustments were made to correct this impression.

One strange effect caused me some concern. Clearly, the M of MARGARET and the final T of SCIENTIST should appear to be on the same horizontal level but the letters M and T have different weights. To compensate for it being the lighter letter, the T was drawn slightly higher than the M but it still *appeared* to be significantly lower.

It took a little while to understand this illusion. My eye was relating the M to the I that labels the first hour-line but was relating the T to the I of XI, the last hour label. The extra width of the XI compared with the I was causing the deception.

Gilding

Prior to gilding, the slate was transferred to a table where it was carefully washed to ensure that there was no slate dust or other dust in the V-cuts. This is a messy job which explains the plastic sheeting covering the carpet in Fig. 11.

Fig. 11 — Gilding Complete

When the slate was dry and as free as possible from dust, gold-size was painted into the

V-cuts. Slate is almost impervious so the V-cuts can be flood-gilded. This means that the size can be applied beyond the edges of the V-cuts; the surplus is rubbed off later.

The size needs to be left 12 to 18 hours to set and reach the right degree of tackiness before the gold leaf is applied. During the time that the size was setting, the room was left undisturbed with the door shut and the central-heating turned up a little.

I was helped with the gilding by a Japanese colleague, Emi Sato, another stone-cutter with previous experience of sundial work. Gilding requires draught-free conditions and is best carried out in a hermetically sealed room. The applied gold leaf needs to be left for a minimum of three days and preferably a week before the surface of the slate is rubbed.

Fig. 11 shows the gilding complete and the gold clearly extends beyond the confines of the V-cuts. The gnomon has been placed on the slate to enhance the photograph. Margaret Stanier was an enthusiastic bellringer so the gnomon support is in the form of a little bell. The gnomon and its support were fabricated in stainless steel by Teversham Engineering[4] and the gold plating was undertaken by Modern Metal Finishes[5].

The flat surface of the slate was rubbed down using wet and dry paper. This removed the surplus gold and size, and left only the gold in the V-cuts. This job required copious quantities of water so the slate was taken outdoors. The gold was then burnished with a firm but soft brush under running water.

Rubbing down offers rewards and disappointment in equal measure. The surplus gold is rubbed off quite quickly but any problems with the gilding show up quickly too.

Fig. 12 — Blemishes in the Gilding

Fig. 12 shows a typical gilding problem. Part of the outer end of the upper right-hand arm of the X of XI seems to have been missed. This can be caused by residual dust acting as a barrier to the size, or this patch may have been missed when either the size or the gold

was applied. The slate was carried back indoors and every minute detail of every feature on the dial was inspected and blemishes such as that in Fig. 12 were attended to.

Fig. 12 also shows the characteristic chatter marks of hand-cut letters. Sand-blasted lettering and other machine-cut lettering do not show this feature. The photograph illustrates another illusion. The lettering is lit from below and this lighting tricks the eye into thinking that the V-cuts stand out from the slate whereas they are actually cut into the slate.

Fixing

The final task before the sundial was taken to Newnham College was to glue three 14 mm fixing-dowels into the holes in the back of the slate. The finished dial was now ready to be fixed to the wall. Two strong men from Ivett & Reed did the heavy lifting and the fixing.

Fig. 13 shows the sundial a few minutes after the scaffolding was removed. Emi Sato and I are admiring the new dial and lamenting the absence of sun!

Fig. 13 — With Emi Sato enjoying the new Sundial

We had been given explicit instructions about where to place the dial relative to the faux balcony. Unfortunately, in the specified position, the holes for the upper fixing-dowels would have been drilled into one of the joints in the stonework so the dial is perhaps 50 mm lower than agreed with the planners!

Given the camera angle used in Fig. 13, the dial does perhaps look a little low but when the sun came out, it was clear that the chosen position was preferable. Fig. 14 shows the dial half-way through the eighth hour and even at this time, early in the afternoon, long shadows are being cast by the greenery above the stone panel. This is despite the fairly aggressive cutting-back which is clear in Fig. 13.

With the planning problems now receding into history, I am better placed to look back on the many enjoyable aspects of this project. I wonder whether casual passers-by see this as just another sundial. How many notice VI where there is usually XII? How many spot anything unusual about the orientation of the gnomon? Will Newnham College remember to cut back the greenery? Will there be an upsurge in demand for unequal-hours sundials?

Fig. 14 — Half-way through the Eighth Hour

REFERENCES

1. Frank H. King: 'The Margaret Stanier Memorial Sundial', *BSS Bull* 23(iii) pp. ??–??, (September 2011)
2. Ivett & Reed, *http://www.ivettandreed.co.uk*
3. David Kindersley: *Optical Letter Spacing*, 1996, reprint, Cardozo Kindersley, 2001.
4. Teversham Engineering Ltd, *http://www.tevershamengineering.co.uk*
5. Modern Metal Finishes Ltd, *http://www.mmfgold.co.uk*

Annika Larsson is proprietor of *Inscriptorum*, a Swedish design workshop. She has a background in lettering and stone-cutting and examples of her work abound in the U.K. and Sweden and elsewhere in mainland Europe. She has worked with Frank King on a number of sundial projects, most notably the large noon mark on the Stock Exchange in Paternoster Square in London. She may be contacted at *info@inscriptorum.com*