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THE QUEENS' COLLEGE DIAL, CAMBRIDGE

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No one who visits Queens' College, Cambridge, can fail to be impressed by the large painted sundial in the Old Court as shown in Figure 1. It is not the first dial installed in the College, however little is known of the earlier examples except that these were not as elaborate. All the dials installed on this wall appear to have been painted on the surface, ie. there are no incised lines to guide the restorer when correcting the ravages of time.

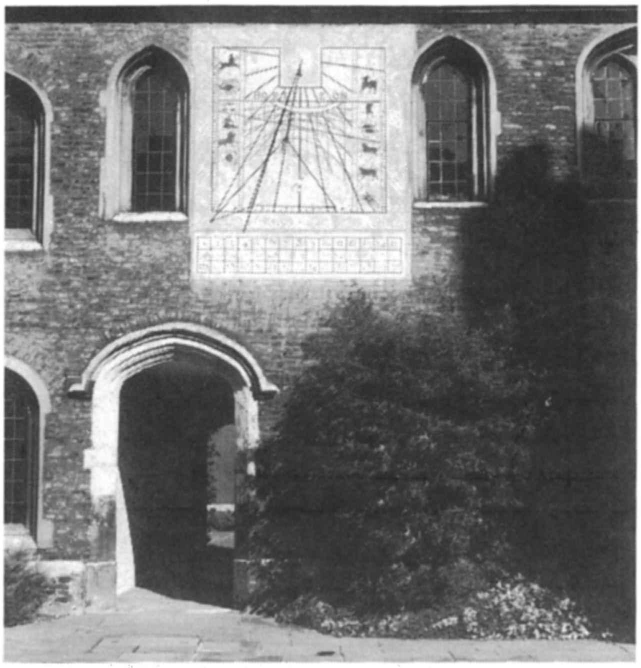

FIGURE 1: The Queens' College dial in the Old Court.

The first illustration of a sundial on this site is found in *Views of Cambridge*, Loggan, 1675, whilst the earliest records in the college about a dial on the chapel wall occur in the Bursar's accounts for the year 1642. This account is a little ambiguous although the details appear to be the expenses for the refurbishment of an existing dial:

For stone and work about the chapel dial......	£1 14s 6d
For gilt for the dial	£0 4s 6d
To the painter for the dial	£0 5s 4d
For the cock of the dial	£0 18s 0d
For the oil, white lead and hire of hair cloths	£0 6s 0d

According to M.M. Scarr in his pamphlet - "The Dial in Old Court, Queens' College", this was for constructing a new sundial, the first item being for providing a flat stone surface for the painting of the dial. As the total cost for the dial would only have been £3 8s 0d, this seems too small for an entirely new dial, and it would have cost much more than 5s to set out an entirely new dial, even in those far off days. As the area covered by the dial is about 7 x 6 feet, £1 14s 6d for suitable stone and fixing it in place seems insufficient, for the outer bricks of the building had to be removed to allow this layer of stone to be inserted. The expenses were probably no more than for repairs and restoration of an existing dial. In 1968 the surface of the stone was no longer smooth enough to take the painting of the dial and it was rendered with a layer of cement mortar. This of course destroyed the painting of the previous dial, the present dial is an reproduction made from the measurements taken of the old dial before its destruction. This is not quite so bad as it may seem because by 1860 the sundial had been so badly looked after that it was derelict, with its iron gnomon rusted away almost completely. The present gnomon is replacement and is a rather ungainly piece of ironwork which casts a multitude of misleading shadows. On the active portion of the gnomon is a small wooden ball painted gilt, to which reference will be made again later in this account.

Mrs. Gatty puts the date of the dial at 1733, for the college records show that the dial was repainted in that year, but it may have been more than a straightforward repainting because the dial was expecially admired by those who saw it on completion. Since the dial existed in this place before painting, the restored dial could hardly be considered new even if greatly altered.

Old records abound with the details of the repainting of sundials but it is rare to find any continuous sequence of this continuing process. The gilt ornamentation might last twenty or more years in outside conditions, whereas the linseed oil and lead pigments of the old paints could not last above ten years without serious deterioration and loss of protection to the surface beneath, hence the frequent necessity for repainting. Even with more modern paints, the dial has been repainted six or seven times in the present century, and modern synthetic paints have much more staying power than the old. Of course some colours are more fugitive than others.

Tradition would have it that Sir Isaac Newton designed this dial. Obviously the dial existed much earlier than him and like many of the Newton attributions, it is completely without foundation. If Mrs. Gatty's statement is true, then the dial was after Newton. It is true that many college undergraduates amused themselves by applying their mathematical knowledge and skills to the art of dialling and often presented a dial of their own particular design to their college. Newton does not appear to have been one of these. Besides Newton was a Trinity College man and would not have contributed to a rival Cambridge college. Perhaps Newton's studies to discover the laws governing the motion of the moon have given rise to this erroneous tradition. In the Great Court of Trinity College is a rather superior type of garden horizontal dial near the College chapel, the pedestal of which was built in 1704, the dial plate on it was made by Troughton of London circa 1750. So Newton did not even choose to embellish his own college with a sundial of his own design.

DESCRIPTION OF THE DIAL

Within the confines of the Old Court, one is in the oldest part of Queens' Collge where the ambience of tradition and age can almost be felt as a physical force. The large sundial (about 7 x 6 feet) dominates this small area, see Figure 2. The overwhelming impression is that of the pale blue border rather than the greatest extent of the central white area, mainly because of the jumble of lines delineated upon it and the shadows cast by the black-painted gnomon and its two supporting struts. The root of the gnomon originates in a gilt sun-burst, as do the hour lines for the Roman numerals painted gilt on the blue border. The subdivision into quarter hours is by short black strokes, with a short cross stroke to distinguish the half-hours but only along the

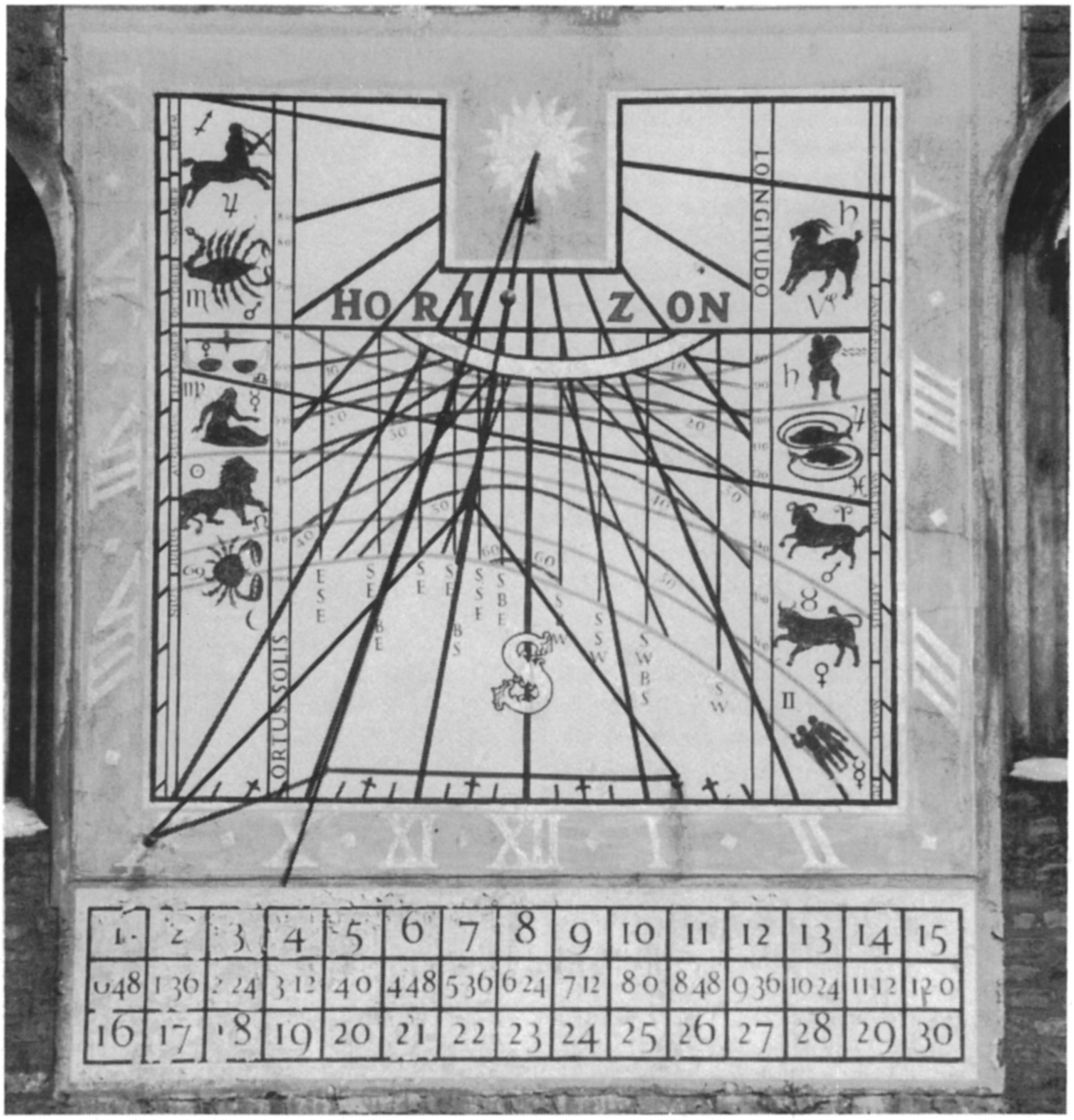

FIGURE 2: A closer view of the Queens' College dial

horizontal scale. Gilt lozenges emphasize the half hours between the hour numerals.

Of course the indication on the dial is true solar time for Cambridge. As Cambridge is almost on the zero line of longitude of Greenwich, no correction for longitude is required, however to convert Cambridge solar time to the more prosaic Greenwich mean time, the Equation of Time correction needs to be applied to the dial indications. Additionally, as the dial is consulted mostly in the summer period, an hour has to be added to the dial indication and equation correction to determine the appropriate British Summer Time. It is better to look at your quartz crystal watch, which will take only a second or so, because there is no table for the Equation of Time corrections placed near the dial. This would have been a much more useful addition than a moon table of dubious value, of which more anon.

The months of the year (delineated in Latin) are contained within a very narrow border between the hour subdivisions and the zodiacal signs in a vertical strip on each side near to the numerals. There is conjecture that the months were designed around the Julian and not the Gregorian calendar, however the dial is not so closely laid out that it makes much difference in spite of the present discrepancy of about 16 days between the two calendars. The date is read on the dial by the shadow of the gilt ball on the gnomon on the green lines extended to the month signs. It is of dubious accuracy for the curves are not quite correct, it is almost impossible to arrive at the correct calendrical date from the dial indication.

THE ZODIACAL SIGNS

The zodiacal signs are painted in red in clockwise rotation from upper right:

Capricornis, Aries, Aquarius, Pisces, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius.

Each zodiacal sign has its associated symbol and planetary symbol in close proximity. Before 1968 some of these details were missing and were replaced in the restoration of that year.

The zodical signs, essential for astrological purposes and given prominence here, have become frozen in time because the star constellations giving rise to these signs are rotating slowly around the earth with a period of about

26,000 years because of the phenomenon known as precession which affects rotating bodies. The signs were drawn up when Aries was the constellation when the sun crossed the equator at the time of the equinoxes in ancient times, ie. about 200 BC, it is known as the "First point of Aries". Since then precession has moved through about 30° of its cycle and so the same occurrence is now in the constellation Pisces. The astrologers continue to prognosticate on the planetary positions as though no change has taken place; the resulting inaccuracy is not of the slightest inconvenience.

The sign of the zodiac is read from the dial by considering the shadow of the gilt ball and the green curves, of which the inclined black line from Libra to Virgo is to be considered as a green line. (The fact that this black line is almost parallel to the V-V of the hour lines is merely a fluke, it is not of significance). One must also know the time of the year since from 21 December to 21st June the days are growing longer and the astrological signs on the right are to be consulted. From 21st June to 21st December the days grow shorter again and the signs on the left are then used. Hence the splitting of the month December at the top, and the corresponding division of June at the bottom of the scale of months.

One has to remember that the signs are for astrological purposes only, it does not correspond to the actual position of the constellations in the night sky. These signs are still of importance to those who believe in astrological predictions, ie. those who read the daily prognostications to be found in most daily newspapers. If the signs are favourable, by all means believe them; if they are gloomy, then regard these as mere superstition for the weak-minded.

The black lines emanating from the point of crossing of the horizontal line and the vertical line indicate the old temporary hours which lingered on even after mechanical clocks were introduced and became common. The daylight period was divided into twelve equal parts, the length of these varying with the season. This system was quite unsuitable for use in northern climes which have such a large variation in the length of daylight throughout the year, it fails completey near to and beyond the Arctic Circle. The transition from one time measuring system to another would take a very long time since older people find it very hard to assimilate something which is replacing a very familiar method. No one has ever managed to persuade the British nation to accept the twenty-four hour clock, for example.

To prevent what would become an utter confusion of black lines, the temporary hour lines are terminated at the golden arc below the horizon line. This area is of no purpose for indications in any case except that it obliterates the line which could have indicated winter solstice.

Two narrower bands on the inside of the zodiacal bands carry "LONGITUDO" on the upper right and "ORTUS SOLIS" on the lower left. The Longitude scale is supposed to give the duration of the day in hours and minutes between sunrise and sunset. The "Ortus Solis" scale indicates the time of sunrise and is read by use of the green lines and the shadow cast by the gilt ball on the gnomon.

The horizontal black line about a quarter of the way down the dial is the "HORIZON", whilst the inclination of the gnomon from the vertical indicates that the dial is a declining one, ie. the wall on which it is delineated is not facing south but is inclined towards the East by about 15°. As a result the dial is arranged to show the hours from 5 in the morning until 5 in the evening (it will do this only at the equinoxes and a lesser range during the rest of the year) instead of the normal 6 in the morning to 6 in the evening of the true south-facing vertical sundial.

The writer has not been able to check the restrictions on the dial indications imposed by the surrounding buildings but the dial is fixed fairly high and only the morning and evening limits of the sundial should be affected, much depending of course upon the season of the year, see the dark shadow to the left of Figure 1 at 10 a.m.

AZIMUTH OF THE SUN

Ther is a set of vertical black lines dropping down from the horizon line which have letters at the lower end which correspond to the reading on a magnetic compass scale. The shadow of the gilt ball on the gnomon falling on these lines gives the bearing or azimuth of the sun at any particular time of day. Between the lines one has to make an estimate of the position.

ALTITUDE OF THE SUN

This is read from the dial with the help of the red curves and the shadow of the gilt ball on the gnomon. The curves have the values ten to sixty degrees indicated by numerals at both ends of the angular height curves. The lines for seventy and eighty degrees are too short to be worthwhile including.

There is a large "S" below these curves to indicate South, merely as an added embellishment, it should not have been placed on the dial but does help to fill up an otherwise vacant space in the centre of the dial. The dial painter made a real effort to make it decorative but did not quite succeed.

THE "MOON DIAL"

The Queens' College dial is often referred to as a "Moon dial" but this is quite misleading, it merely has a table below the main dial to help in the converting of any shadows made at night by the light of the moon into meaningful hours. The table is more to impress than for utility since the moon cannot cast a shadow which can be distinguished until about the time of the first quarter, and similarly after the third quarter when the light is insufficient again. In fact, in the Old Court as it is at the present time, even in the most favourable conditions of atmospheric conditions and phase of the moon, the artificial illumination quite obscures any indication made by the moon. On Friday 24th September, 1991, when the moon was at its most brilliant (being the Hunter's Moon), the illumination inside the Old Court had to be extinguished for the members of the British Sundial Society to be able to see any shadow cast by the moon on the dial, and it also required a dark adapted eye.

THE "MOON TABLE"

The table is based on the fact that the moon completes its monthly cycle on 30 days (actually about 29½ days) and rises about 48 minutes later each night. Commencing at zero error on the first day of the full moon, the figures below the days have to be added to the indication of the dial given by the moon. Since the moon's cycle is very complex as a result of it being the lighest component of the Sun/Earth/Moon system, the resulting accuracy is very poor, thus it gives a guidance rather than a time indication.

One has to know the basis on which this table is drawn up and how it is to be applied. At full moon the error is taken to be zero, seven days before full moon the moon gives an indication on the dial which is 5 hours 36 minutes fast, therefore this must be deducted from the dial reading to obtain the time. Seven days after the full moon, the same amount must be deducted from the reading on the dial. The varying errors of the moon cycle are ignored.

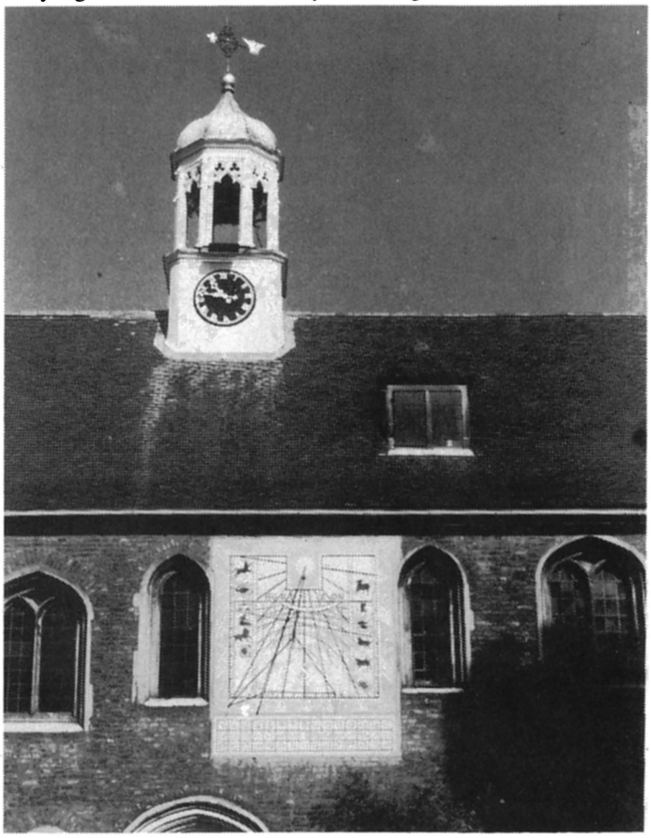

FIGURE 3: The Queens' College dial with the clock cupola above.

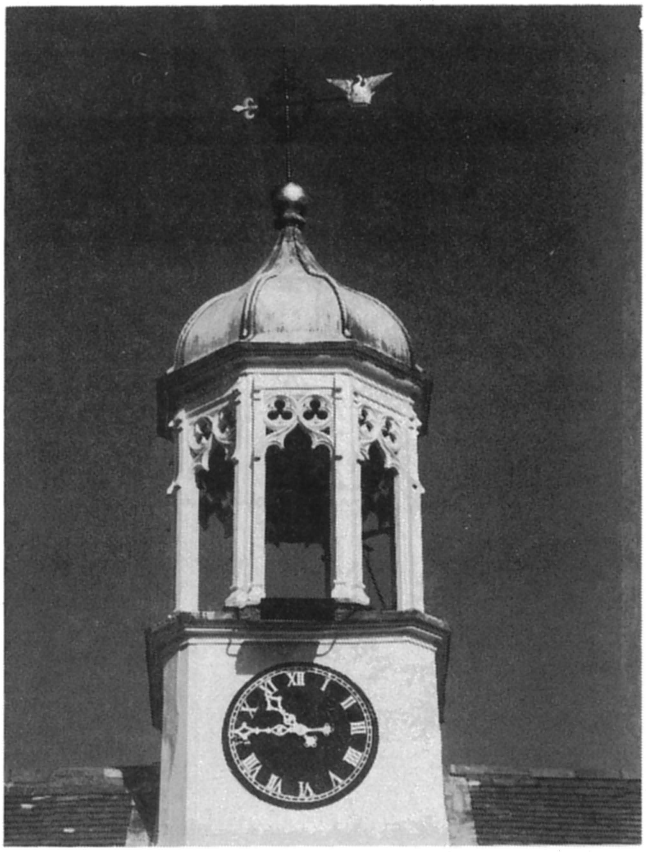

FIGURE 4: The clock cupola in Old Court, the dark shape under the dome is the clock bell for sounding the hours.

In the pamphlet by M.M. Scarr, the explanation of the moon table is not really made clear. For a time the writer thought the order of the figures for the table was incorrect, especially as he had received some queries about the moon table. The apparent jump from the 15th to the 16th day is caused by the division of the day into two x 12 hours. Nevertheless the table appears to be in error because the sequence should be the full moon at zero with a diminishing series of values before the full moon, and a set of increasing values after the full moon. If day one in the table was the date of the full moon the table commences quite correctly with 48 minutes on the day after the full moon and increased up to 5h 35m on the 7th day after the full moon; these values to be added, after which the moon's light becomes insufficient. The 30th day should be zero which it is in the actual table because it has gone through twelve hours. However to make sense the value of time shown in the centre row has to be deducted from 12 hours and this answer deducted from the indication on the actual dial by moonlight for days 23 to 30. A better way would be to insert 0 on the left of the upper row and place the 30 of the lower row under this and reverse the sequence until day 16 comes under the column headed by 14. The same values for the seven days after the full moon would then apply to the seven days before the full moon but with negative values.

The table is actually arranged to indicate from new moon to new moon, and the zero position occurs on the fifteenth day when the full moon shines, so the cycle would cover from day 8 to day 22. Hence the confusion in the table as painted on the dial without some guidance given to the observer. M.M. Scarr in his pamphlet treats the full moon as being on day 15, which makes the lower row in the table correct but this then apparently transfers the errors to the top row. In actual fact if the values shown are added to the reading on the dial, for example on day 14, the day before the full moon where the figure is 11h 12m, this is like subtracting 48 minutes from the dial reading and thus the table is absolutely correct as shown. On day 8 the value is 6h 24m, which when added is equivalent to subtracting 5h 36m. One of course discards every block of twelve hours from the additions made. Adding is a much simpler operation than subtraction.

By the time the average gnomonist has worked out the hour from the moon table and dial indication by moonlight, providing he has not left his calculator at home, it is more than likely that dawn will have broken and the shadow of the moon replaced by one from the sun. About half of the figures in the moon table have no significance at all since the moon is never bright enough to make a useful sahdow on those nights. F.W. Cousins refers to the table as supervacaneous (get your dictionary out). Because there is no hint on the dial itself on how to obtain lunar time, the best that can be said about the "moon table" is that it adds at little extra decoration to the dial and no doubt impresses the gullible. Unless the observer knows exactly how to arrive at the solution and has knowledge of the moon's age plus an ability to perform mental arithmetic, he will be wasting his time in trying to work it out. The moon table is of little use at night because it is hard to read the figures in the dim light of the moon. In any case, there is a clock dial on the roof just above the dial which is illuminated at night for those who do not have the necessary expertise, and for those nights of the month when there is no moon available to illuminate the sundial, see Figures 3 and 4.

Perhaps it might be worthwhile to mention why the error is zero at full moon. Disregarding the error of the moon indications in losing about two minutes an hour, at full moon the moon is situated on the far side of the earth from the sun and is directly opposite the sun, it is precisely twelve hours out of phase with the sun and receives the full illumination as seen from earth. As the moon is turning around the earth in almost twenty-four hours, it is a near enough substitute for the sun when full if the night sky is clear. At new moon it is between the earth and the sun and runs almost in phase with it, with the dark unlit side facing the earth and nothing can be seen. (The moon's orbit is inclined at about 5° to that of the earth's and because the moon is so small, it does not cause an eclipse to be seen on earth except on rare occasions). At new moon the error is also zero but the daily extra time of about 48 minutes to reach the same point after 24 hours time gradually adds up to 24 hours falling behind in about 30 days to complete the Moon's cycle. So there is no real mystery about why an ordinary sundial can be utilised to interpret the time from moonlight. The fact is that with the severe light pollution of the present time, not many of us today can witness the night sky clearly enough to distinguish the natural phenomena once taken for granted by our forbears.

In September 1991 the colours of the dial were beginning to become wishy-washy through deterioration of the paint and in fact the brickwork below the dial was stained with colour leached out from the dial surface. The same effect can be seen on the roof of the building where paint from the clock cupola on the ridge has stained the tiles immediately below. The dial thus has a rather faded look about it a few years after being repainted and many of its features recounted here are scarcely visible to the ordinary viewer without a pair of binoculars.

THE MECHANICAL CLOCK

It has been suggested that this dial may have been erected as a check on the mechanical clock installed in a cupola on the roof almost directly above the dial, see Figures 3 and 4. There is a bell dated 1633 in the cupola which is struck hourly, this is earlier than the clock movement below the cupola. It is quite a large bell and must have disturbed the sleep of countless undergraduates during its lifetime. The dial is just about good enough to set a clock by although any clock installed before the end of the seventeenth century would have been of debatable accuracy of going. Once the long pendulum clock was put into use, an accuracy to within a minute or less a day could be expected, and the dial can be read to within a minute. Had the dial been intended for this purpose, one would have expected to find an Equation of Time table installed nearby, for a correction of the clock by the solar noon indication will lead to errors of up to almost 17 minutes from mean time in the course of the year. Of course it must be remembered that the absolute accuracy of a clock governing an establishment does not matter a great deal if everyone is synchronised to its indications. A few minutes more or less in the seventeenth century would have been of little consequence. It is most likely that the clock was installed so that an acoustic signal would inform everyone of the progress of the hours, the sundial having been installed long before the iron autocrat aloft usurped its principal function. If the dial was used to correct the clock, then it was the last useful function allocated to it.

SUMMARY

There is a good description of the Queens' College dial in *Cambridge Sundials* by Alexis Brookes and Margaret Stanier with a closeup view of the dial and a general view of the dial in the Old Court. As is stated in this little work, the dial is not the most beautiful of the Cambridge sundials, but it is one of the most arresting examples. Without knowledge of the structure of the dial, the average observer would take much time to unravel the apparent spider's web of criss-crossing lines, and it must be regarded as a tour de force of dialling art rather than as a utilitarian device. The actual presentation of the hour indication leaves much to be desired outside the range of nine in the morning to two in the afternoon because of the zodiacal signs. A large dial such as this should be more concerned with accuracy of time indication than showing those of dubious value. These complex dials serve as a reminder that clarity and simplicity lead to excellence of presentation and improved accuracy.

Perhaps at the next repainting the dial can be restored by a more competent artist for the present execution is not as good as it should be. The layout should be altered to restore the winter solstice line, and the word "HORIZON" displayed more artistically. The off-centre golden arc makes the dial appear lopsided and perhaps should be removed, as also all lines immediately above the horizon line which have no part to play in the dial's functioning. This would help to clear up the eyecatching clutter in the centre of the dial. A more elegant gnomon casting only the required indicating shadow would also be a great improvement. This gnomon should be painted in the ground colour of the dial to make it blend into the background, it is only its shadow that should appear black to the observer's eyes.

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An Inventory of the Historical Monuments of Cambridge, Part 1, Royal Commission on Historical Monuments.

Views of Cambridge, Loggan, 1675.

The Book of Sundials, H.K.F. Eden and Eleanor Lloyd, George Bell, 1900.

Sundials, F.W. Cousins, 1969. Page 114 gives an illustration of the Queens' College sundial and a brief explanation. He quotes 1727 as the date of the dial, and that Sir Isaac Newton had no association with it.

Sundials, Their Theory and Construction, A.E. Waugh, Dover Publications, 1973. The use of a sundial to interpret the shadows cast on it by moonlight is briefly presented as a rule of thumb for practical use.

The Dial in Old Court, Queens' College, M.M. Scarr, 1988. This is based upon the booklet first compiled by Professor G.C. Shephard when an undergraduate of the College in 1948. This is the most authoritative treatment of the Queens' College Dial presently available although now out of date and in need of revision.

Cambridge Sundials, Alexis Brookes and Margaret Stanier, Pendragon Press, 1991. Condenses the information of the 1948 Shephard compilation into two pages of text.

The pamphlet by M.M. Scarr is available at the Porter's Lodge, Queens' College, Cambridge, it is a revision of Shephard's compilation. There is also an excellent postcard illustration of the dial. A calendar in 1991 featured the Queens' College dial in a large coloured illustration.