The Antiquarian Astronomer

Journal of the Society for the History of Astronomy

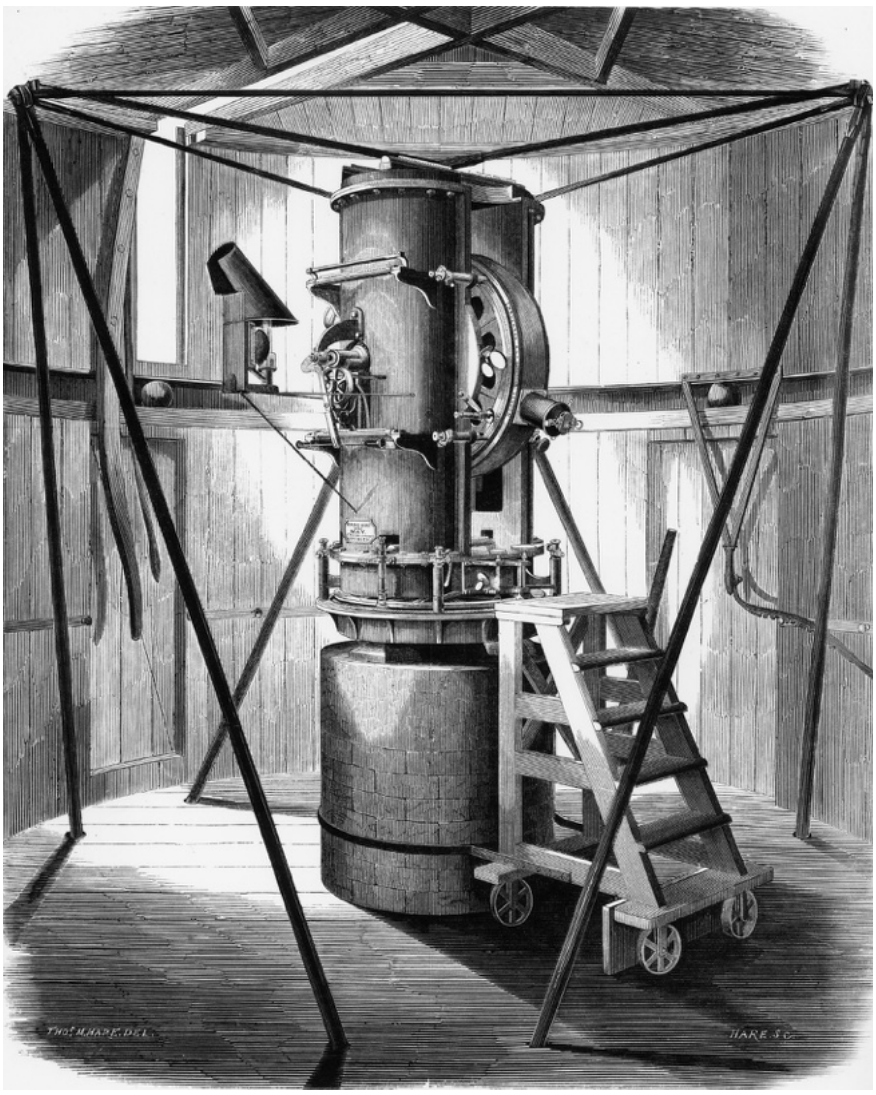

Image by courtesy of the Science Museum, London

Issue 3 December 2006

ISSN 1740-3677

The cover illustration

Airy's Altazimuth

One hundred and sixty years ago, in May 1847, at the Royal Observatory, Greenwich, the first observations were made with a new instrument that was to make an invaluable contribution to astronomical knowledge. The year 2007 also marks the 110th anniversary of its final observations - in November 1897.

The instrument was designed by the seventh Astronomer Royal, Sir George Airy, specifically to increase the number of measurements of the Moon's position, especially in those parts of its orbit where it cannot be observed with meridian instruments; it was originally known as the Altitude and Azimuth Instrument, but was soon renamed by its creator the Altazimuth, and proved to be an outstanding success.

With it, the number of positional observations of the Moon was almost doubled, and these were a major contribution to the refinement of the theory of the Moon's complex motion and hence to greatly improved ephemerides of its future position.

A number of vertical circles had previously been used successfully, notably by Giuseppe Piazzi at the Palermo Observatory, but in order to achieve the stability and accuracy required for lunar positional observations a fresh approach to its design was required. Airy's considerable grasp of engineering principles, as well as the astronomical requirements, enabled him to achieve this, and his Altazimuth proved to be the first of a number of instruments designed by him which were all to remain in use for many decades, and to influence the design of generations of later instruments.

This woodcut, by Thomas Hare, was made shortly after the instrument's completion and was originally published in the September 1847 issue of the *Illustrated London News*. It was also used, with permission, to illustrate Airy's description of the instrument in *Greenwich Observations* for 1847. It is reproduced here by courtesy of the Science Museum, London.

In his description Airy comments: "The step-ladder, it will be seen, turns in a circle round the central pier. It has been found convenient to attach to the revolving frame two boards, whose edges are in a plane parallel to the plane of the vertical circle; the eye being directed along these to view the object, the instrument is placed very nearly in the proper azimuth; and then the telescope is directed accurately by the ring-finder." These boards are not shown in the illustration.

An account of this important instrument appears on pages 83 to 94 of this issue of *The Antiquarian Astronomer*.

Compiled by G. E. Satterthwaite

ISSN 1740-3677

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A Message from the Editorial Team

Creating Issue 3 of *The Antiquarian Astronomer* has been an extremely rewarding and fascinating, if hard, task. It has been our great pleasure to work with authors, reviewers and those to whom we turned for support. To all of them we offer our sincere thanks for being unfailingly helpful, even when our requests seemed pedantic, if not frankly bizarre. Our colleagues serving on the Council of the Society for the History of Science have, once again, given us their confidence, and sound advice when we needed it. It is in such encouraging circumstances that Issue 3 has gestated.

Our experience with Issue 2 was that the area to which researchers and authors needed to give closer attention was the full and correct referencing of sources of information. We found the same with Issue 3. This is not about formatting a Word document; but about ensuring that when you find a fact that is relevant to your line of enquiry, you record accurately everything about that fact, and the source whence it came. This is not only good research practice, it is essential if you are to guide others to that same fact. We cannot stress this too strongly; the full and accurate keeping of records is the hallmark of a careful, credible researcher. Those are the qualities we seek to foster.

With this Issue in your hands, you cannot fail to recognise that it is about twice the page count of Issues 1 and 2. We believe that this reflects a genuinely high level of activity amongst members of the Society; and a genuinely high level of commitment to publish the results of that activity. This is an excellent augury for the future of the Society. We said in Issue 2: "It is axiomatic that a Journal such as this can succeed only if it receives papers to publish." We have received the papers we asked for, and each one has a real contribution to make to the body of knowledge in which we are all so interested. We need now to ensure that the number of papers submitted continues at this level. We have some papers promised for Issue 4, but we need more.

We suggest that every member of the Society will have acquired information and knowledge that someone else will find useful. Let one example suffice. In preparing this Issue we needed to check the names of the Ipswich-based company, Ransomes & Sims, which has had many names during its long history. We saved a great deal of time checking what names were used, and when, because one member had researched that very topic. Information such as this should be recorded for the benefit of others. The Society's Survey of Astronomical History is one place to do that, this Journal is another. Prospective authors should notice that this Issue contains short (2000 word) and long (13,000 word) papers. It is almost certain that most of our members have research material that needs to be written up. However short or long it is, please do send it to the Journal. Research is not complete unless it is made available for posterity. Our aim is to make as pleasurable as possible the process of placing research findings permanently on record.

K.L.Johnson and W.R.Withey
Editorial Team

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Independent Reviewers of papers

Papers published in *The Antiquarian Astronomer* are reviewed first by the Editorial Team then by a reviewer who has had no previous involvement with the paper. The Editorial Team and the authors wish to acknowledge with many thanks the advice and support offered by the Independent Reviewers for papers in Issue 3:

Dr M. T. Brück	Former Senior Lecturer, University of Edinburgh
Dr A. Chapman	Wadham College, Oxford
P. B. J. Gill	Eastbourne Astronomical Society
Dr R. Hutchins	Magdalene College, Oxford
P. D. Hingley	Librarian, Royal Astronomical Society
Professor A.J. Meadows	Formerly University of Leicester
Dr F. Watson	Anglo-Australian Observatory
S. Williams	Secretary, Society for the History of Astronomy

Lord John, 2nd Baron Wrottesley and the Wrottesley Hall Observatory

J. Armitage
Director, Pendrell Hall Observatories Group

Lord John Wrottesley (1798-1867) was a man of considerable importance in the field of 19th century science, particularly during the first three decades of the Victorian era. He held a number of important offices during this time, including being President of the Royal Astronomical Society (1841 to 1843), of which he was a founder member in 1820; President of the Royal Society 1854 to 1857; and President of the British Association for the Advancement of Science for 1860. He was always to seek a good understanding between scientists and government, and also to promote the general public understanding of science. Although today the name of Lord John Wrottesley is largely forgotten, he created a legacy that remains with us to the present day.

The Honourable John Wrottesley (Figure 1) was the son of Lord John Wrottesley (9th Baronet, later 1st Baron Wrottesley 1771-1841). He was born at Wrottesley Hall in South Staffordshire on 15 August 1798. He entered Westminster School, which had been attended by many members of the Wrottesley family, in 1810, and matriculated to go up to Christ Church College, Oxford in 1816. He obtained a B.A. degree in 1819 and M.A. in 1823[1].

Figure 1
Lord John, 2nd Baron Wrottesley
Courtesy of the Royal Astronomical Society

It seems that it was whilst he was at Oxford that a life-long interest in astronomy was aroused, under the influence of the work of Dean Cyril Jackson (1746-1816) and of Stephen Peter Rigaud F.R.S. (1774-1839), who was then Reader in Experimental Philosophy, but later became Savilian Professor of Geometry, then Savilian Professor of Astronomy, at the University.

The Hon. John Wrottesley initially worked as a lawyer in London, entering Lincoln's Inn in 1819, and practicing as a barrister from 1823. Whilst still only 22 years old, he was involved as an early member of the Astronomical Society of London, which was to become the Royal Astronomical Society (R.A.S.), of which he was Secretary 1831 to 1833, and President 1841 to 1843[2].

Whilst living in the London area, he settled at Blackheath, where between 1829 and 1831 he constructed an observatory. Observations started there in the spring of 1831. He was at that time particularly interested in the positional astronomy of 6th- and 7th-magnitude stars, a task that occupied him from 1831 to 1835. In 1838 he presented to the R.A.S. a catalogue of the Right Ascensions of 1318 stars[3], a work that was well received: in February 1839 he was awarded the R.A.S Gold Medal for his work in positional astronomy.

The year 1841 was one of great significance in many ways for him. In February of that year he was elected President of the R.A.S. In March his father, by then the 1st Baron Wrottesley, died and the Hon. John Wrottesley succeeded to the title, becoming the 2nd Baron Wrottesley. In April he was elected a Fellow of the Royal Society, a body of which he became President in 1854, and on whose Council he served until his death in 1867[4].

In November 1854 he succeeded the 3rd Earl of Rosse, as President of the Royal Society, a position he held until he resigned in 1857. In 1860 he was elected President of the British Association for the Advancement of Science (B.A.A.S), succeeding The Prince Consort. He had always been active in promoting scientific matters to government, and for 16 years was the Chairman, and most active member, of the Parliamentary Committee of the B.A.A.S. He was always keen to promote to the wider public an understanding of science, and was a founder member of the Society for the Diffusion of Useful Knowledge[5].

After the death of his father, the 2nd Baron returned to Wrottesley Hall, where between 1841 and autumn 1842, he constructed an observatory in the grounds. It was "… on an elevated position, about 500 yards to the N. by W. of the mansion." [6] (location 52° 37' N; 2° 13' W) overlooking the present-day A41 (an old coaching road), which runs north-west from Wolverhampton (Figure 2).

Figure 2

View from the A41 looking south-east towards the site of the Wrottesley Hall observatory

The observatory site is in the grove at the position arrowed. Photograph by the author in September 2006.

Some instruments were transferred from Wrottesley's Blackheath observatory; others were newly acquired. Three main instruments known to have been in the Wrottesley Hall observatory are[7]:

1. A 3¾-inch transit telescope of 62 inches focal length (focal ratio (f) 16.6) made by Thomas Jones of Charing Cross, London in 1831, which had been transferred from the Blackheath observatory.

2. A 7¾-inch achromatic equatorial refractor having a focal length of 129 inches (f 16.6). The flint glass was "… by Guinand." [8]. The elder George Dollond (1774-1852) supplied the crown glass, and also "… gave the curves to the glasses …" [9].

3. The 'Lee Circle', which was loaned by the R.A.S. in 1842, and installed in 1843. This altazimuth transit circle was made by Edward Troughton (1753-1852), mathematical instrument maker, of London in 1793. It had a 2-inch objective lens with a focal length of 30 inches (f 15.0). The circles were 24 inches in diameter. The instrument had been donated to the R.A.S. in 1828, becoming instrument No. 17. It had been installed first at the Bedford (England) observatory of William Henry Smyth (1788-1865), then at the observatory of Dr John Lee (1783-1866) at Hartwell House, near Aylesbury, England.

At the time of writing, we have not located images of the Wrottesley Hall observatory or of its transit and equatorial telescopes. However, we may deduce the appearance of the instruments from information available about other observatories.

The transit instrument was probably very similar to that commissioned by Smyth for Lee's observatory (Figure 3). They have very similar specifications, and both were constructed by Thomas Jones of Charing Cross, in successive years: Wrottesley's in 1831; Lee's in 1832.

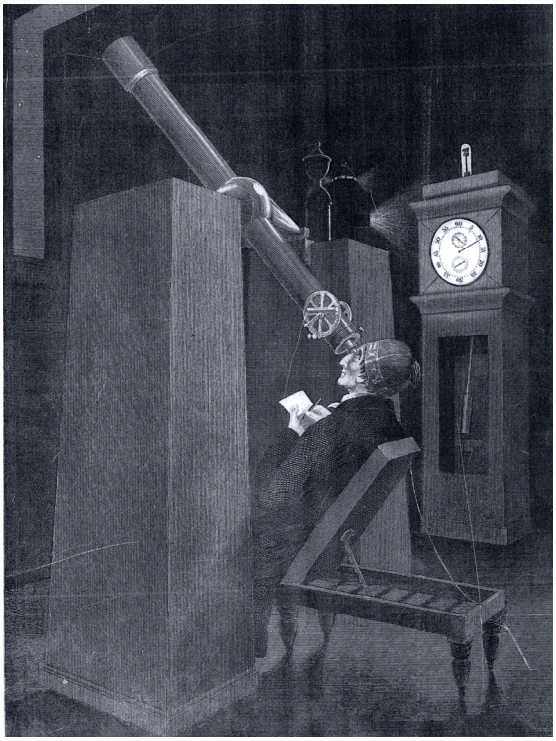


Figure 3

Dr Lee using his transit instrument in his Hartwell Observatory

This transit instrument was built by Thomas Jones in 1832. For the source of image see Note 10.

The equatorial telescope was mounted in the 'English' style by George Dollond, who made three similar mounts: for Smyth (Figure 4), for the Regent's Park Observatory of George Bishop (1785-1861) and for Lord Wrottesley. Smyth states[11] that the hour and declination circles of all three were "… cast from the same moulds which were cut for me; …" However, Wrottesley states[12] that he purchased the telescope and the equatorial piers from a Mr Beaumont of Finningley, Yorkshire, which may mean that Dollond originally made the mount for Beaumont. This possibility is still being investigated.

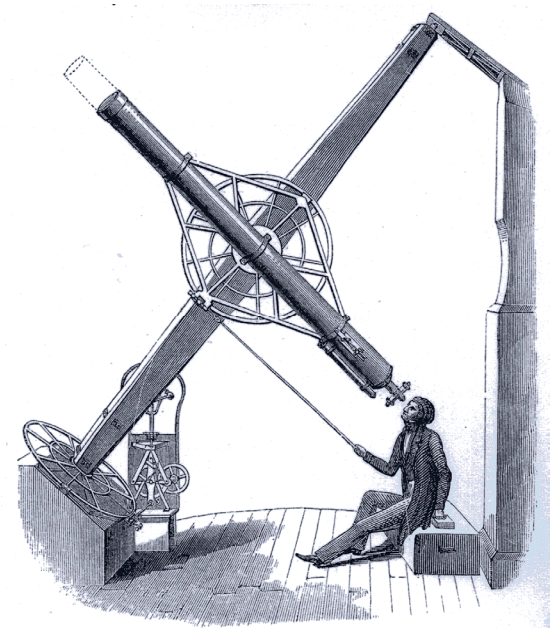


Figure 4

The Dollond equatorial mounting for W. H. Smyth's Bedford Observatory

Image is from Reference 13, Page 338.

In the early days of the Wrottesley Hall observatory, Lord Wrottesley's observer was Mr Richard Philpott (dates not known). Census information from the 1850s indicates that he and another member of Lord Wrottesley's staff, possibly Mr Frederic Morton, his "… second assistant …"[14] resided in the observer's quarters at the observatory. Work on positional astronomy continued at the new observatory, resulting in 1851 in a report of attempts to measure stellar parallax using measures of double stars[15]; in a catalogue of the Right Ascensions of 1009 stars in 1854[6]; and in 1861, a study of 398 double stars[16]. The latter was to be Lord Wrottesley's final major work. He died at Wrottesley Hall on 27 October 1667.

In the later part of the 19th century, the Wrottesley Park observer was Joseph Hough, M.A. (1838-1924), who came to the Staffordshire area having previously been a master at Burnley Grammar School in Lancashire. He married a local girl and settled at Park House in Codsall Wood. Park House had an Annexe that served as a schoolroom. It was here that children from nearby Wrottesley and Chillington Halls would tend to be sent to be tutored by Hough, who thus fulfilled a dual rôle - school-master and observer.

In the early 20th century, the observatory was no longer operational, but Hough continued to look after it on a 'caretaker' basis. He died in 1924 at the age of 86. Whilst at Codsall Wood he had always been an active member of the small mission church of Saint Peter's, where a memorial to him in the form of a stained-glass window that depicts the three wise men, said to have been astronomers.

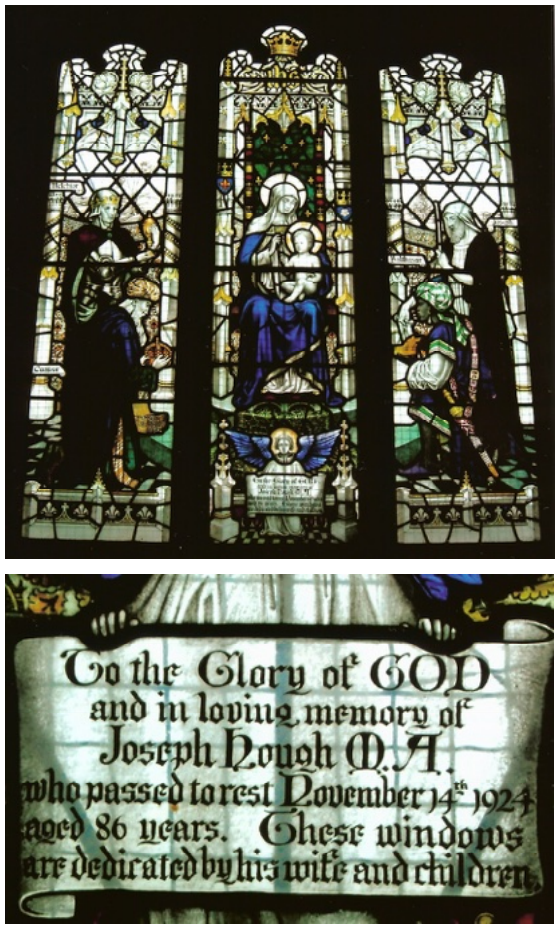


Figure 5

Memorial window to Hough in St Peter's church, Codsall Wood, Staffordshire

The lower image is a detail of the dedication seen at the foot of the middle light.
Photographs by the author, September 2006

The 2nd Baron Wrottesley also held the title of Lord of the Manor of Sedgley, a few miles away in the Black Country. It seems that he might have maintained astronomical interests there, as well as at Wrottesley Hall. On Sedgley Beacon, at 247 metres above sea level the highest point in the area, stands a 'folly' known as Beacon Tower (Figure 6). It is said that the present structure is the result of rebuilding by Lord Wrottesley in 1846. He is said to have used the tower subsequently for the purpose of astronomical observation[17, 18]. Some dispute this claim, but it is possibly true. From the top of the tower there is certainly a commanding and a totally unobstructed view. The tower is now in need of significant and costly restoration work, particularly internally.

Figure 6

Sedgley Beacon Tower from the north-west

Photograph by the author, September 2006.

The current state of the Wrottesley Hall observatory can be gleaned from Figures 7 and 9. All parts of the original structure shown in the plan (Figure 8) can be seen and identified, though they are in a ruined state and overgrown with vegetation. In places the walls still stand to a height of about 1 metre. Some of the bricks and the stone facing from the walls is still on the site, but it is known that much has been removed.

The most impressive part of the structure still standing is the two massive pillars, in the location of the transit room. These presumably were used to mount the transit instrument. Notice that the west pier is now shorter than the east one. This is because these piers are not monolithic, as were those at Hartwell Observatory, but comprise stone components cemented together. At least one component of the west pier is still on site.

Figure 7

The remains of the transit piers at the site of the Wrottesley Hall observatory

The upper image shows the piers from the east; the lower image is from the north. Notice the damage to the east pier, and the height difference between the two piers. In the background of the upper image can be seen part of the track on which the dome rotated (see also Figure 9).

Upper photograph taken by Mr D.J. Holden, September 2006, and published with his permission. Lower photograph by the author, September 2006.

In the area of the former equatorial room can be seen the remains of the track on which the dome turned (Figure 9) . It is complete, but much rusted. Also obvious are the remains of what could have been the north pier of the equatorial telescope. This is hard to confirm. So far, examination of the site has had to be limited to a broad over-view because it is not possible to enter the ruins in the comfort and safety necessary to conduct a proper archaeological examination. This will be undertaken in due course.

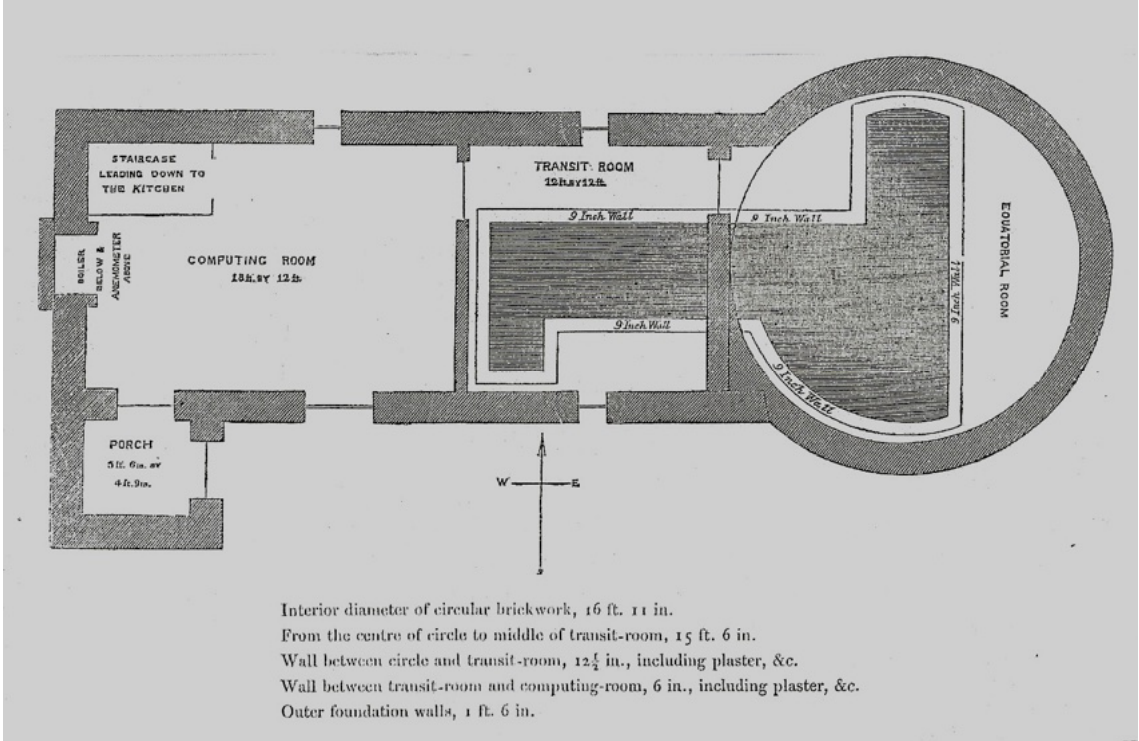


Figure 8

Plan of the Wrottesley Hall Observatory

The source of this image is given in Note 6.

By courtesy of the Royal Astronomical Society.

Figure 9

A view from the south-east of the equatorial room area of the Wrottesley Hall Observatory

Photograph by the author, September 2006.

The floors of the computing room, the transit room and the equatorial room have disappeared, so parts of the observatory are many feet below present ground level.

The site of the Wrottesley Hall observatory is now in the care of the Pendrell Hall Observatories Group, which is based a short distance away, at Pendrell Hall in Codsall Wood (location 52°38' N; 2°13' W). The site is not only in a ruined state, but also considerably overgrown. However, conditions have been improved, such that those inspecting the site can now walk freely around it. The prospect of re-building the observatory is considered to be out of the question, both now and in the foreseeable future. In the meantime, the fact that the site is now cared for of a group of enthusiasts, who have its well-being at heart, ensure that not only will its deterioration be minimised, but its story, and that of the 2nd Baron Wrottesley, will become more widely known.

Acknowledgements

Acknowledgements are due to the following individuals who have assisted in various ways during the preparation of this paper: Mr P.D. Hingley, Librarian of the R.A.S.; Mr A.W. Yates of Pendrell Cottage, Codsall Wood; Mr D.J. Holden of Codsall; Mr A. Jaworski and Mr J. Jaworski of Staffordshire County Council. Acknowledgement is also given for information supplied by The Staffordshire Society.

Notes and References

1. For more detail see the obituary notice of Lord Wrottesley. E.W.B. John, Second Baron Wrottesley. *Monthly Notices of the Royal Astronomical Society*. 1868, 28, 64-68.
2. J.L.E. Dreyer, M.A., Ph.D., D.Sc. and H.H. Turner, M.A., D.Sc., D.C.L., F.R.S. Editors. *History of the Royal Astronomical Society 1820-1920*. London: Royal Astronomical Society. 1923.

3. Lord Wrottesley, A catalogue of the Right Ascension of 1318 stars in the Astronomical Society's catalogue, being chiefly those of 6th and 7th magnitudes. *Memoirs of the Royal Astronomical Society*. 1838. X**.** 157-234.
4. See Reference 1.
5. Layton, David. Lord Wrottesley F.R.S., pioneer statesman of science. *Notes and Records of the Royal Society*. 1986, 23 (2), 231-246.
6. Lord Wrottesley. A Catalogue of the Right Ascension of 1009 stars contained in the catalogue of the British Association. *Monthly Notices of the Royal Astronomical Society*. 1854. XIV (3), 69-74. Page 69. The catalogue was published in full in: Lord Wrottesley. A Catalogue of the Right Ascension of 1009 stars contained in the catalogue of the British Association for the Advancement of Science, being chiefly those of the 6th and 7th magnitudes. *Memoirs of the Royal Astronomical Society*. 1854, XXIII, 1-32. The plan of the Wrottesley Hall Observatory shown in Figure 8 above is on page 2 of this second publication.
7. Lord Wrottesley. Reference 6. Pages 69 and 70.
8. Lord Wrottesley. Reference 6. Page 69.
9. This assumed to be H. Guinand, son of Peter Louis Guinand (1784-1824), who was then working in France.
10. Captain W. H. Smyth, R.N., K.S.F., D.C.L., F.R.S. &c. *Ædes Hartwellianae*, *or Notices of the Manor and mansion of Hartwell.* London: Printed for private circulation by John Bowyer Nicols and Son, Parliament Street. MDCCCLI. Plate XI, facing Page 231. Much of the astronomical content of this book, including the engraving of the transit room of the Hartwell Observatory, is also included in a later book by Smyth: Vice-Admiral W.H. Smyth, K.S.F., D.C.L., F.R.S., F.R.A.S. etc. *The Cycle of Celestial Objects Continued at the Hartwell Observatory to 1859. With a notice of recent discoveries, including details from the* 'Aedes Hartwellianae' London: Printed for private circulation by John Bowyer Nicols and Sons, Parliament Street. M.D.CCC.LX. This book is commonly known by the only words present on its spine - *Speculum Hartwellianum*. It is frequently confused with the 1851 publication.
11. W.H. Smyth. Reference 10. Page 244.
12. Lord Wrottesley. Reference 6. Page 69.
13. Smyth, Captain W. H. *A Cycle of Celestial Objects, for the use of naval, military, and private astronomers.* London: John W. Parker, West Strand. 1844. 2 volumes.
14. Lord Wrottesley. Reference 6. Page 72.
15. Lord Wrottesley. On the Results of Periodical Observations of the Positions and Distances of Nineteen of the Stars in Sir John Herschel's Lists of Stars, Favourably Situated for the Investigation of Parallax, Contained in Part III. Of the Philosophical Transactions for 1826, and Part I. 1827. *Philosophical Transactions of the Royal Society of London*. 1851, 141, 333-356.
16. Lord Wrottesley. A Catalogue of the position and distances of 398 double stars. *Memoirs of the Royal Astronomical Society*. 1861, XXIX, 85-168.
17. Green, D. Beacon Tower, Sedgley. *West Midlands Follies*. Issue 58 Summer 2004.
18. www.sedgleylocalhistory.org.uk/Etshl/beacon. Accessed November 2006.

Joseph Gurney Barclay and the 1860 10-inch Cooke refractor[1]

Charlie Barclay
Director, Blackett Observatory, Marlborough College

Joseph Gurney Barclay (1816-1898) F.R.A.S., was a partner in the banking firm of Barclay, Bevan & Co. He was, like his grandfather, Robert Barclay of Clapham[2], a keen Astronomer who observed regularly at his home Knotts Green House in Leyton, Essex, England, and he was a frequent contributor to the *Monthly Notices of the Royal Astronomical Society*. Employing professional astronomers, he made many original observations, especially following the acquisition of a 10-inch Cooke refractor in 1860. Gifted to the Radcliffe Observatory, Oxford in 1885, the 'Barclay Equatorial' continued in professional use until 1935 when it was removed to Marlborough College in Wiltshire, England, where it is now in full computerized use following complete restoration.

Joseph Gurney Barclay (Figure 1), my great-grandfather's first cousin, was born in 1816 into a wealthy family, the great-great-grandson of David Barclay of Cheapside (1682-1769), the founder of what has become Barclay's Bank. Inheriting a large house and grounds and a huge personal fortune, it might be supposed that as an archetypal Victorian gentleman his interest in astronomy would be more social, and that the acquisition of a top-of-the-range telescope was therefore an article of one-upmanship and beauty, to show off to friends. On all counts this appears to have been far from the truth.

Figure 1

Joseph Gurney Barclay as a young man

Original picture is the property of David Barclay, by whose courtesy this image appears.

Joseph (hereafter identified as J.G.B.) was a keen observer, who took the running of his observatory and the friendship and working partnership of the professional astronomers he employed as seriously as his banking work, a carriage ride away in the City of London (he used to drive himself daily from Leyton to the City behind a Suffolk cob)[3]. His contribution to astronomy can be judged by his many papers, many of which included his own observing input[4,5,6], published between 1862 and 1884 in the *Monthly Notices of the Royal Astronomical Society*. He had been elected a Fellow of the Royal Astronomical Society on 9 November 1855, supported by unusual numbers of the prominent names in astronomy at that time. Perhaps most notable was the description in 1863[5] of the detection of a faint, magnitude 10.5, companion to the bright star Procyon (α Canis Minoris), which was not independently confirmed until 1896.

J.G.B. is described in the records of the Religious Society of Friends (the Quakers)[7]:

> " His deep Christian character in which humility was a marked feature manifested itself in a broad philanthropy and kindly consideration for all with whom he came in contact."

This view is born out by his care for his astronomer assistants, and the eventual gift of the 10-inch refractor to the Radcliffe Observatory. He appears to have been somewhat a loner when it came to work, but he was very much a family man - he hosted many gatherings of his extended family and cousins (including Arthur Kett Barclay F.R.S. (1806-1869), who was also a keen astronomer with an 5.9-inch Troughton and Simms refractor)[8]. He also held public open days in his 'pleasure gardens' - his home, Knotts Green House (Figure 2).

Figure 2

Open Day at Knotts Green House

Image from the *Illustrated London News* dated 15 July 1865.

Robert Barclay, friend of William Herschel

J.G.B.'s love of astronomy seems to have stemmed from an early age, and was probably stimulated by books and memories of his grandfather, Robert Barclay (1758-1816). Robert was interested in astronomy from childhood. He later constructed an observatory, and regularly observed from the grounds of The Elms, his large house in Clapham, where J.G.B. spent his childhood.

Robert's first cousin, Thomas Collinson, son of Jane Barclay of Clapham, was also a keen observer. Both were friends of, and regular correspondents with, William Herschel (1738-1822)[9]. After visiting Herschel in Datchet (to where he had moved in August 1782[10]) in December 1783, two years after the discovery of Uranus, Collinson wrote to Robert on 3 December an intriguing letter[11]. It indicates their interest the new field of astronomical research 'beyond the meridian', which had dominated observers in the early 18th century, and would continue to do so well into the 1800s:

> " I ventured to pass Saturday night last with Herschel in the open space till midnight, in which situation I seldom suffer. His late finished great telescope [likely to be the 20ft] I turned to several parts of the heavens but found no place without stars not even near the horizon, a circumstance which distinguishes his instrument from any other hitherto made. The Moon appeared thro' it too light to be contemplated with safety to the eyes and we had too little time to put on the greater magnifying powers to diminish the splendour. We therefore contented ourselves with his first made large telescope [presumably the 7ft], which showed Orion gloriously and unified all we saw thro' yours. Double and double-double stars it showed us to great advantage and we beheld divers nebulae or radiant spots in the heavens so thickly sown with stars that they appeared like glittering dust. We also saw the new comet (Herschel) and the Georgian Sidus [Herschel's name for Uranus]. But instead of going on with telling you what I saw, it will be of more consequence to inform you of what he has seen. In a small portion of the Galaxy, twelve degrees broad by 3 degrees long he counted forty-three thousand stars and in various other parts of the heavens there seem particular systems of stars which seem to have reference to each other. Then another system and so on without end. His discoveries of Mars are wonderful. He has not only ascertained its equatorial and polar parts but he has beheld this snow diminish and increase as each pole has been turned towards or from the Sun. White spots have likewise been visible in the tropical regions such as the snowy summits of our Andes would exhibit at great distance from our Earth. He has seen so much as to enable him to ascertain the diurnal revolution of Mars and to calculate the Sun's declination there. In Jupiter's belts and spots he has seen very extraordinary changes and peculiarities and distinguished one of Jupiter's satellites on his body, it happening to have a dark broad belt behind it, the shadow of this satellite appeared on the planet at the same time. On Saturn he has discovered belts and spots as on Jupiter."

This letter shows that at the time Herschel was beginning systematic sweeping with the 20-foot reflector, to augment Messier's catalogue of nebulae, he had come to the realisation that the stellar density distribution he had measured suggested the disc shape of our own galaxy. However, in the light of modern knowledge the wording could be read to imply that Herschel had also realised the nature of 'island' nebulae (now known to be independent galaxies).

On Collinson's advice Herschel also began to study the correlation between a star's visible spectrum and what later would be called its spectral type, having previously "… not thought much scientific worth could come of spectroscopy."![12]

From Clapham to Leyton

Robert Barclay married Anne Ford, who gave birth to four sons and four daughters. The eldest son, Robert, who was born in Clapham in 1785, succeeded his father as partner in the banking company. Robert junior seems to have moved to Leyton by 1832. Essex records[13] show that 31 acres and Knotts Green House were acquired in 1821, but that Robert lived in the neighbouring 100-acre estate of Forest House at Whipps Cross, (Figure 3) where he lived until 1853[14]. He had three sons and six daughters. The eldest son, also named Robert, was born in 1815, married in 1842 and died, childless, six months later. J.G.B., the second son, was born in 1816 at 13 Russell Square, J.G.B. was educated at home, in Knotts Green House, because as a member of a long-standing Quaker family, he

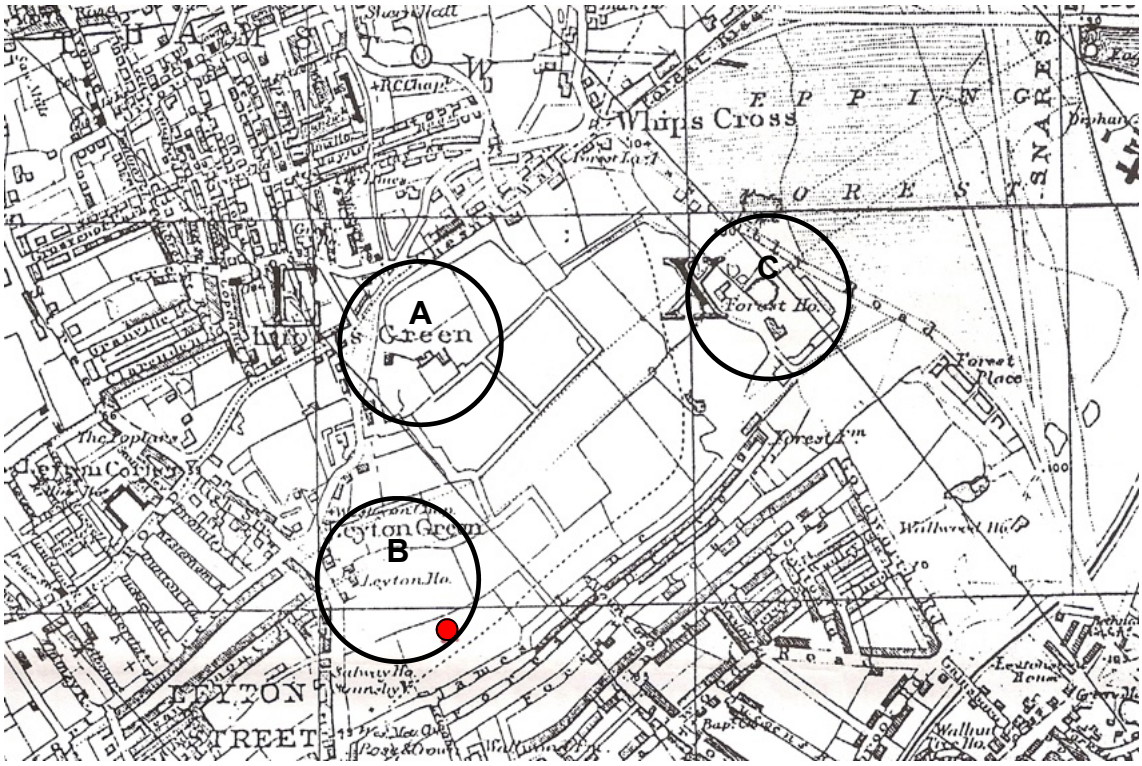


Figure 3

The location of Barclay houses in Leyton, Essex

The circles show: A - Knotts Green House; B- Leyton House; C - Forest House.
The coordinates of the observatory are marked by the small, solid circle within circle B.
This map is taken from: G.W.Bacon. Ordnance Atlas of London and Suburbs. London: G.W.Bacon. 1888.

was unable to enter Cambridge University, which was not yet open to Quakers[15]. J.G.B. married Mary Walker Leatham in 1841. In the next year his elder brother, successor to the family fortune, died. Thus it was that in 1853, on the death of his father, J.G.B. inherited the principal Barclay properties and the whole Barclay interest in Barclay, Bevan, Tritton and Co. Mary died in 1850 having given him two sons. He remarried in 1857, to Margaret Exton.

The Observatory

J.G.B. set up his observatory in 1854 with a 7½-inch Cooke equatorial and a 4-inch Troughton and Simms transit circle. In late 1855 or early 1856, he began to study earnestly the star Procyon, following a letter (published 21 December 1855) to the Editor of *The Times* from John Russell Hind (1823-1895), who was then working at the Regent's Park observatory of George Bishop (1785-1861). This letter alluded to the suspected existence of a companion star to Procyon:

> "… on 10th January 1856 I discovered a small star within the blaze of the light of the larger one, and which I roughly estimated at from 3 to 4 seconds of time by the sound of the clock preceding Procyon in RA, and but little removed to the north in December." [16]

J.G.B. sent a "… rough sketch …" of his observations to Hind, who raised the topic again in 1863, and J.G.B.'s observer, Mr Hermann Romberg, then used the 10-inch Cooke refractor to measure the position angle of the companion[17].

J.G.B.'s own description of the Observatory is found in the Leyton Observations[18]:

> " My observatory is erected in the midst of the pleasure-grounds which surround my residence at Leyton, in Essex, about six miles N.E. from the City of London; its position being 51° 34' 34" N. latitude and 0h 0m 0.87s W. longitude, and about ninety feet above the level of the sea. The building consists of a quadrangular room, sixteen feet square, surmounted by a wooden dome, covered with copper and lined with American cloth, which I found prevented the internal condensation of vapour; it revolves on gun-metal wheels connected by a ring. The shutter which covers an aperture of two feet, is opened by means of a cord passed through a hole to the interior, and runs on two iron rods fixed at tangents to the dome, by which arrangement it can be opened and shut with the greatest ease and rapidity, the

> dome being moved by a lever fixed to the wall, and working against iron pins screwed into the rim of the dome. Light falls into this room through four windows in the horizontal angles projecting beyond the circular base of the dome. The Refractor stands on a massive pier of brick-work, being 15ft 6in square at the base, 6ft 6in high, and set back in six ramps, on which is placed a circular slab of stone; the foundations being concrete, four feet thick, and drained below on solid gravel, the whole being covered with asphalt. On the west side is a second room, 12ft 6in square, which contains the Transit-Circle, the roof being flat, so as not to impede the view from the dome. The telescope is a powerful and handsome instrument made by T. Cooke & Sons of York, with an object-glass having a clear aperture of 10 inches and a focal length of 12 feet. It is mounted equatorially in the German fashion. The strong cast-iron pillar on which it is supported is in two parts. The lower part is 3 feet in height, with a diameter at the base of 3 feet 3 inches, and at the top 1 foot 6 inches; the upper part is 4 feet in height, the diameter at the top is 1 foot 1 inch. The two parts are bolted together with flanges and eight screw bolts and nuts. At this place there is a limited motion in azimuth, by which the Telescope is put truly into the meridian. The polar axis is 4 feet 2 inches long; the pressure on the upper bearing is relieved by two friction-wheels, the lower pivot is also relieved by two friction-wheels. At the lower end of the polar axis is carried the hour-circle, 13 inches in diameter, with two sets of divisions and verniers, graduated to 1m of time, and read off to 2s. The declination axis, 3 feet 2 inches in length, carries at one end the Telescope, at the other the counterpoise and the declination-circle, of 24 inches in diameter, which is graduated to 10' of space, and reads by the two verniers to 10" of arc. The Clock is driven by a heavy weight descending under the floor of the Observatory, and regulated by a double conical pendulum. The motion is communicated to the Telescope by a brass rod and wheels, and tangent-screw working into a strong ratcheted driving-wheel at the upper end of the polar axis. The instrument is provided with eye-pieces, magnifying from 50 to 1600 times. The view of the horizon is almost uninterrupted. The Telescope is furnished with a finder of 3 feet focal length and 3 inches aperture, which shows to the ninth magnitude."

No images of the observatory or its instruments have yet been discovered. Furthermore, until late 2006, its exact position was uncertain, because the coordinates given by J.G.B. place it outside known extent of the grounds of Knotts Green House. However, it seems that that J.G.B. kept near-by Forest House after his father's death, and though living in Knotts Green House himself, he built the observatory on Forest House land. He also acquired Leyton House at Leyton Green, extending the Barclay estate even further.

It appears that when first used in 1862, not only was the 10-inch refractor one of the largest instruments to have been produced by Thomas Cooke and Sons of York from their new Buckingham Works, but it was also one of the largest in the Britain and Ireland. The larger refractors were the 13⅓-inch at the observatory of Colonel Edward Joshua Cooper (1798-1863) at Markree Castle, County Sligo, Ireland (which had fallen into disuse by 1860), the 11¾-inch 'Northumberland' telescope at Cambridge and the ex-Sir James South (1785-1867) 11¾-inch telescope at Dunsink, north-west of Dublin, which was transferred in 1862, but not installed until 1863[19].

The observers

Having purchased the 10-inch Cooke refractor, for about £1200[20] in 1860, J.G.B. realised that professional astronomers would be needed to maximise its use. His first observer, from 1862 to 1864, was H. Romberg (a pupil of, and successor to, Johann Franz Encke (1791-1865) of the Berlin Observatory. On his arrival in 1862 Romberg wrote[21]:

> " It is proposed to measure, as far as practicable, the stars in W. Struve's last Pulkova Catalogue, Bessel's selected list, the known revolving double stars, and a number observed by Admiral Smyth in the Bedford Cycle. Observations of the fainter small Planets it is hoped to procure, with a new wire-micrometer provided with illuminated wires in a dark field."

In the same paper he also stated that he was going to use the meridian-circle:

> "… not only for the common determination of time, longitude and latitude, but for observation of Planets, and later for ascertaining the positions of Comparison-Stars."

Following Romberg's return to Berlin, J.G.B., on the recommendation of Hind, employed Charles George Talmage (1840-1886), who trained at the Royal Observatory, Greenwich but was then the Director of Bishop's observatory (which by now had moved to Twickenham), where he had studied the Sun. J.G.B. and Talmage worked on projects including: double star measurements for Struve's catalogue[22]; observations of Jupiter and Saturn (Figure 4), Uranus and newly-discovered Neptune; and timing many lunar occultations. The work was published privately in the Leyton observations. J.G.B. sent Talmage to observe the 1882 transit of Venus in the West Indies, where he took successful timings. Afterwards his delicate health began to fail, and he died in 1886, whereupon activity at the observatory ceased.

Oxford and the Radcliffe Observatory[23]

Since 1861 the work of the Radcliffe Observatory, Oxford, England had become increasingly incon-

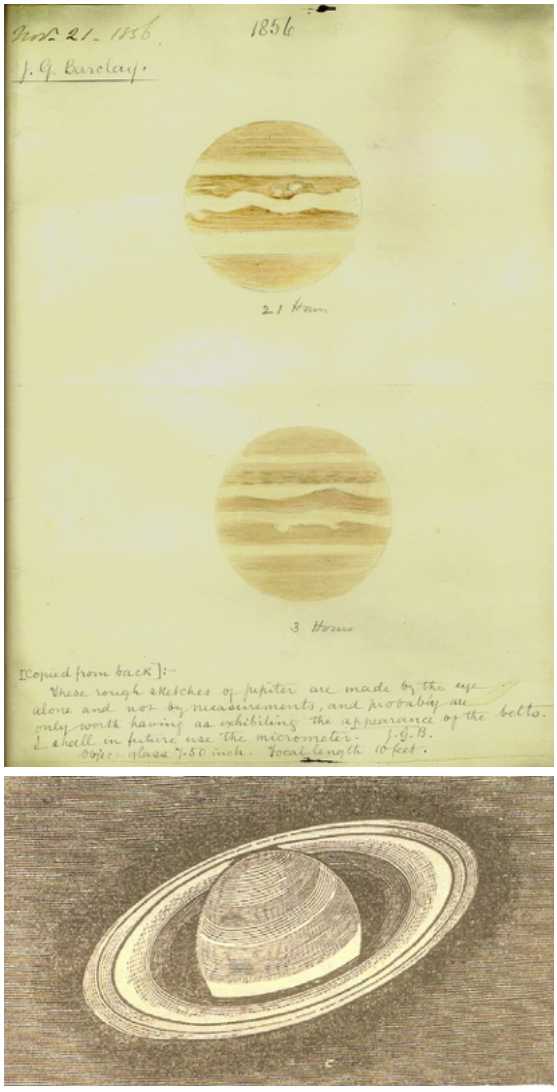


Figure 4

Planetary observations by J.G.Barclay

Jupiter drawing: Text at the top of page : "1856 Nov 21 1856. J.G.Barclay." Text at bottom of page: " [Copied from back]:- These rough sketches of Jupiter are made by the eye alone and not by measurements, and probably are only worth having as exhibiting the appearance of the belts. I shall in future use the micrometer. J.G.B. Object glass 7.50 inch. Focal length 10 feet."
Saturn image: This is from: R.J.Mann. *Dr Mann's Guide to Astronomical Science*. Norwich: Jarrold. No date (probably mid-to late 1800s. Page 253.

sequential because it lacked a first-class instrument. The situation became worse in 1875, when, only half a mile from the Radcliffe Observatory, the University Observatory was established in the 'Parks'. The Savilian Professor of Astronomy, Revd Charles Pritchard (1808-1893), accepted for the University Observatory the gift of a 13-inch photographic reflector from his friend Warren De La Rue (1815-1889). This telescope was already 21 years old, and the mirror was of speculum metal, not the 'modern' silvered glass.

Whereas benefactors were attracted to the University Observatory, the Radcliffe Observatory commanded no such support[24]. Thus, when Edward James Stone (1831-1897) became Radcliffe Observer in 1879[25], he was shocked by the state of the Observatory, which had a barely-adequate budget and no funds to renovate or to acquire decent instruments. Stone originally made a plea to the R.A.S. for loan of an equatorial telescope, but during the course of frequent encounters with J.G.B. at R.A.S. meetings, persuaded him to donate his 10-inch Cooke refractor to Oxford and the Radcliffe Observatory. In view of J.G.B.'s age (he was by then 63 years old) and the lack of a professional observer at his observatory, J.G.B agreed. He gave his transit instrument to the University Observatory[26]. Despite the growth in apertures, especially of reflector telescopes, Barclay's 10-inch refractor, with its superb Cooke lens, made a very welcome addition to the instruments at the Radcliffe Observatory.

The Barclay telescope was installed in the north-west corner of the Radcliffe Observatory grounds in a wooden shed with a sliding, corrugated-iron roof (Figures 5 and 6). There it remained until 1907, when it was transferred to the former heliometer building (Figure 7), from which the instrument had been removed. It was used regularly to observe M31 (the Andromeda galaxy) and immediately gave the Observatory better capability for observing comets, novae and minor planets. On 31 August 1885, the nova in M31 (now recognised as a supernova) was announced, and using the Barclay telescope Observatory staff recorded visual magnitude estimates until 10 December, longer than any other observatory in the Britain and Ireland. The rate of fading of the light curve enabled bounds to be set on the supernova's energy output and scale of such events in the 1950s theories of nucleo-synthesis.

The Barclay telescope was the main non-transit instrument at the observatory for 10 years, until 1897, when the next Radcliffe Observer, Arthur Alcock Rambaut (1859-1923), persuaded the Radcliffe Trustees to refurbish and re-equip the Observatory with a 24-inch/18-inch photographic/visual double refractor by Grubb of Dublin. This telescope was installed in its own large dome in 1903 (Figure 7) [27].

J.G.B. was above all a calm man, and this, combined with his generosity and business acumen, saved the Bank in the financial crisis of 1866. He retired in 1896 after converting the old firm into Barclay and Co. Ltd, and died on 25

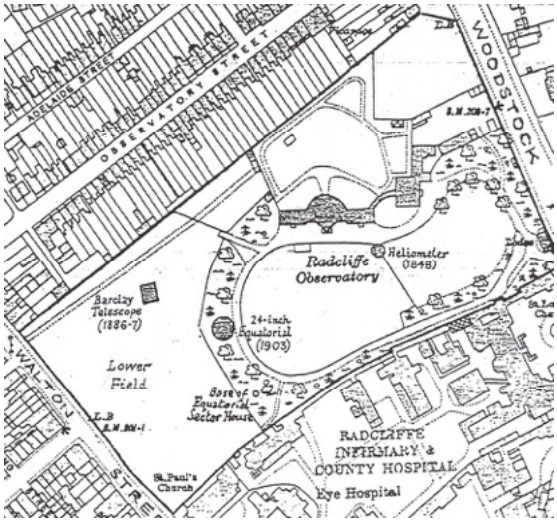


Figure 5

Site of the Barclay 10-inch Cooke refractor at the Radcliffe Observatory, Oxford

This is an extract from the Ordnance Survey 1887 survey. North is at the top. The scale is not known.

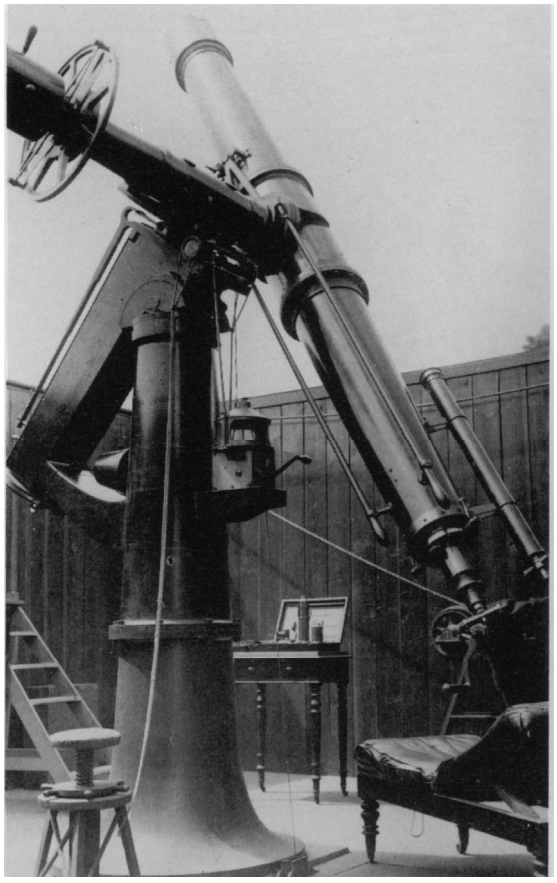


Figure 6

The Barclay refractor *circa* 1900 in the wooden shed with a sliding roof

Radcliffe Trust papers (Bodleian Library). Accession Number DD Radcl. D43.

Figure 7

The Radcliffe Observatory *circa* 1922

The heliometer, was housed in the octagonal building in the centre foreground. The building in the left background housed the 24-inch equatorial.

Reproduced by courtesy of the Bodleian Library.

April 1898, aged 81, at Exton House, Brighton[28]. His Knotts Green property was submerged in the advancing tide of London suburbs and became Livingston College, for training missionaries in basic medicine before they left for the tropics.

The move to Marlborough College

In 1935 the Radcliffe Observatory site was sold, and the Observatory moved to South Africa. It appears that Sir Basil Philpott Blackett (1882-1935)[29] heard that the Radcliffe Observer was seeking good homes for the Observatory's instruments. Marlborough College aspired to establish a good teaching Observatory and to expand its existing Natural History Society (which had been carrying out observations and publishing them internally, with an 1880 4-inch Cooke refractor). The sum of 800 guineas was raised by the Marlburian Club, of which Sir Basil was President, to build the Observatory and to purchase a copper dome from a private observatory in Torquay. The Observatory was opened in 1935 by the last UK based Radcliffe Observer, Harold Knox-Shaw (1885-1970), and was named in honour of Sir Basil, who died in a road accident some six months before.

From 1935 the Barclay telescope was used by successive generations of Marlburian pupils under the supervision of enthusiastic teachers and members of the pupil-led Radcliffe Society, mainly for planetary observation, but also for solar work (using projection methods). However, over time the motor drive became damaged, and despite in-house attempts to keep the instrument going it had largely fallen into disrepair and was not being used to anything like its full potential.

On being appointed the Head of Physics at Marlborough College in 1997, I took responsibility for the Observatory. Unaware of the name of the

telescope, its provenance or family connection, I began overseeing its restoration and modernisation by astronomer, designer and engineer Mr Norman Walker, who formerly had been employed at the Royal Greenwich Observatory, Herstmonceux. The restoration (funded by the College) was completed in 2002 (Figure 8). Professor Joe Silk F.R.S., the current Savilian Professor of Astronomy at Oxford, reopened the Observatory (Figure 9). In September 2004, I became the first Director, with responsibility for outreach and education.

Figure 8

The restored Barclay Equatorial in the Blackett Observatory of Marlborough College

Photograph by the author September 2005

The telescope's prime function is to enable direct viewing at the eyepiece, primarily within the College to support the flourishing General Certificate of Secondary Education Astronomy course, but also to support local groups, primary schools and teachers. Work focuses on lunar detail, planetary observations including Uranus and Neptune, polar cap variations on Mars, and changes in cloud features on Jupiter and timings of shadow transits of the Galilean moons. Solar filters have been added, and direct observation of the Sun, including use of a crystal-based H-alpha filter, enables fine detail of penumbral filaments and of prominences to be seen and drawn. In June 2004 we were able to measure the Astronomical Unit to incredible accuracy, thanks to the European Southern Observatories programme devised for the transit of Venus, when contacts were timed to 10th second, and witnessed by some 450 visitors. The original Cooke optics are, by acclaim of experienced visitors, astounding, and allowed in September 2005 observation by eye of Pluto near the theoretical magnitude limit of the instrument.

The link with Oxford University has been maintained; as an Academic Visitor to the Astrophysics department, and a member of Green College Common Room, I am linking public outreach at the former Radcliffe Observatory site with one of its original instruments. In Summer 2006 we launched at Green College a series of astronomy lectures for the Public Understanding of Science, including lectures by Professor Roger Davies, Chair of Physics, Philip Wetton Professor of Astrophysics in Oxford University and Professor Jocelyn Bell-Burnell C.B.E., F.RS. With Heritage Open Days attracting 700 visitors, the history, significance and work of the former Radcliffe Observatory is being brought back into the public eye.

Figure 9

Professor Joe Silk, F.R.S. (on the left) and Mr Norman Walker at the 2002 opening of the restored Barclay telescope

Photograph taken by, and reproduced with the permission of, Mr S Ellis, Marlborough College.

Acknowledgements

I must acknowledge the help and assistance given by Peter Hingley (R.A.S. Library), Professor Roger Davies (Oxford Astrophysics), Dr Roger Hutchins (Magdalene College Oxford), Anne Charles (ex Radcliffe Infirmary), Dr Terry Rogers (Marlborough College Archivist), 'Kisty' Creighton (née Barclay, great-granddaughter of J.G.B., and possibly the last to have known his children), and for his research, leading to the Paragraph t the foot of column 1 on Page 14, Dirk Pelly (formerly Director of Barclays Bank International and a distant cousin). I am also grateful to Mr Ken Goward (Treasurer of the Society for the History of Astronomy) for corroboration of the details of the Leyton Observatory and for supplying information about the image of Saturn shown in Figure 4. Special thanks are due to Dr Roger Hutchins for his time and care taken in reviewing and editing the draft paper.

Notes and References

1. The topic of this paper was presented at the second Autumn Conference of the Society for the History of Astronomy, held at the Birmingham and Midland Institute, in Birmingham, England on 8 October 2005.
2. In researching this paper I have realised that Robert Barclay of Clapham (1758 – 1816) my direct antecedent is an important character in this family story. At present, details of his observatory (where Thomas Collinson, his half-cousin was his co-worker) and its instruments remain undiscovered, and will be the topic of future research.
3. H. Barclay and A. Wilson-Fox. *A History of the Barclay Family*. London: St Catherine Press. 1934. Pages 264, and 253-254. The authors do not cite the location of the primary sources. Hereafter this is referred to as: Barclay and Wilson-Fox. *The Barclay Family*.
4. Hermann Romberg. Observations of Comet II. 1862 taken at the observatory of J. Gurney Barclay, Esq., at Leyton, Essex, and communicated by him. *Monthly Notices of the Royal Astronomical Society*. 1863, XXIII (3), 92-94.
5. J. Gurney Barclay. Note on a small companion of Procyon, &c. *Monthly Notices of the Royal Astronomical Society*. 1863, XXIII (6), 196-197. This paper includes, on page 197, a note authored by Hermann Romberg: Measures of the small star near Procyon. I have been unable to trace any other acknowledgements of these Leyton observations. The next independent observation seems to be that of W. Struve on 19 March 1873 (*Monthly Notices of the Royal Astronomical Society*. 1873, XXXIII, 430-433, and subsequently *Monthly Notices of the Royal Astronomical Society*. 1874, XXXIV, 555-559. However, the confirmation was credited to J.M Schaeberle in 1896 using the 36-inch refractor at Lick Observatory (Patrick Moore. *Brilliant Stars*. London: Cassell Publishers Ltd. 1996. Page 85).
6. C.G. Talmage. Occultations of Neptune and ν^2 Cancri, observed at Mr. Barclay's observatory, Leyton. *Monthly Notices of the Royal Astronomical Society*. 1874, XXXIV (5), 273-273.
7. *Dictionary of Quaker Biographies* (unpublished document) held at Friends House, London. At this time the whole banking branch of the Barclay family were committed Quakers, and had been since Robert Barclay (1648-1690) (J.G.B.'s Great-great-great-grandfather), later known as the 'Apologist', joined the 'Friends' movement in its earliest days in 1664. The origins of the London banking fraternity Barclays, Bevans, Trittons, etc. arose from the gatherings and business conducted by the main Quaker families in London in the mid-18th century. J.G.B.'s grandfather in Clapham was at the centre of Quakerism there, and J.G.B. himself became an 'Overseer' in the movement.
8. Derek Howse. The Greenwich list of observatories: A world list of astronomical observatories, instruments and clocks, 1670-1850. *Journal for the History of Astronomy*. Number 51. November 1986, 17 (4), i-iv, 1-100, (page 69). Also see the amendment to this entry in: Derek Howse. The Greenwich list of observatories: Amendment list No. 1. *Journal for the History of Astronomy*. Number 80. August 1994, 25 (3), 207-218, (page 215).
9. Barclay and Wilson-Fox. *The Barclay Family*. Reference 3. Page 253.
10. Michael Hoskin (Editor). *Caroline Herschel's Autobiographies*. Cambridge, England: Science History Publications. 2003. Pages 66-67.
11. Barclay and Wilson-Fox. The Barclay Family. Reference 3. Page 253.
12. D. Malin and P. Murdin. *Colours of Stars*. London: Cambridge University Press. 1984. Page 11.
13. *The Victoria History of the County of Essex*. Volume VI. Updated 1973.
14. Forest House was demolished in 1898 to build Whipps Cross Hospital.
15. Barclay and Wilson-Fox. *The Barclay Family*. Reference 3. Page 264. See, too, Reference 7.
16. J. Gurney Barclay. Reference 5. Page 196.
17. Hermann Romberg. In: J. Gurney Barclay. Reference 5. Page 197.
18. J.G. Barclay. *The Leyton Observations*. These were privately published volumes containing the combined observations of J.G.B. with his observers - first Romberg, then Talmage. Copies of Volumes I, II, III and IV are held in the R.A.S. library. (Volume V was not published.)
19. http://12.1911encyclopedia.org/O/OB/Observatory.htm "Observatory". LoveToKnow 1911 Online Encyclopedia ©2003, 2004. Accessed September 2006.
20. J.G. Barclay. *The Leyton Observations*. Reference 18.
21. Hermann Romberg. Reference 4, Page 94.
22. J.G. Barclay. *The Leyton Observations*. Reference 18.
23. For additional detail see Jeffery Burley and Kristina Plenderleith (Editors). *A History of the Radcliffe Observatory Oxford*. Oxford: Green College. 2005.
24. Ivor Guest. *Dr John Radcliffe and his Trust*. Oxford: The Radcliffe Trust. 1991. Pages 287-288.
25. When installed, this telescope was the 3rd largest refractor in Britain. It was used to take the first British photograph of the newly-discovered Pluto in 1930 (see Burley and Plenderleith, 2005. Reference 23. Page 15). It is now restored and in use at the University of London Observatory at Mill Hill.
26. No record of the fate of the 4-inch transit instrument has yet been found, but Dr Roger Hutchins (Magdalene College, Oxford) has informed the author of a 4-inch lens in storage under the Clarendon Laboratory in Oxford, so perhaps part of this instrument has survived.
27. A.D Thackery (Radcliffe Observer). The Radcliffe Observatory 1772-1972. Oxford: The Radcliffe Trust. 1972.
28. Anonymous. Obituary - J.G.Barclay. *Monthly Notices of the Royal Astronomical Society*. 1898, 59, 218-219.
29. Sir Basil Phillott Blackett, K.C.B., K.C.S.I. (Marlborough College 1893-1900) was Controller of Finance at the Treasury after World War I, then served for five years in India as financial member of the Viceroy's Executive Council. On his return to Britain he became a Director of the Bank of England. He died in a motoring accident in Germany in August 1935. See his obituary in: Journal of the Royal Statistical Society. 1936, 98 (4), 775-777.

Note added in proof

As this paper was in its proof stages, information was found to confirm that the Barclay family held a total estate of about 100 acres (42 hectares) in the Leyton area, including Knotts Green House, Leyton House and Forest House. On an 1882 Ordnance Survey map, Essex Survey Sheet 073 Scale 1:10,560, is marked a rectangular building at the coordinates given by J.G.B. in Reference 18. See page 13 of this paper for J.G.B's text, and Figure 3 showing the location. It seems as if the observatory has, at last, been located.

Women in Astronomy: An Essay Review

Madeline Cox
Librarian, Society for the History of Astronomy

Interest in the history of women in astronomy has increased dramatically in the last 30 years. This interest has come from the growing number of professional scientists, historians and feminists researching the lives and work of earlier generations, as well as from amateur astronomers. It is reflected in the vast amount of literature on the subject, both in books and journals, and on the internet[1]. This Essay Review will focus on monographs published in the last 10 years (1996-2006), and will be restricted mainly to pre-20th century women. The scope includes researchers, translators, computers and astronomical assistants as well as observers. Where appropriate, it includes books that discuss the role of women scientists, as well as pure astronomy books. Part 2, to be published later, will consider encyclopaedias and large works of reference .

With the hindsight of history, we recognise that many women of the past overcame the social constraints of their day to acquire scientific knowledge, which enabled them to contribute to our understanding of the heavens. Their pioneering efforts were often made at great personal cost, required determination, courage and dogged commitment, and led to the eventual acceptance of the female astronomer and the admittance of women to higher education. By examining their lives in a wider social, scientific and economic context we are better able to appreciate their contributions and the obstacles they sometimes had to face – prejudice, ridicule, isolation, denial of a fulfilling personal life. For that reason, I have included in this Review books dealing with these wider issues.

One of the best known of all women astronomers is Caroline Herschel (1750-1848). She is best remembered as the devoted servant of, and amanuensis to, her brother, Sir William Herschel, the discoverer of Uranus, builder of giant telescopes, and the first natural historian of the heavens. But she also achieved fame in her own right as the discoverer of comets and nebulae. She received many awards in her later life.

Caroline's life has been well documented, most notably in *The Memoirs and Correspondence of Caroline Herschel*[2] (1879) and in *The Herschel Chronicle*[3], first published in 1933. The *Chronicle* was based on two autobiographies that Caroline wrote in the 1820s and 1840s, but it was condensed, and much useful material was omitted. Likewise, Caroline's autobiographies were never published in full and the historian Michael Hoskin has made good these omissions by two recent books, The *Herschel Partnership as seen by Caroline*[4] and *Caroline Herschel's Autobiographies*[5], both published in 2003. *The Herschel Partnership* is a narrative based on Caroline's diaries and her autobiographies, published in full for the first time.

The story of how William rescued his sister from a lifetime of domestic drudgery in their birthplace, Hanover, Germany, is well known. Bringing her over to Bath, England, William trained her to be his housekeeper, an opera singer and later, his astronomical assistant. In gratitude, Caroline devoted her life to William's well-being and career, and in the process became as famous as her brother. Her role as astronomical assistant included recording and reducing his observations, writing up his papers for publication and producing workable star catalogues from his thousands of observations. Her own discoveries were made mostly when William was away on business or after his marriage in 1788, on holiday.

What comes through very forcibly in Hoskin's works are Caroline's hard work, commitment, discipline, devotion to William (which we had always known about) and her loneliness and bitterness in old age (which perhaps was not so well known). Hoskin has done historians of astronomy a service by allowing them full access to the primary sources for the first time[6], and by his own measured reflections on Caroline's life.

Her life is also discussed in Patricia Fara's Book *Pandora's Breeches: Women, Science and Power in the Enlightenment*[7], which investigates the theme of partnership in science. The author is a

lecturer in the history and philosophy of science, and her thesis is that modern attempts to "rediscover" women can overstate their achievements and make them seem self-sacrificing martyrs. What we need, she says, are realistic historical models that also show the feminine side of their personalities.

Fara says that Caroline was rewarded not for her own discoveries, but as William's amanuensis. Only after William's death did she gain recognition for her own work. She accepts the claim that Caroline was the first female professional astronomer to be over-stated, but admits that she *was* indispensable in establishing William's career and reputation. She also contends that Caroline colluded in her down-trodden status: "I did only what a well-trained puppy dog would have done" [8], becoming in her old age a prickly, solitary woman. Fara further claims that Caroline damaged her psyche through self-renunciation and self-denial, and through her willingness to take on the most menial of tasks; for example, sieving manure during the construction of the giant telescopes. She wanted to be like other women, but also shunned their company, finding many of them vain and trivial.

Fara discusses the guild tradition in Germany. This allowed women access to certain types of work, and thus made them more visible than they were in other countries. Guild members were classed as artisans, which included those working at observatories. Fara claims that between 1650 and 1720, 14% of German astronomers were women. An example is Maria Eimmart Müller (1676-1707), who trained in her father's observatory in Nuremburg, then married her physics teacher, who inherited the observatory! [9]

Fara also considers another German female astronomer, Maria Winkelmann (1670-1720), who was interested in astronomy as a child. She married Gottfried Kirch, Germany's most famous astronomer of the time, who worked at the Preussiche Akademie der Wissenschaft, Berlin. She assisted him in the observatory in an unpaid capacity, and discovered a comet that he had missed. Following the practice of the time, her observations were written up in his name, though he later acknowledged his wife's discoveries.

Maria petitioned Akademie unsuccessfully for more funding for the observatory, and on the death of her husband she was forced to leave her home, and her work there. She moved to a private observatory, working as a master astronomer with two students whom she also trained. Her son, Christfried, inherited his father's post at the Academy – neither she nor her daughters were allowed academic posts. Kirch's life illustrates the difference between artisan and professional astronomers in Germany: she could work in partnership with a male astronomer at a private observatory, but could not be employed in a publicly financed post.

Fara's investigation also includes Elisabetha Hevelius (1647-1693), who worked with her husband Joannes (1611-1687) at his observatory in Danzig. Joannes described his wife as "… a diligent collaborator and a keen student of maths ..." and remarked that "… women are definitely just as well suited to observing as men." [10]. After visiting them, Edmund Halley said that their results could match any English observations of the day. There is a famous portrait of the two of them operating a large sextant: they were the last of the great naked-eye observers (Figure 1). After

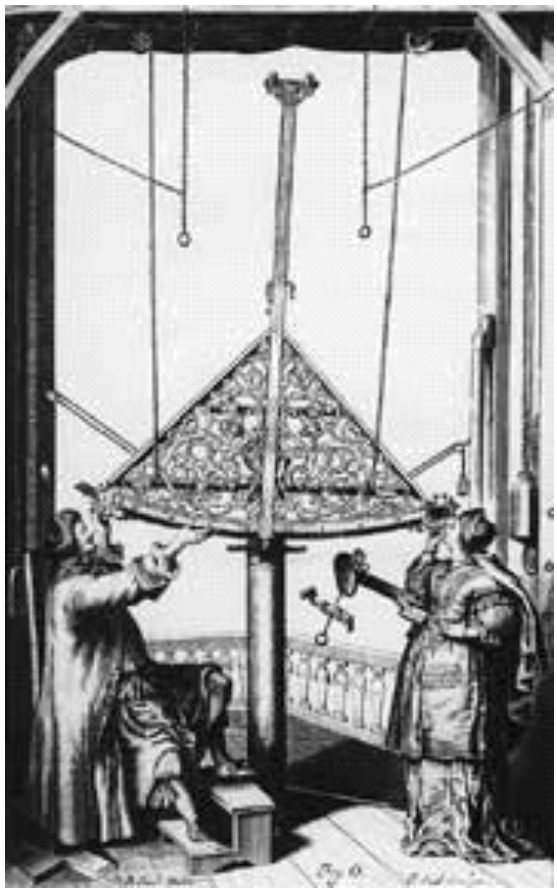


Figure 1

Johannes and Elisabetha Hevelius using their brass, 6-foot sextant

Image is from Hevelius. *Machinae Coelestis pars prior* Published in Danzig in 1673.

the death of Joannes, Elisabetha devoted her life to getting his work into print, including his unpublished observations, his star catalogue and his star atlas[11].

In emphasising Elisabetha's feminine side, Fara is at pains to point out her domestic duties. As the wife of a wealthy brewer (Joannes' money enabled him to carry out his astronomical work) she would be expected to spend a lot of time simply running the household, as well as seeing to the numerous visitors who made a way to their door as their fame as astronomers spread. Fara claims that by including these domestic details, she gives the reader a truer picture of Elisabetha's daily work, which in fact makes her scientific achievements all the more remarkable, as astronomy had to be squeezed in on top of all her other duties. Fara suggests that Elisabetha may have served as a rôle-model for Margaret Flamsteed (discussed later).

The German Maria Cunitz (1610-1664) was one of the few early women astronomers who was not the daughter or wife of an astronomer. She attempted to correct the orbital calculations of the planets in Kepler's Rudolphine Tables[12], and although she wrote under her maiden name, most people believed that it was her husband's work because she acknowledged his assistance in the Preface. However, in a later edition he added his own Preface stating that the work was hers alone. Because she was a serious astronomer, and also a woman, she was ridiculed in print for neglecting her household duties and spending most of the day in bed[13]. This myth of the female astronomer created by this bigotry unfortunately survived, and was believed, for many years.

Fara's approach allows us to see the women's work in a wider, albeit domestic, context. She is saying: we have discovered (or re-discovered) these women scientists, now let's have a closer look at their lives as a whole. We do not need to shout about them any more, we can therefore take a measured look at their achievements, which are even more remarkable when one considers all the other work they had to do in a day[14].

Another book about scientific partnerships, and relationships between men and women is *Women, Science and Medicine 1500-1700: Mothers and Sisters of the Royal Society,* edited by Lynette Hunter and Sarah Hutton[15]. It is a wide-ranging collection of essays, mainly by British lecturers in the humanities, for example, cultural history, rhetoric, Renaissance studies, the history of science and medicine, English and the history of astronomy and related sciences.

The editors discuss the social context of science and technology in England between the years 1500 and 1700, with particular reference to women. It was impossible for women to gain access to higher, institutional learning between the dissolution of the monasteries in the mid-17th century and their admission to universities, starting in the 1870s. The Royal Society was founded in 1661 to promote the new scientific method, but women were not admitted until 1941. Few records thus remain of women's involvement in scientific work between these dates; work that would have taken place by and large in the home. The home was the domain of both men and women before the Industrial Revolution, and women's skills would include not only the traditional ones of food preparation and cooking, making medicines and caring for the sick, but also those needed for the economic running of the household, for example, dyeing and simple bookkeeping.

Chapter two of *Women, Science and Medicine* discusses Caroline Herschel and Margaret Flamsteed as assistant astronomers within this context[16]. The authors suggest that Caroline Herschel combined the duties of guild apprentice and housekeeper and "… has received surprisingly cursory attention from recent historians." [17], which is patently not the case. Their summary of Caroline's life adds little not already well known, at least to historians of astronomy. Their conclusion is that Caroline never presented herself as anything other than William's assistant and housekeeper, an assessment with which we may concur. When showered with medals and honours in her old age she grudgingly remarked that they were of little use to her. As Fara also remarked, a lifetime of dedication to William, his career and his memory brought her neither happiness nor contentment.

In discussing the life of Margaret Flamsteed (1670-1730), the authors have drawn on information from her notebooks, preserved in the archives of the Royal Greenwich Observatory. These show that during the early years of her marriage, Margaret, wife of the first Astronomer Royal, John Flamsteed (1646-1719), studied mathematics and astronomy under his guidance. Topics she studied included geometry, axioms, optics, trigonometry, motion, gravity, Kepler's theories, solar parallax and tides. She helped her husband by copying his observations during the

day, but she also made her own observations of the Sun, Moon and Jupiter's satellites. This work would have been carried out in addition to her household and extensive public duties (the Royal Observatory was, after all, a state institution), looking after students and other visitors, and entertaining guests. She was renowned for her hospitality and cooking and was teased about her interest in mathematics and astronomy.

On the death of her husband in 1719, Margaret was forced to leave the Royal Observatory. She successfully contested the ownership of his instruments, which he himself had financed. She then challenged the Crown to stop further distribution of Halley's 1712 version of Flamsteed's *Historia Coelestis Britanniae* and won. She also oversaw and paid for, publication of her husband's work. She comes over as a formidable woman, who contributed much to establishing the Royal Observatory at Greenwich as one of the leading observatories of the day, and ensuring that John's work gained the recognition it deserved. The authors are to be congratulated on bringing Margaret Flamsteed's life and work to our attention.

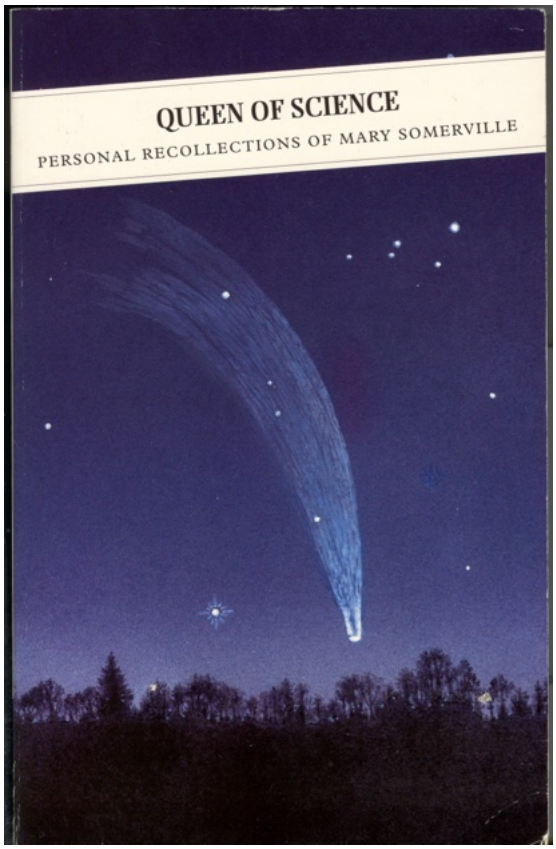


Figure 2
The reminiscences of Mary Somerville

Caroline Herschel and Mary Somerville (1780-1872), are often linked, as they were the first women to be given honorary membership of the Royal Astronomical Society (R.A.S.) in 1835. Mary's personal recollections were re-issued in 2001[18] (Figure 2). Allan Chapman has further rounded our view of her in *Mary Somerville and the world of science,* 2004[19]. This book puts Mary's work in the scientific, historical and social context of the late 18th and early-19th centuries.

Sommerville grew up in a loving, well-connected Scottish family and was able to move easily in intellectual circles. She showed interest in mathematics and astronomy from an early age, though she was largely self-taught in these subjects, and as a girl used to study in secret at night. Her second husband, Dr William Somerville (1770-1860), was supportive of her work in translating and writing scientific texts, though he took no direct part in it. At literary and scientific s*oirées* in London she met the most illustrious figures of her time; Sir John Herschel became her closest astronomical friend and advisor.

By the 18th century, the study of science by women had become desirable as an entry into polite society, so Somerville was hardly breaking new ground. But the books written for and by "ladies" tended to be populist, accessible and moralistic in tone[20], not at all like Somerville's intellectually demanding tomes. One of her most important works was an exposition and translation of Laplace's *Mècanique Céleste*[21], which she published in 1831 as *Mechanism of the Heavens*[22]. This was one of the most advanced works of celestial mechanics ever written, and became the first book written by a woman to be used as a university textbook. Another of her books, *The Connexion of the Physical Sciences*[23], a wider-ranging work, went through ten editions to 1877. It was concerned with the inter-relationship of quantifiable physical forces – gravity, light, sound, electricity and magnetism. In it she suggested using the perturbations in the orbit of Uranus to pinpoint the location of an unknown planet. This suggestion was taken up by John Couch Adams in his search for Neptune.

Whereas Caroline Herschel was patho-logically modest and saw herself only as William's assistant, Mary Somerville was happy to put her name to her work and be celebrated in her own right. She was also an intellectual, which Caroline was not. She comes over in this book as a much happier and fulfilled character at many levels,

following her own interests and desires as well as looking after her family. As a writer and not an observer, she is one of the women in astronomical history whose work was possible to do alone, not as half of a partnership with a man: it is impossible to imagine any woman observer being able to set up and run her own observatory, either alone or with a male assistant, under any circumstances, at any time in the past.

A surprising number of women in astronomy came from Ireland. One of the best known is Agnes Mary Clerke, who was born in the small town of Skibbereen, County Cork, in 1842. Not a practising astronomer herself, she was nevertheless responsible for bringing knowledge of the new fields of spectroscopy and astrophysics to a wider, public audience. A brilliant linguist, writer and researcher her *Popular History of Astronomy during the Nineteenth Century*[24] went through four editions between 1885 and 1904, and has recently been re-issued[25]. Her attention to detail gives her work undisputed authority, which is why it is still a major secondary source for historians of astronomy today. For example, there are more than 500 names in the index to her *History* alone. She also wrote *The System of the Stars*[26] in 1890*,* a biography of the Herschels[27] in 1895 and *Problems in Astrophysics*[28] in 1903.

Clerke's story is well told in Mary Brück's *Agnes Mary Clerke and the Rise of Astrophysics*[29]. A renowned astronomer of Irish birth herself, the author has meticulously researched Clerke's early life in Ireland. A banker by profession, her father was himself interested in astronomy and ran the local timekeeping service. He encouraged all his children in their interests, and educated them himself at home.

As young women, Clerke and her sister Ellen, spent ten years in Italy, where much of their time was taken up by reading in the libraries of Florence. On returning to Britain in 1877, the whole family settled in London, where they spent the rest of their lives. Clerke's first professional attempt at writing was for the *Edinburgh Review*, a leading academic publication at that time. Her first, unsigned, article about astronomy, was about Copernicus in Italy - a subject that she had researched whilst in Florence[30]. In an article published in 1880 she was concerned the chemistry of the stars[31]. The article received rave reviews. It brought her to the attention of Lady Margaret Lindsay Huggins (1848-1915), a leading spectroscopist of the day, and the two became firm and lasting friends. Clerke also corresponded and met some of the leading contemporary figures in astronomy, for example, Sir Norman Lockyer, Edward Holden, George Ellery Hale and Edward Pickering. They supplied her with the latest information on observations and theory, and photographs for her books and many articles; in return she publicised their latest discoveries. Clerke also wrote numerous entries for the *Encyclopaedia Britannica,* which were considered to be so accurate and thorough that they were published without alteration through several editions.

Brück's book highlights how dependent women were on the encouragement and support of their families if they were to progress in science. Lack of access to higher education and professional careers meant that a private income was necessary for them to carry out their researches. Independence of spirit and sheer doggedness were also necessary attributes; Clerke had both in great measure, as her health was always delicate.

Clerke is also one of the subjects of Susan McKenna-Lawlor's W*hatever Shines Should be Observed. [Quicquod nitet notandum]*[32]. The author, herself Irish, is a well-known astronomer who in this book celebrates the achievements of five distinguished Irish women of the past. Besides Agnes Clerke there is her sister Ellen; Mary, Countess of Rosse; The Honourable Mary Ward, and Lady Huggins. Ellen Clerke was, first and foremost, a poet, but she also wrote on scientific and literary topics[33]. The other four were primarily interested in the sciences.

The author makes the point that even though all five women were born to aristocratic or professional families with a passion for learning and access to books and instruments at home, it still required determination to acquire the necessary technical and scientific knowledge to carry out observations, experiments and research without formal training. "To achieve recognition was a pioneering activity without discernible ground rules." as the author says in her preface[34].

Mary, Countess of Rosse, (1813-1885) was born in Yorkshire. She married William Parsons, later 3rd Earl of Rosse, in 1836. They lived at Birr Castle, where the Countess helped to finance and design the six-foot mirror for the telescope known as the 'Leviathan of Parsonstown'. She took an interest in technical aspects of the project, though she was not herself an observer. She corresponded with William Fox Talbot, and was an early pioneer

Figure 3

The Honourable Mary Ward
cousin of the 3rd Earl of Rosse

in photography. The re-equipped dark room at Birr Castle is the oldest extant, and the Countess herself worked with its chemicals, as she helped the Earl to photograph the Moon when he was trialling the Daguerreotype and collodion processes.

The Honourable Mary Ward (1827-1869) (Figure 3), a cousin of the 3rd Earl of Rosse, had a penchant for natural history and microscopy. She produced excellent drawings of scientific instruments, which attracted the attention of both Sir James South (1785-1867) and Sir David Brewster (1781-1868). The latter used her illustrations in his own publications. In return, he supplied her with science books – as a woman she had no access to libraries or to universities. Her drawings of the 'Leviathan' were used during its recent r extensive refurbishment, because the original engineering drawings for the project have never been found.

Ward was also interested in observational astronomy, and in 1859 produced a book entitled *Telescope Teachings: An Observing Guide for Novice Observers; The Function of Maps, Tables, and Almanacs and What to See in the Night Sky*[35]. She included her own drawings of sunspots and how to observe them. In 1858 she kept a diary for several weeks tracking the path of Donati's comet (Figure 4). Her detailed drawings, showing its

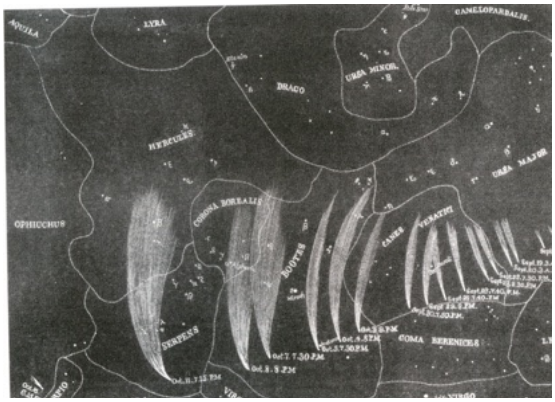


Figure 4

An illustration by the Honourable Mary Ward

This drawing shows the path of Donati's comet as seen from Earth. It was published on page 12 of Ward's 1859 book *Telescope Teachings* (Reference 35)

ever-changing appearance, are in McKenna-Lawlor's book. She was one of only a few women allowed to visit the Royal Observatory, Greenwich. Tragically, she died at the early age of 42, after an accident at Birr Castle involving a steam road locomotive, just two years after the 3rd Earl. McKenna-Lawlor calls Mary Ward "… a courageous and brilliant lady ..." [36], and the authors admiration of her clearly shines through.

The chapter on Agnes Clerke in McKenna-Lawlor's book confirms Brück's findings that she too had enjoyed the support of a cultured, loving family. Her decision by the age of 15 to write a history of astronomy was aided by her outstanding ability as an linguist (she could speak all the major European languages, as well as Latin and Greek). This allowed her to consult many of her sources in their original languages, which gave her work enormous authority, as did her collaboration with many of the leading astronomers of the day. She won high praise from Sir Robert Ball, and from Lady Huggins, who became a close friend and whose work she publicised in her book *Problems in Astrophysics*[37]. In this book, Clerke criticised the directors of some of the leading observatories for not pursuing, what she considered to be, useful lines of enquiry in spectroscopy. One critic replied that she was obviously not familiar with the constraints and complexities of observing schedules[38]. However, all recognised the underlying truth of what she was saying.

Clerke was one of the first members of the British Astronomical Association (B.A.A.), who from its inception in 1890 admitted women to membership. The B.A.A. thus gave women in astronomy a voice for the first time, and they made

good use of it. For further details see Chapter 14 of Chapman's *The Victorian Amateur Astronomer*[39]. These developments will also be discussed in more detail in Part 2 of this Essay Review. Women were not allowed full membership of the R.A.S. until 1916, when amateurs and professionals alike were admitted. This was a few years after Clerke's death, but she had been made an honorary member in 1903 and regularly attended its meetings, although only as an observer.

By far the longest chapter in McKenna-Lawlor's book is devoted to Lady Huggins. As Margaret Lindsay Murray she was born in Dublin, to a solicitor at King's Inns. She was educated at home and later in Brighton. Despite the lack of a formal education in science, she was inspired by her Scottish grandfather to take an interest in astronomy. Her early reading included Sir John Herschel's O*utlines of Astronomy*[40] and the work of Dionysius Lardner[41]. As a girl she studied sunspots and carried out simple experiments in photography. She was excited by the discoveries in the new field of spectroscopy and met William Huggins, a pioneer in the field. The two subsequently fell in love and married in 1875. They settled at Tulse Hill in south London, where William had his own observatory furnished with instruments on loan from the Royal Society. Margaret became his sole collaborator, both in the laboratory and in the observatory, where visual and photographic spectroscopy took place. In the laboratory, Margaret attended to the batteries and mixed chemicals, pioneering the use of dry gelatine photographic plates.

William and Margaret Huggins were the first to identify the Balmer series of hydrogen lines in the spectrum of the star Vega, and to examine the spectrographs of nebulae. The green line they discovered could not be identified with any terrestrial element, and caused much controversy. They also discovered the violet line in the M42, the Great Nebula in Orion, and Margaret's name was given as joint author in a paper on the subject in the *Proceedings of the Royal Society*[42]. McKenna-Lawlor claims this was the end of Margaret's assistantship and the beginning of her partnership with her husband as an equal. They published fourteen papers in their joint names.

However, Margaret also wrote many articles in her own name, including one describing the use of the astrolabe[43]. She also studied archaeoastronomy. In 1892 she was awarded the Actonian Prize of the Royal Institution of Great Britain. She was active in women's education, and corresponded extensively with Sarah Whitney at Wellesley College, Massachusetts, to whom she bequeathed a large portion of her papers. In 1903 she was made an honorary member of the R.A.S.

In 1897 William was knighted, and unusually, Margaret was mentioned in his citation as his gifted collaborator[44]. Sir William was President of the Royal Society from 1900 to 1905, as a result of which Lady Huggins had to shoulder much of the burden of those years (he was now in his 80s). She also edited his work after he retired in 1907. After his death in 1910, Lady Huggins began to write a sketch of Sir William's life, but she never completed it. Other undertook that task, and it was published privately in 1936[45].

There is an extraordinarily long piece in McKenna-Lawlor's book concerning Lady Huggins's dispute with Professor Hugh Frank Newall (1857-1944) of Cambridge University. The dispute concerned two matters: the interpretation of the green line in the spectrum of certain nebulae (which Sir William had suggested might be nitrogen); and whether Sir William had been assisted by James Clerk Maxwell (1831-1879) in developing his "line of sight" method for calculating relative velocities of stellar objects. Her dispute with Newall was prolonged and fought passionately, though eventually it was settled.

All Sir William's instruments were sent to Cambridge University, where they were housed in a specially dedicated "Huggins Dome". Lady Huggins was zealous in defending her late husband's reputation, and in preserving his memory, much as Caroline Herschel, Elisabetha Hevelius and Margaret Flamsteed had done previously for their men-folk. Nevertheless, theirs is one of the few equal partnerships between a man and a woman in astronomy, and it was recognised as such by the scientific community at the time. The book has an extensive bibliography and two appendices listing Margaret and William's joint papers and the contents of her notebooks, which were bequeathed to Wellesley College.

The author of *Whatever shines should be observed* is in no doubt as to the contribution made by her female subjects to the advancement of women's education:

> "… they contributed within society to a gradual erosion of those barriers raised against the participation of women in academic life …" [46]

These, and other pioneering women, had shown that they were capable of producing work of the

highest quality, and gradually it became acceptable for women to attend university and obtain degrees. Oxford and Cambridge Universities opened their doors to women in 1868, and the University of Ireland in 1879.

McKenna-Lawlor's book is a very readable account of the lives of the four women, though it is rather extravagant in tone. For example, the author claims that Ward was one of only three women to receive the *Monthly Notices of the Royal Astronomical Society*, but it seems that copies were simply given to her by Sir William Rowan Hamilton (1805-1865). She also implies that Ward was the only woman allowed to visit the Royal Observatory at this time. In fact, Maria Mitchell had done so in 1856, as had Maria Edgeworth and William Henry Smyth's daughter.[47]

A further treatment of Lady Huggins is to be found in Ian Glass's book *Revolutionaries of the Cosmos: the Astro-Physicists,* published in 2006[48]. This book examines in detail the lives and achievements of eight well-known scientists in the field of physical astronomy, and includes a chapter on Sir William Huggins. Within this there is an account of Margaret's contribution to the rise of spectroscopy – "… an able and enthusiastic assistant." William called her on the occasion of their marriage[49]. Glass covers much the same ground as McKenna-Lawlor, including Margaret's background and early interest in astronomy, the M42 "nebulium" mystery, her experiments with photographic processes, their joint work on the *Atlas of Representative Stellar Spectra*[50]*,* and their investigations into the spectra of radioactive elements. Glass also quotes Margaret's views on the status of contemporary women scientists:

> " I find that men welcome women scientists provided they have the proper knowledge. It is absurd to suppose that anyone can have useful knowledge of any subject without a great deal of study. When women have really taken the pains thoroughly to fit themselves to assist or to do original work, scientific men are willing to treat them as equals. It is a matter of sufficient knowledge. That there is any wish to throw hindrances in the way of women who wish to pursue science I do not for a moment believe." [51]

After Sir William's death, the Royal Society granted Lady Huggins an annual pension of £100 for her services to science as Sir William's assistant. She wrote that she had not sought this, but accepted it as an honour to her dead husband, and felt she had really earned it during her 35 years of very hard work[52].

This statement was taken as a starting point for a deeper analysis of Margaret's contribution to Williams's work by Barbara Becker, an American historian of science. In a 1991 book entitled *Creative Couples in the Sciences*[53] Becker maintains that they carefully cultivated the image of the ideal Victorian couple – the man as intellectual and inventor, the woman as assistant and organiser. But she maintains that this image disguised the real extent of Margaret's involvement in William's research - she actually drove the agenda in many ways, so should be called a collaborator, not an able assistant. Her evidence for this view comes from an examination of William's and Margaret's notebooks held at Wellesley College[54]. For example, photography appears as a method of recording spectroscopic data only after their marriage in 1875, obviously driven by Margaret's expertise, knowledge and experimentation in this field. It was she also who first recorded in the notebooks a desire to photograph the spectrum of a nebula, a fiendishly difficult and painstaking procedure to undertake. She was confident by 1887 that she would be able to interpret any results obtained, and between them, they eventually did manage to obtain such a result with M42, which was the subject of their first joint paper in 1889, in which William wrote:

> " I have added the name of Mrs Huggins to the title of the paper, because she has not only assisted generally in the work, but has repeated independently the delicate observations made by the eye." [65]

Their care over the results was later vindicated, as it was proven that the line in the spectrum of M42 did not correspond to the magnesium or any other line known at the time, exactly as they had said.

Becker has delved deeply into the Huggins's working relationship to make her point about their equal partnership. She places their work within a historical context and offers useful insights into how scientific methodology and research methods have evolved.

In the United States, the first employment as we know it - regular wages in return for work - open to women first appeared in astronomy in the 1840s, with so-called 'women computers'. Computing was thought to be well suited to the temperament and abilities of women because it was lowly, routine and repetitive, such as card punching and error checking. Women computers were employed by the United States Nautical Almanac Office from its inception in 1849. Their work is

Figure 5
Maria Mitchell
at the Vassar College Observatory
Mitchell is the figure on the extreme left looking directly at the camera.

analysed in *The Contributions of Women to the Nautical Almanac Office, The First 150 Years* by Merri Sue Carter, Phyllis Cook and Brian Luzum[56], after analysing Almanac Office records.

The first women computers were highly educated, outstanding in their field, and often considered mathematical prodigies. Some were piece-workers, working from home, but most were regular staff of the Almanac Office. As the nature of the work evolved, almanac production became more automated, and more women were hired. Their number peaked in 1963, since when it has declined. In 1999, at the time of its 150th anniversary, only four women were employed.

The first woman computer was the well-known Maria Mitchell (Figure 5), born in 1818 in Nantucket. Her father kept a telescope on the roof of his house and encouraged Maria to use it. In 1847 she discovered a comet, which caused a sensation. For this discovery she received a Gold Medal from the King of Denmark. In 1849 she was appointed as a computer for the *American Ephemeris & Nautical Almanac*. Working from home, she received and sent her assignments by mail. Her work involved computations chiefly of the planet Venus, work which she carried out for 20 years. In 1865 she became Professor of Astronomy and Director of Vassar College Observatory in New York state, where she conducted research on the Sun and Jupiter, as well as carrying out astrophotography and recording solar eclipses.

The second woman computer was Mrs Elizabeth Brown Preston Davis (1863-1917), who worked at the Almanac Office from 1893 to 1894. Her work involved assisting in the preparation of the tables of the Sun and planets computed by Professor Simon Newcomb (1835-1909), whose former employee she was. She had undertaken post-graduate-level mathematical work, but was not allowed to receive a degree. She was married with four daughters, and was a member of the American Mathematical Society. She is listed as both assistant and pieceworker in the annual reports of the Nautical Almanac Office. Other work she did included computing comet orbits, proof-reading textbooks and writing magazine articles on mathematics. In an article highlighting her achievements[57] we read the following:

> " She competed with a number of men mathematicians for a high place in the Nautical Almanac Office and routed them all in three hours. In two more she had solved all the difficult problems of higher mathematics and astronomy submitted to her, was pronounced by the enthusiastic examiners 100-100, more than perfect and got the place."

This, then, was the calibre of women employed as lowly computers on derisory wages.

The first woman employee to be listed as "assistant astronomer" rather than "computer" was Catherine de Mille Lewis in 1923, who became "Junior Astronomer" in 1924. She worked at the Nautical Almanac Office from 1919 to 1927.

Mrs Isabel Martin Lewis (Figure 6) became in the 1933 the first woman to be given the prestigious title of "Astronomer" in the Nautical Almanac Office. She published three books on astronomy: *Splendors of the Sky*[58], *Astronomy for Young Folks*[59] and *A Handbook of Solar Eclipses*[60]. The last book focused on phenomena that accompany solar eclipses, and it is considered a valuable source book today. She was a member of eclipse expeditions to Russia and Peru, and organised her own expedition to Honeylake California in 1930 for a totality lasting only 1.5 seconds! The path of the eclipse was only $^{5}/_{8}$ mile wide. It was the difficulty of tracking and recording the event attracted her, to test the accuracy of the data supplied by the Nautical Almanac Office. She was a member of many professional astronomical societies. She died in 1966.

Another woman who started her career at the Nautical Almanac Office was Helen Wright (born 1914), a Vassar College graduate, who became a Junior Astronomer in 1942. She also

Figure 6
Mrs Isabel Martin Lewis

wrote 25 books, including *Sweeper in the Sky: The Life of Maria Mitchell*[61] and *Explorer of the Universe: A Biography of George Ellery Hale*[62]. Her *Sweeper in the Sky* has been re-issued[63]. It is a very readable account of Maria's life, vividly evoking the early 19th century Nantucket whaling community, and stressing the importance of navigational astronomy to its economy. It further illustrates the beginnings of higher education for women in the United States: Mitchell was the first female professor of astronomy anywhere in modern times, and was a tireless campaigner for women's education.

A complete list of all women known to have worked , or contributed to publications of the Nautical Almanac Office, is appended to this very important paper. I particularly welcomed the inclusion of photographs of many of these largely unknown women. The article highlights the low status that women employees were at first given (even though some produced outstanding work) and goes on to show how throughout the 20th century they gradually climbed the professional ladder. The first woman supervisor of the Office was Berenice Morrison, in 1971.

A very similar story is illustrated by the careers of the women computers at the Harvard College Observatory, under the directorship of Edward Charles Pickering (1846-1919). Henrietta Swann Leavitt (1868-1921) worked at Harvard

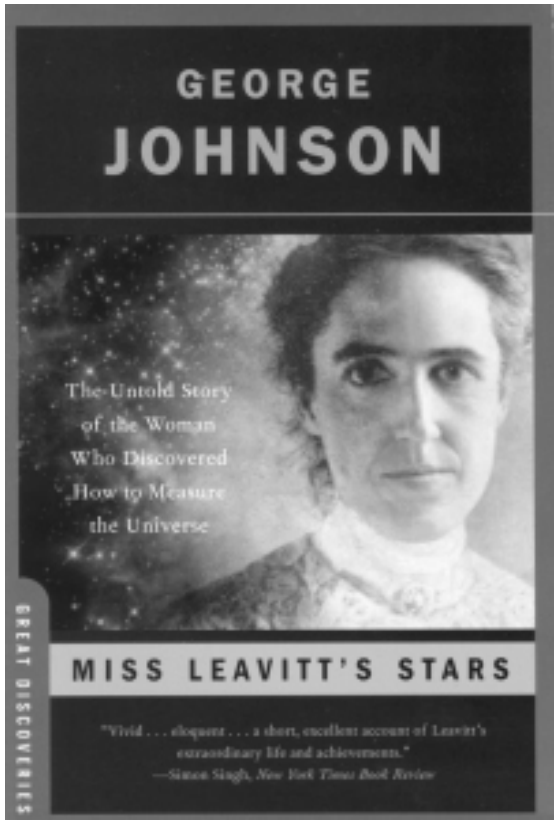


Figure 7
Henrietta Swann Leavitt (1868-1921)

intermittently from 1893 until her early death. She is famous for her discovery of the Cepheid period-luminosity law, which gave astronomers a standard candle to measure distances beyond the Milky Way. A short biography of her, entitled *Miss Leavitt's Stars: The Untold Story Of The Woman Who Discovered How To Measure The Universe*[64] (Figure 7) appeared in 2005.

It was written by the *New York Times* science writer George Johnson. He has attempted to place Leavitt in the context of discoveries about distances in the universe from the early days of the Observatory to the present. The so-called Great Debate of the 1920s is particularly well treated. Aimed at the non-specialist, it explains very clearly the methods used to calibrate distance scales. It also highlights progress that women were slowly making in higher education: Leavitt attended Radcliff College. Astronomy was one of the subjects she studied.

In the British Isles, the Royal Observatory was the first institution to employ women, in 1891, under the directorship of William Henry Mahoney Christie (1845-1922). These women also worked as computers. They were exceptionally gifted, and

were paid derisory wages for their troubles. Observatories at Cambridge, Oxford and Edinburgh followed suit. Further details will be discussed in the second part of this Review.

Several conclusions can be drawn from the lives of the women mentioned here. The majority were born into comfortable middle or higher-middle class families with independent means but who still had struggle to gain access to scientific books and periodicals, and to learn how to operate equipment. Most showed an interest in astronomy an early age, and were lucky to have the encouragement of a father, brother or husband. Some 'married into the job' and became competent assistants; a few managed to follow their own interests unaided. Observers had a harder time than translators or expositors because of the complexity of their operations, requiring equipment, staff and acquired skills. Doggedness, courage and persistence were necessary for them to gain acceptance and recognition, not always in their own lifetime. But all of them in some way led to today's professional women, and to the availability of higher education to all. It is a salutary, uplifting and inspiring experience to read about their lives.

Acknowledgements

The author gratefully acknowledges the assistance of the following in her research: Dr Mary Brück, Mark Hurn, Les Jepson, Kevin Johnson, Karen Moran, Dr Reg Withey, the staff at Warsop Public Library and at King's Mill Hospital Library.

Notes and References

1. See *Women in Astronomy: A Comprehensive Bibliography.* Compiled by Ruth S. Freitag Science Reference Services Library of Congress (Science Reference Services) at http://www.loc.gov/rr/scitech/womenastro/womenastro-intro.html
2. Mrs John Herschel. *Memoir and Correspondence of Caroline Herschel*. London: John Murray. 2nd edition 1879.
3. Constance Lubbock. *The Herschel Chronicle: The Life-story of William Herschel and his Sister Caroline Herschel.* Cambridge: Cambridge University Press. 1933. This was re-printed by the William Herschel Society in 1997.
4. Michael Hoskin. *The Herschel Partnership as viewed by Caroline*. Cambridge: Science History Publications. 2003. For a review of this book see: *The Antiquarian Astronomer: Journal of the History of Astronomy.* Number 1. 2004. Page 53.
5. Michael Hoskin (Editor). *Caroline Herschel's Autobiographies*. Cambridge: Science History Publications. 2003.
6. The prime collection of manuscripts relating to the Herschels is held by the Royal Astronomical Society, London. It was listed by J.A. Bennett in: *Memoirs of the Royal Astronomical Society*. LXXXXV, 1978. These papers have been microfilmed in 24 reels and are available for purchase. The work of William Herschel were published in : J.L.E. Dryer (Editor). *The Scientific Papers of Sir William Herschel*. London: Royal Society and Royal Astronomical Society. 1912.
7. Patricia Fara. *Pandora's Breeches: Women, Science and Power in the Enlightenment.* London: Pimlico. 2004
8. Quoted in Hoskin, *The Herschel Partnership*. Reference 4. Page 152 .
9. Fara. *Pandora's Breeches*. Reference 7. Page 140.
10. Fara. *Pandora's Breeches*. Reference 7. Page 137.
11. These were first published in Gdansk in 1690.
12. Maria Cunitz. *Urania Propitia, sive Tabulae Astronomica mirè faciles, vim hypothesium phsicarum a Kepplero proditarum complexae; Fcillimo Calculandi Compendio, Sine Ulla Logarithmorum Mentione, Phenomenis Satisfacientes*. Olsnae Silesiorum. 1650.
13. The myth concerning Cunitz was begun by a German pastor called Johann Eberti in his *Open Cabinet of Learned Women*, published in 1706. He wrote: "She was so deeply engaged in astronomical speculation that she neglected her household. The daylight hours she spent, for the most part, in bed because she had tired herself from watching the stars at night." Quoted in Fara. *Pandora's Breeches*. Reference 7. Page 144. This falsehood was re-gurgitated by other writers for many years, because it confirmed their opinion that being an astronomer was incompatible with a wife's domestic duties.
14. A pioneering work of the 1980s that attempted to rediscover female scientists was Margaret Alic's *Hypatia's Heritage*. London: Women's Press. 1986. Her Introduction says, Page 3: "We have to recognise the existence of their work before its significance can be fairly assessed."
15. Lynette Hutton and Sarah Hutton. *Women, Science and Medicine 1500-1700: Mothers and Sisters of the Royal Society*. Strand: Sutton Publishing. 1997.
16. Rob Iliffe and Frances Willmoth. Astronomy and the Domestic Sphere: Margaret Flamsteed and Caroline Herschel as Assistant Astronomers. In: Hutton and Hutton. *Women, Science and Medicine.* Reference 15. Pages 235-265. Caroline Herschel's lifetime (1750-1848) does not actually fall within the dates of the book's remit, 1500-1700.
17. Iliffe and Willmoth, In: Hutton and Hutton. *Women, Science and Medicine.* Reference 15. Page 257.
18. Dorothy McMillan, Editor. *Queen of Science: Personal Recollections of Mary Somerville*. Edinburgh: Canongate Classics. 2001.
19. Allan Chapman. *Mary Somerville and the World of Science*. London: Canopus Publishing. 2004. For a review of this book see Society for the History of Astronomy, *Newsletter*. Issue 6. March 2005.
20. For example Jêrome De Lalande's *Astronomie Des Dames.* 1795; and Margaret Bryan's *A Compendium System Of Astronomy In A Course Of Familiar Lectures.* 1797.
21. Pierre Simon, Marquis de Laplace. *Traité de Mécanique Céleste.* 5 volumes. Paris: Bachelier. 1799-1825.
22. Mary Somerville. *The Mechanism of the Heavens*. London: John Murray. 1831.
23. Mary Somerville. *On The Connexion of the Physical Sciences*. London: John Murray. 1834.
24. Agnes Mary Clerke. *A Popular History of Astronomy during the Nineteenth Century*. Edinburgh: Adam and Charles Black. 1885.
25. Agnes Mary Clerke. *A Popular History of Astronomy*

during the Nineteenth Century. 4th Edition. Reprinted by Decorah. Io: Sattre Press. 2003.

26. Agnes Mary Clerke. *The System of the Stars*. Edinburgh: Adam and Charles Black. 1890.
27. Agnes Mary Clerke. *The Herschels and Modern Astronomy*. London: Cassell and Co. Ltd. 1895.
28. Agnes Mary Clerke. *Problems in Astrophysics*. London: A. & C. Black. 1903.
29. Mary Brück. *Agnes Mary Clerke and the Rise of Astrophysics*. Cambridge: Cambridge University Press. 2002. For a review of this book see Society for the History of Astronomy, *Newsletter*. Issue 6. March 2005.
30. Agnes Mary Clerke. Copernicus in Italy. *Edinburgh Review*. July 1877, 146, 102-118.
31. Agnes Mary Clerke. The Chemistry of the Stars. *Edinburgh Review*. October 1880, 152, 408-443. This article was published anonymously
32. Susan M. P. McKenna-Lawlor. *Whatever Shines Should Be Observed [Quicquid Nitet Notandum]*. London: Kluwer. 2nd Edition. 2003. Astrophysics and Space Science Library, Volume 292.
33. Ellen's life and career is perfunctorily treated in this book. For a better assessment see Brück. *Agnes Mary Clerke and the Rise of Astrophysics*. Reference 29.
34. McKenna-Lawlor. *Whatever Shines*. Reference 32. Page xix.
35. Mary Ward. *Telescope Teachings: An Observing Guide for Novice Observers; the Function of Maps, Tables, Almanacs and What to See In the Night Sky*. London: Groombridge & Sons. 1859.
36. McKenna-Lawlor. *Whatever Shines*. Reference 32. Page 50.
37. Clerke. *Problems in Astrophysics.* Reference 28.
38. Richard Gregory, a science writer for *Nature*, was Clerke's only hurtful critic.
39. Allan Chapman. *The Victorian Amateur Astronomer: Independent Astronomical Research in Britain 1820-1920.* Chichester: John Wiley & Sons. 1998. (Wiley-Praxis Series in Astronomy and Astrophysics). Chapter 14: Now Ladies As Well As Gentlemen.
40. John Frederick William Herschel. *Outlines of Astronomy*. London: Longmans, Brown, Green & Longman. 1849.
41. For example, Lardner's *Cabinet Cyclopaedia*, which ran to 133 volumes between 1830 and 1851.
42. William Huggins and Mrs Huggins. On the Spectrum, Visible and Photographic, of the Great Nebula in Orion. *Proceedings of the Royal Society*. 1889, 46, 40-60.
43. Margaret Huggins. The Astrolabe. *Astronomy and Astrophysics*. 1894, 18, 793-801.
44. McKenna-Lawlor. *Whatever Shines*. Reference 32. Page 96.
45. John Montefiore. *A Sketch of the life of Sir William Huggins* (begun by J. Montefiore from material collected by Lady Huggins, and completed by Charles E. Mills and C.F. Brooke). Richmond, Surrey: "Times" Printing Works. 1936.
46. McKenna-Lawlor. *Whatever Shines*. Reference 32.
47. I am indebted to Dr Mary Brück for this information.
48. Ian S Glass. *Revolutionaries of the Cosmos: The Astrophysicists*. Oxford: Oxford University Press. 2006. For a review of this book see Society for the History of Astronomy, *Newsletter.* Issue 11. July 2006.
49. Glass. *Revolutionaries of the Cosmos*. Reference 48. Page 138. The debate as to whether Margaret Huggins was simply an assistant or a true collaborator is dealt with by Barbara Becker. See Reference 53.
50. Sir William Huggins and Lady Huggins. *An Atlas of Representative Stellar Spectr*a. London: William Wellesley and Son, and Hazel Watson and Viney. 1899. (Publications of Sir William Huggins' Observatory. Volume 1.)
51. Glass. *Revolutionaries of the Cosmos*. Page 147.
52. Larmor correspondence, Royal Society. Quoted by McKenna-Lawlor. *Whatever Shines*. Reference 32. Page 105.
53. Barbara Becker. Dispelling the Myth of the Able Assistant: Margaret Huggins and the Work of Tulse Hill Observatory In: Helena M. Pycior, Nancy G. Slack and Pnina G. Abir-Am. *Creative Couples in the Sciences.* Brunswick, New Jersey: Rutgers University Press. 1996. Pages 98-111. A version of this can be found at http://eee.uci.edu/clients/bjbecker/ExploringtheCosmos/week7b.html. Accessed September 2006.
54. Observatory Notebooks of William and Margaret Huggins. Whitney Observatory Library, Wellesley College, Wellesley, Massachusetts, United States of America.
55. William Huggins and Mrs Huggins. On the Spectrum, Visible and Photographic, of the Great Nebula in Orion. *Proceedings of the Royal Society*. 1889, 46, 40-60. Pages 48-49.
56. Merri Sue Carter, Phyllis Cook and Brian Luzum. *The Contributions of Women to the Nautical Almanac Office, The First 150 Years*. In: Alan D. Fiala and Steven J. Dick (Editors). *Sesquicentennial Symposium Proceedings*. Washington, D.C.: United States Nautical Almanac Office. 1999. Pages 165-177.
57. A Woman of Pluck – The Mathematical Ability of Mrs Davis and Her Struggle for a Degree. Date Unknown, John Hopkins Special Collections. Quoted in: Fiala and Dick. *Sesquicentennial Symposium Proceedings*. Reference 58. Page 168.
58. Isabel Martin Lewis. *Splendors of the Sky*. New York: Duffield & Co. 1919 .
59. Isabel Martin Lewis. *Astronomy for Young Folks*. New York: Duffield & Co. 1922.
60. Isabel Martin Lewis. *A Hand Book Of Solar Eclipses.* New York: Duffield & Co, 1924.
61. Helen Wright. *Sweeper in the Sky: The Life of Maria Mitchell*. New York: Macmillan. 1949.
62. Helen Wright. *Explorer of the Universe: A Biography of George Ellery Hale*. New York: E. P. Dutton & Co. 1924.
63. Helen Wright. *Sweeper in the Sky: The Life of Maria Mitchell.* Commemorative Edition. New York: College Avenue Press. 1997. Contains newly discovered photographs taken by Maria Mitchell.
64. Johnson, George. *Miss Leavitt's Stars: The Untold Story of the Woman Who Discovered How to Measure the Universe*. New York: Norton Atlas Books. 2005.

Samuel Foster and His Circle

Mike Frost
Past-Chairman, Coventry and Warwickshire Astronomical Society

Samuel Foster (c.1600-1652) was one of England's first observational astronomers. He was born in the Midlands (there is evidence for Coventry and Northampton) and like his contemporary and correspondent, Jeremiah Horrocks, was educated at Emmanuel College Cambridge. Foster taught in Coventry before briefly taking up the post of Gresham Professor of Astronomy in London in 1636. After relinquishing the post he returned to Coventry, where he produced his seminal work on sundials, *The Art of Dialling*. He also began a series of astronomical observations, in conjunction with John Twysden, John Palmer, and possibly Walter Foster, his brother, and Nathaniel Nye of Birmingham. In 1641 he returned to the professorship of Gresham College, where he remained until his death. He was part of a group that met regularly at the college for discussions; the nucleus of this group went on to found the Royal Society.

The first half of the 17th century saw a blooming of astronomy in England. The theories of Copernicus and Kepler, and the telescopic observations of Galileo and others were beginning to circulate. The first telescopes appeared, and there was a thriving industry in the production of instruments such as quadrants, sectors and cross-staffs, which could be adapted for astronomical use[1]. The first English professorships of astronomy, at Gresham College, London and at Oxford, date from 1598 and 1619 respectively. The blossoming of the scientific method in England, exemplified by the establishment of the Royal Society, was still in the future, but a number of individuals were beginning to undertake systematic programmes of observation.

The most famous of these individuals was Jeremiah Horrocks (c.1618-1642). Horrocks is best known for his prediction of, and then observation of, the transit of Venus on 24 November 1639, although this discovery was a result of several years of careful observation and refinement of existing tables. Horrocks was in correspondence with William Crabtree, who also observed the transit, and with other astronomers from the north of England, such as William Gascoigne, the inventor of the micrometer[2].

It is less well known that around this time there was another group of astronomers, observing from the English Midlands. This group was centred around Samuel Foster, Professor of Astronomy at Gresham College in 1636, and from 1641-52. Other members of the group included John Twysden and John Palmer. Walter Foster, Samuel's brother, was also involved, and possibly Nathaniel Nye of Birmingham.

When I discovered that Samuel Foster had connections to both Coventry and Cambridge, I realised that I could use my local knowledge of these two cities to find out more about him.

Birthplace and family history

The family history of Samuel Foster is threadbare and the sources contradictory. The closest we have to a contemporary biography is from Aubrey's *Brief Lives*, published in 1680. John Aubrey was born in Wiltshire, studied Stonehenge (giving his name to the feature called "The Aubrey Holes") and then moved to Oxford, where he became an antiquarian and compiled a wonderfully idiosyncratic, eclectic and entertaining series of potted biographies. Aubrey's life of Foster is one of the briefest. In full it reads:

> "From Mr Beyes, the watchmaker, his nephew: Mr Samuel Foster was born at Coventry (as I take it); he was sometime usher of the school there. Was professor at Gresham College, London: where in his lodging, on the wall, in his chamber, is, of his own hand drawing, the best sundial I do verily believe in the whole world. Among other things it shows you what o'clock 'tis at Jerusalem, Gran-Cairo etc. It is drawn very skilfully." [3]

The biography indicates the field in which Samuel Foster was most famous – the design and mathematical development of sundials. Aubrey's biography would seem to be definitive on Foster's birthplace, were it not for the "*as I take it*", a typically woolly addition. Unfortunately, the next biography to be published contradicts Aubrey. John

Ward's *Lives of the Professors of Gresham College*, published in 1740, has a longer account, which begins:

> "Samuel Foster was born in Northamptonshire, and admitted a sizar at Emmanuel college in Cambridge on 23 of April 1616, where he took the degree of batchelor of arts in the year 1619, and that of master in 1623. The following year he published his treatise, called "The Use of the Quadrant". He never had a fellowship, and is therefore placed by Mr. Fuller among the learned writers of the college, who were not fellows (Fuller, History of the University of Cambridge, p. 147)".[4]

I have attempted to find out which of the two suggested birthplaces is the correct one. I wrote to both the Northamptonshire and the Warwickshire Record Offices. The Northamptonshire office told me they had no information on Samuel Foster. However, Mr G.M.D. Booth, the Senior Archivist of Warwickshire County Record Office, was rather more forthcoming, if still inconclusive:

> " We have had enquiries about Samuel Foster before, and the suggestion was made that he was born not far from Newhall Green (where he apparently lived in the 1630s). We searched the registers of the parishes of Fillongley, Great Packington and Corley (as Newhall lies in Fillongley but near to the other parishes) but without any success." [5]

I deal later with the question of where the Newhall Green suggestion might have come from.

Another line of attack was to search for Samuel Foster and his known family in the online genealogy sites. I know of three siblings; an elder brother, Walter, of whom more below; and two sisters, Martha and Elizabeth, who are mentioned in Foster's will[6]. Martha's married name was Beyes, and so it is reasonable to conclude that she was the mother of the watchmaker mentioned by Aubrey. Martha lived in Coventry, and Elizabeth, who took the married name Poyner, lived in Northampton. There is also a cousin, Thomas Martin, who was minister of Little Houghton, a village south of Northampton.

A search on www.familysearch.org turned up several of these names in the right locations at around the right period.

> In 1575, Elizabeth, daughter of Richard Foster, was baptised at Holy Trinity, Coventry [probably too early].
>
> On 21 December 1599, a Martha Foster was baptised at Braunston [mid-way between Coventry & Northampton].
>
> A Foster family lived in Moulton, a village north of Northampton. Libeas Foster, son of John Foster, had 8 children with these birth dates: William (1 January 1598); Walter (1600); Sarah (15 August 1602); Jane (8 July 1604); Thomas (January 1607); John (1 November 1609); Ann and Elizabeth (24 April 1612). [Walter and Elizabeth but no Martha and no Samuel – so almost certainly a red herring!].

Frustratingly, although there are candidates in both Coventry and Northampton, and half-way between, I do not believe any of these is genuinely Samuel Foster's family.

A colleague in the Rugby Local History Group[7], using a catalogue of wills for Northamptonshire and Rutland, has identified a series of wills by Fosters living in Northampton. Again, however, there is no proof that these people have any connection to Samuel Foster.

Education at Cambridge

Ward's biography indicates the next phase of Samuel Foster's life - his education at Emmanuel College, Cambridge. Foster is part of a great tradition of astronomers from Emmanuel College – others include Jeremiah Horrocks (matriculated 1632), Fred Hoyle (matriculated 1933) and the author. (matriculated 1981). Foster and Horrocks belong to the extraordinary cohort of students who studied at Emmanuel College in the first half century of its existence, 1584-1634. Other Emmanuel College scientists from this era include two more astronomers, John Bainbridge and John Palmer; and John Wallis, geometer and cryptographer, who anticipated Newton's ideas on infinite series[8]. All three feature later in this paper.

During the first half of the 17th century, Emmanuel College was the country's leading centre for radical Protestant thought. The college attracted philosophers of the puritan neo-Platonic tradition, such as Ralph Cudworth and John Worthington, not to mention an extraordinary number of people who went on to emigrate to the American colonies, including William Blackstone (first settler in Rhode Island), John Cotton (eminent preacher) and John Harvard (founder of America's first university). It is said that 35 of the first 129 'Oxbridge' graduates in the American colonies (up to 1650) were educated at Emmanuel College[9].

All student entrants to Emmanuel College sign the college entry register. When Jeremiah Horrocks signed this register on 18 May 1632 (Figure 1), he indicated "Lancastro" (county of Lancashire) as his county of origin. Unfortunately,

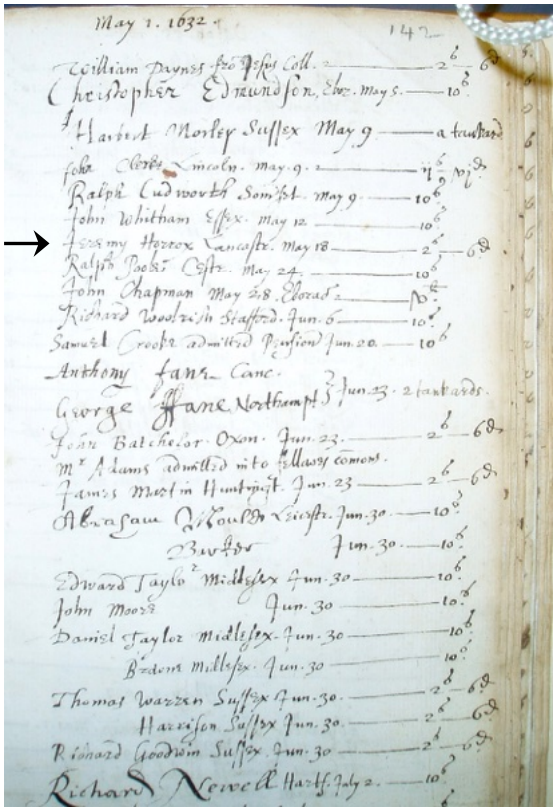


Figure 1

Signature of Jeremiah Horrocks on the Emmanuel College entry register

Horrocks's signature is indicated by the arrow.
Photograph by the author, September 2006

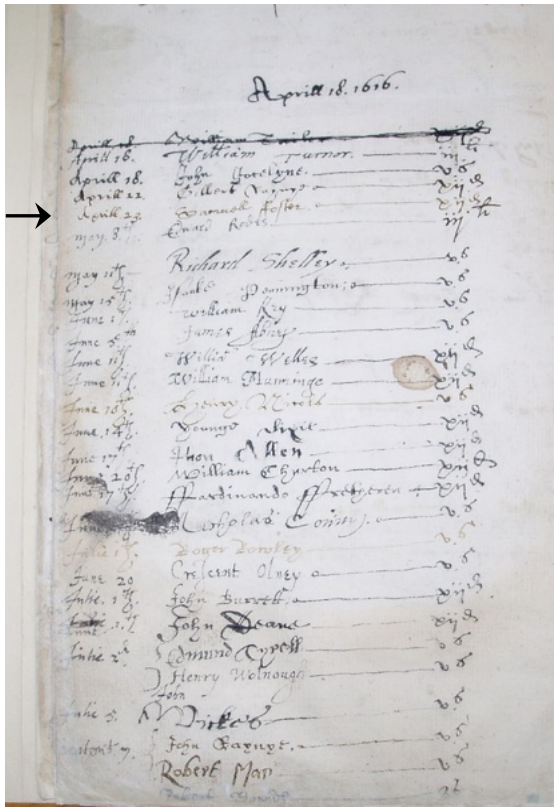


Figure 2

Signature of Samuel Foster on the Emmanuel College entry register

Foster's signature is indicated by the arrow.
Photograph by the author, September 2006

Samuel Foster's entry (Figure 2), 16 years before Horrocks, is less informative. Under a column headed "Aprill 18 1616", is the following entry:

April 23 Samuel Foster ---------- XIId

This indicates that Samuel Foster paid 12 pence, the admission fee for a sizar; for like Horrocks (and later Isaac Newton at Trinity College), Samuel Foster was a sizar, paying reduced fees in return for performing menial duties in college, such as waiting at tables and emptying chamber pots. There is no sign in the entry of a county of origin. Two years earlier, the register had been signed by his brother (Figure 3):

May 28 Walter Foster ---------- 6 [?]

This shows that Walter Foster paid a 6 shillings admission fee; so it appears, intriguingly, that he was NOT a sizar. Venn's directory of Cambridge alumni[10] confirms the registration dates, and confirms Samuel Foster (and not Walter) as a sizar. (It is amusing to speculate whether or not Samuel had to dispose of the contents of his brother's chamber pot!). Ward's history of

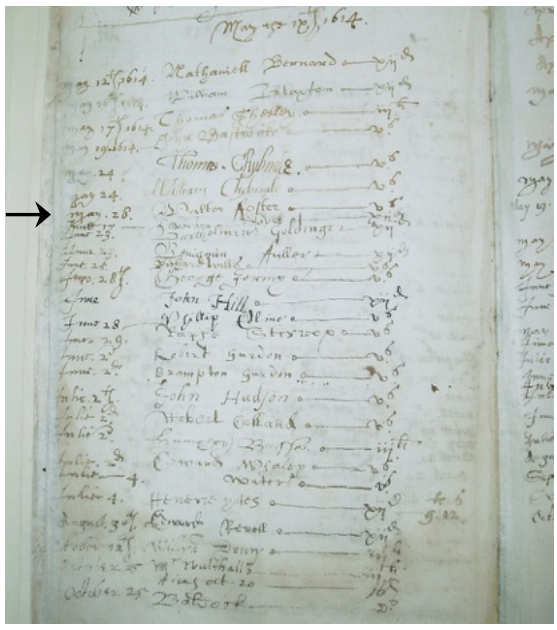


Figure 3

signature of Walter Foster on the Emmanuel College entry register

Foster's signature is indicated by the arrow.
Photograph by the author, September 2006

Gresham College includes Walter in the chapter on Samuel Foster: Walter's admission date is given as 24 May 1614. Ward adds the intriguing detail that Walter was "*previously at Oxford*" [11]; so perhaps he was more than two years older than Samuel.

Newly admitted students to Cambridge University were sent by their college in batches to matriculate, days or weeks after admission to their college. In the university register[12] names are recorded by an officer of the university, rather than signed by the students themselves Names appear in one of three columns: primus, secondus or tertius/quadrantary, which correspond to first, second or third/fourth-class students. I am unsure of the criteria for each class, except that names in the first column are preceded by "Mr.", so I infer that the division is likely to be gentleman, scholar, sizar, or a similar classification. Samuel Foster (July 1616) is listed in the third column, as a "tertius". Jeremiah Horrocks (July 1632) is also a third-columnist, just above John Worthington, although these two are in a column headed "quadrantary". I could not find an entry for Walter Foster. Venn's directory[13] confirms that although he was admitted to Emmanuel College, he never matriculated into the university. One possible reason for this would be if he had already been a student at Oxford University. However, the Oxford equivalent of Venn's *Directory* does not list him[14].

These admissions to Cambridge University give clues to Samuel Foster's circumstances. The Foster family must have been relatively wealthy to be able send two children to university; but the fact that Samuel was a sizar suggests limits to that wealth. Speculatively, a professional family background such as lawyer, teacher or clergyman would not be inappropriate.

Teaching in Coventry

Typically, although Aubrey tells us that Samuel Foster was an usher (or assistant schoolteacher) in Coventry, he does not tell us exactly where or when. The principal educational establishment in Coventry at that time was the school founded by John Hale in the reign of King Henry VIII, and named for him. Unfortunately, the King Henry VIII School and its archives were destroyed during a German air-raid in 1941. Consequently, the school was able to offer only a brief passage on Foster from a school history dated 1945. This turned out to be a paraphrase of Aubrey's biography. However, the Archivist was able to provide some very useful background detail:

> "I can tell you that Philemon Holland was Usher at the school from 1608 to 1628, after which he became Headmaster until 1629. Therefore Samuel Foster must have joined the School, as Usher, no earlier than 1628." [15]

Another detail is in Poole's history of Coventry:

> " In 1629, Mr. Phinehas White, who succeeded Philemon Holland, made an application to the council of the corporation for permission to employ an assistant at his own cost, in consequence of the extraordinary number of scholars …" [16]

So Foster may have been the usher, or assistant teacher (these may have been separate posts) to Phinehas White. Poole's book also clarified the structure of the school. There were two departments – the usher's, or low school, and the headmaster's or high school. The headmaster received an annual salary of £40; the second master £20; the singing master and the bailiff £3 each. The school received £70 annually in rental.

By 1629, Samuel Foster had already published his first work - *The Use of the Quadrant* dated 1624. This eventually appeared as an appendix to the works of Edmund Gunter (Gresham Professor of Astronomy 1619-1626), who also wrote on the use of the Quadrant[17]. I have seen only the 5th edition of this work, dating from 1675. In this, Foster mentions London several times, but makes no mention of Coventry, or of any other location in the Midlands. Perhaps this indicates that he was living in London in 1624; or that he modified the work after he had moved to London in later life.

I am, however, able to confirm Samuel Foster's location for at least part of the year in 1635. Coventry City Archives contain multiple copies of a document by Samuel Foster dated October 1635, comprising surveys and acreages for Warwickshire and Coventry County. The document is titled: *The Survey of Warwickshire, made by Mr. Samuel Foster October 1635*[18]. On one copy, the title is expanded to "Mr. Samuel Foster, mathematician".

The content of the document (Appendix 1 to this paper) is a laborious calculation of the acreage of Warwickshire and of the city of Coventry, followed by a long division, which shows that:

> [the] "…County of Warwick only, containeth the aforementioned plot of the city and count of Coventry 33 times and 4/5 parts of the aforesaid libertie of Coventry, which appeareth by this division."

In other words, the county of Warwickshire was 33.8 times the size of the city of Coventry. It is not clear for what purpose Foster carried out this calculation, or whether it was ever useful.

Gresham Professor of Astronomy

Foster's next move was to London. Ward's biography continues:

> "His inclination led him chiefly to the mathematics, and upon the death of Mr. Gellibrand, astronomy professor in Gresham College, he was chosen in his room, upon the 2 March 1636; but quited the place again on the 25 of November following, and was succeeded by Mr. Mungo Murray." [19]

Gresham College, in Bishopsgate, north of the City of London, was named for Sir Thomas Gresham, the founder of the Royal Exchange. When Gresham died in 1579, he specified that on the death of his wife his estate should go to the City of London, for the establishment of a college to give public lectures to the people of London. Lectures began in 1598; with professors of astronomy, geometry, law, physic, rhetoric, divinity and music, housed in his mansion and gardens in Bishopsgate. Each professor was expected to lecture on a particular day of the week; in Latin in the morning, repeating the lecture in the afternoon in English. Wednesday was astronomy day[20].

The Bishopsgate buildings are long gone. However, the name of Gresham College lives on in a public education program run by the City of London, based at Barnard's Inn Hall. The seven professorships remain, with the addition in 1995 of an eighth Gresham Professor - of Commerce. Recent Professors of Astronomy include Roger Tayler (1969-1975), Martin Rees (1975), Heather Couper (1993-1996) and Colin Pillinger (1996-2000). The current Gresham Professor is John Barrow, of Cambridge University, a prolific author of popular science books[21].

Henry Gellibrand's main claim to fame was the recognition that compass needles dip (responding to the vertical component of the Earth's magnetic field). He also had interests in sun-dialling, but did not otherwise make great contributions to astronomy[22]. Contrary to the implication of Ward, Gellibrand was not replaced immediately after his death; elections were scheduled twice in February 1637, but Foster was eventually elected in March ahead of two other candidates[23].

So why did Foster resign his professorship within nine months? Ward says nothing about it, but Adamson[24] sheds very interesting light, quoting a contemporary source, Johanne Hunneades:

> " Mr. Foster our lecturer in Gresham College is put out because he will not kneel down at the communion table when he takes the communion."

In other words, Foster's beliefs were a problem; many Puritans equated kneeling for communion with Catholicism. These were dangerous times. In particular, Archbishop Laud, tormentor of religious dissidents, had expressed his dislike on religious grounds of Foster's predecessor Henry Gellibrand. Foster may have perceived similar criticism. Adamson quotes the Minutes of Gresham College as saying that " … he [Foster] thought it safest to resign."

Adamson goes on to say that the College might have been grateful to receive Foster's resignation, as they were under some pressure from King Charles I to appoint Foster's successor, Mungo Murray, to "… the reading of the Geometry and Astronomy lectures which[ever] shall fall first vacant and at the committee's dispose." Murray, a Scot lately of Oxford University, was clearly a political appointment by the Royalists. By all accounts he was not much use as a scientist.

The Art of Dialling

It is uncertain where Foster went to when he left Gresham College. Ward tells us that:

> " After the surrender of his professorship, he continued to pursue his mathematical studies." [25]

However, I know exactly where he was on 21 September 1637. For the following year, 1638, Foster published his second and most important book, *The Art of Dialling*[26], which is a manual for the construction of sundials. The title page advertises that the book shows "… how to describe the Houre-lines upon all sorts of Plaines, Howsoever, or in what Latitude soever Situated". This is achieved by the use of dialling scales, a computational device that Foster invented.

From the point of view of tracing where Foster was residing, the most important part of the *Art of Dialling* comes at the end:

> " An Appendix, shewing a ready way to find out the latitude of any place the Sunne … By the Meridian Altitude, and declination of the sun had; how to find the Latitude of the place, or the elevation of the Pole above the horizon." [27]

Finding the latitude of your location is vital if you want to align correctly the gnomon of a sundial and so use the sundial to tell the time accurately. Foster recommended observing the altitude of the Sun above the horizon at mid-day (i.e. its highest point), and supplied a table of correction factors for the Sun's position along the ecliptic on every day of the year. He concluded the Appendix with a worked example.

> "… For example. Upon the 21 of September 1637, I observed the Sunnes altitude in the Meridian to be 34gr. 10 min. Upon which day I find that the Sunne's place to be (as before) 8gr. 23 min. of [symbol for Libra], and the declination of 3 gr. 20 min. And because the Sun is in a south ligne, I add this declination and Meridian altitude together, the summe 37 gr. 30 min. is the altitude of the aequator, and this taken out of 90 degrees leaveth 52 gr. 30 min. for the Latitude of Coventrie. FINIS" [28]

The latitude of Coventry is 52 degrees and 25 minutes; 52 degrees 30 minutes lies about 10 miles to the north. This may be weak evidence that Foster was actually observing from a location north of Coventry (e.g. Newhall Green, at 52 degrees 28 minutes north) or it may be an imperfect observation, faithfully reported. However, other latitudes mentioned in Foster's later work appear to be accurate to within one minute, so it is possible that he was observing from north of the city.

Observations from distant places

Ward tells us that:

> " He [Foster] made several curious observations of the Sun and Moon, as well as at Gresham College, as in other distant places (see his Miscellanies)." [29]

The *Miscellanies*, or, "mathematical lucubrations", was a posthumous publication of Foster, consisting of a series of papers on varied topics supplied after Foster's death by his brother, Walter, to Samuel's friend John Twysden - "a learned and scientific man who acquired great proficiency in astronomy as well as medicine." [30]

The curious observations are in a paper entitled *Observationes Eclipsum*, and consist of details on eight lunar eclipses, four solar eclipses, one comet, and one sun-spot, made during the period 1638-1652. But there is a problem. John Twysden cheerfully admits in the introduction to the *Miscellanies:*

> "[to] the observations of some Eclipses, the motion of the late comet, with some other things, I have added my own, which being themselves not worthy of the presse, I made choice to hide under the shadow of so great a person." [31]

This means that in some cases there is no way of telling which observations were by Foster and which by Twysden!

Fortunately, for the first lunar eclipse recorded there can be no doubt that Foster was involved, as it was made "… in the presence and with the assistance of John Palmer and John Twysden". Here is the account in full:

> " The observation of the Moon's eclipse, which happened at New-hous near Coventry, the ninth day of Decemb. complete in the year 1638, 13h 58. after noon [1:58 A.M.] In the presence and with the assistance of John Palmer and John Twysden.
>
> " Half her circle, that is to say 7 dig 1/4 , were darkened when Rigel was high 24 deg 58 ½ m. The hour of the night 12g 45m.
>
> " Two thirds of her diameter, or eight digits, were obscured when Rigel was high 24 gr. 37 m., the hour of the night was 12 gr. 50m.
>
> " 11/12 of the diameter was enlightened or 11 dig and some what more Arctur. high 31 gr. 56 ½ min, the hour 3h. 45 min. Rigel was between South & West. Arcturus upon the eastern coast.
>
> " The right Ascen. Of the Sun at midnight, after the tenth of December 268 gr. 49m. four hours after 269g 00m. Therefore the hour of the night was at the first observation 12 gr. 45 min, At the second 12 gr. 50 min. At the third 3 gr. 45 min as by an exact appearance it appeareth. For the latitude of Coventry is 52 gr. 29 min. as I have often made trial. Rigel declies 8gr. 41 min. towards the South, and hath right Ascens 74 gr. 20 m. For its longitude is 71 gr. 49 m. with its southern latitude 31 gr. 11 min ½ Arctur. declines toward the north 21 gr. 8 min. and hath right Ascens 209 g. 49 m. For its longitude is 199 gr. 11 ½ min. with North latitude 31 gr. 02 m." [32]

In this record, the latitude of Coventry is given as 52 degrees 29 minutes, still approximately 4 minutes north of the city's actual position. However, a named location, "New hous", is specified, and it is this that may have given rise to the later belief that Foster "lived in Newhall Green during the 1630s".

There is, however, a more likely location for the site of the observations. According to McGrory's *Illustrated History of Coventry's Suburbs*[33], a mansion called "New House" was built in 1586, two miles north-west of Coventry, in the area now known as Radford (at the present-day junction of Keresley Road and Sadler Road). The latitude of New House was 51 degrees 26 minutes north. Although it is a considerable stretch to label Newhall Green as part of Coventry, New House fits this description much better. The latitude of New House was 51 degrees 26 minutes north. However, New House fits the description 'near Coventry' rather better than Newhall Green does. Figure 4 shows a 1702 engraving of New House, and Figure 5 shows the location of New House in the 1729 map by Henry Beighton[34].

New House was built on the site of Whitmore Park, a moated hunting ground of 436 acres presented by King Edward VI to Sir Ralph Sadler.

Figure 4

New House, Coventry

This 1702 engraving shows the location from which Foster, Palmer and Twysden probably observed the lunar eclipse of 9 December 1638.

From: J.Britton. Architectural Antiquities of Great Britain. 1835. By courtesy of Warwickshire County Record Office.

Sadler sold the park to John Hales, the founder of King Henry VIII School, and Hales built New House, a fine domed and turreted mansion, leaving the rest of the park as a "wilderness". The house remained in the Hales family until the early 17th century. By 1640 ownership had passed to Sir Christopher Yelverton, baronet of Eston Maudinit, Northamptonshire, who was married to John Twysden's sister, Anne[35]. Twysden, the editor of Foster's *Miscellanies,* dedicated it to Susanna Longueville, the wife of Yelverton's son, Henry:

> " Your Ladyships most humble servant and affectionate Unkle, John Twysden."

One can imagine Twysden, Palmer and Foster dining with Twysden's in-laws before going into the 'wilderness' to observe the eclipse.

New House was demolished in 1778, and replaced by a smaller house. By the 1920s nothing was left of the New House estate, and a housing estate forming part of a Coventry suburb was built on the site. This includes a Foster Road (Figure 6), running parallel to Keresley Road. Nearby is Yelverton Road. Whitmore Park gives its name to another Coventry suburb just to the north. I enquired of the Coventry City Archives about these names, and was told that:

> "… interwar Town Clerk Frederick Smith was a local historian who liked giving relevant names to new streets all over the city." [36]

The connection to Samuel Foster is not certain (other roads in the area are named for 19th century novelists) but the presence of Sadler Road and Yelverton Road certainly suggests a memorial to Whitmore Park and to New House.

Figure 5

Detail from Henry Beighton's 1729 map of Warwickshire showing New House

From: *Antiquities of Warwickshire* by Sir William Dugdale (1730).

Samuel Foster and his friends were not the only ones to observe the lunar eclipse of 9 December 1638 - Jeremiah Horrocks observed it too, from his home in Much Hoole, Lancashire. Moreover, Horrocks had asked his cousin, Thomas, who had emigrated to the New World, to observe the same eclipse from America, and to note how many hours before dawn the eclipse finished. Thomas observed the eclipse from Quidnick, Rhode Island, and sent his observations to Horrocks. By comparing the timings of the eclipse from Quidnick and from Much Hoole, Horrocks was able to calculate (albeit with a large margin of error) the difference in longitude between the two locations.[37]

Figure 6

Foster Road, Radford, Coventry

This road may be named for Samuel Foster
Photograph by the author, September 2006.

More observations by Foster and his circle

Other events in *Observationes Eclipsum*[38] include the following:

More lunar eclipses:

" The observation of the Eclips of the Moon, anno. 1641, made upon St. Mary hill neer the Tower in London, the eighth day of October about 8 at night."

" The observation of the Moons Eclips, as it happened at Aubrey in Somersetshire. The latitude of that village is 51 deg. 10 min, as it hath several times been observed by me."

" The Eclips of the Moon observed at London Anno 1643 Septem 17, between 7 and 8 afternoon. Latitude 51 deg. 30 min"

" The Eclipse of the Moon observed at London An. 1645 Janu 31 upon Friday, between the hours of 7 and 9, at night. The latit 51 deg. 30m."

" Eclipsi Lunae observata London: 1649, May 15"

" An Eclips of the Moon observed at Gresham Colledge"

" The Moon's Eclips observed as it happened at Easton in Northamptonshire, March the 14th, 1652 about three of the clock at night.. Latitudo 52 gr. 15 min, A Joh Twysden & Joh Palmer."

Solar eclipses:

" The Eclips of the Sonne which happened May 22 P.M. 1639, observed in Old Bayly in London A Samuele Foster & Joh Twysden. The latitude of London is 51 deg. 32 min. for so others and we have observed it."

" The Eclips of the Sun observed in London August 11th, 1645"

" The Eclips of the Sun 1649 October 25th afternoon, observed at Gresham Colledge in London."

" The Sun's Eclips, observed at London 1652, March 29, before noon."

" The Sun's Eclips observed at Easton in Northamptonshire 1652, March 29 current, about 9 in the morning Lat. 52 gr. 15 min." [This is same eclipse as the previous entry.]

The best of the solar eclipses was that of 29 March 1652, "Mirk Monday", which was total in lowland Scotland and the eastern coast of Ireland. According to one contemporary source:

"… the country people tilling, loosed their ploughs. The birds dropped to the ground." [39]

The eclipse of 22 May 1639 was annular from Scandinavia, and was more than 70% throughout England. The track for this eclipse is shown in Figure 7. Samuel Foster and John Twysden observed from London.

Figure 7

Track of the annular eclipse of 1 June 1639 (22 May Old Style)

Jeremiah Horrocks observed from Much Hoole, William Crabtree from Broughton and Nathaniel Nye from Coventry. Graphic supplied by Sheridan Williams (see Reference 39).

Other observations:

" The motion of the late Comet as it was observed at Easton in Northamptonshire Anno 1652, Lat 52 d. 15m."

" Upon Tuesday the second of July in the year 1651, about eight of the clock at night, at Easton in Northamptonshire, under the elevation of the North Pole 52d. 15 min., I saw in the body of the Sun (through an excellent Tellescope whose Glasses were very clean) a very dark round spot in diameter about 12 part of the Sun's diameter…"

Easton may be the village of Ecton, to the east of Northampton, where John Palmer became rector in 1641; or Easton Maudit, family seat of the Yelvertons, five miles south-east of Ecton. Ecton is at 52 degrees 15 minutes north; Easton is at 52 degrees 13 minutes. The Somersetshire location of Aubrey may be connected with Walter Foster, who had become rector of Allerton, Somerset. The latitude of Bishopsgate was about 51 degrees 32 minutes north. The centre of the City of London is closer to 51 degrees 30 minutes.

It is worth pointing out how unusual such detailed observations were during the first half of the 17th century, within fifty years of the invention of the astronomical telescope. At that time there were no Royal observatories, no Astronomers Royal, no Royal Society, and no formal journals in which to report observations. There were exactly

two salaried astronomers in England: the Gresham Professor, Mungo Murray, a non-entity appointed for political reasons, and John Bainbridge, the Emmanuel College man, who held the newly-established Savilian Professorship of Astronomy at Oxford University. I know of only two groups of serious observational astronomers in England at this time: Jeremiah Horrocks, William Crabtree, William Gascoigne and others in the north of England; and Samuel Foster, John Twysden, John Palmer (and possibly Nathaniel Nye) observing from the Midlands and London.

The solar eclipse of 22 May 1639 was observed by Jeremiah Horrocks and his colleagues from the north-west of England. William Crabtree wrote to William Gascoigne:

> " You shall also have my observations of the Solar eclipse here at Broughton, Mr. Horrocks between Liverpool and Preston, and Mr. Foster in London." [40]

So, in the year, 1639, when Horrocks and Crabtree observed the transit of Venus, the two groups of astronomers were exchanging observations. Horrocks was, as far as we know, the only person to predict that a transit would happen, on or about 24 November 1639. It is not widely known that, in the letter in which he alerted Crabtree to the possibility of a transit, Horrocks also wrote:

> " If this letter should arrive sufficiently early, I beg you will apprise Mr. Foster of the conjunction [transit of Venus], as, in doing so, I am sure you would afford him the greatest pleasure." [41]

However, the evidence suggests that it is unlikely that Samuel Foster ever did see the transit. We do not know, for example, if Crabtree passed on to Foster Horrocks's information. He may not have had time, and even if he did, there is no certainty that he knew Foster's whereabouts. We know that Samuel Foster was in Coventry on 21 September 1637 and on 9 December 1638; and was in London on 22 May 1639. If he had returned to Coventry for the latter part of 1639 it is unlikely that a letter from Crabtree would have reached him in time.

Moreover, as discussed later in this paper, Foster knew many of the founders of the Royal Society. An observation of the transit of Venus by Samuel Foster would surely have been known to people such as John Wallis, who knew both Foster and Horrocks.

There is, however, another astronomer from the Midlands who might have had a connection to the transit of Venus. He is better known for his military activities, as a master gunner.

Nathaniel Nye

According to the Dictionary of National Biography, Nathaniel Nye was baptised in Birmingham on 18 April 1624, the son of Allen Nye, whose name later appears as a governor of King Edward VI's school, Birmingham[42]. Nathaniel Nye is most famous for his 1647 book *The Art of Gunnery*, a practical guide to the deployment of artillery. However, from an astronomical point of view, his most interesting works were written earlier in his career: a series of almanacs for the town of Birmingham, for the years 1642, 1643 and two for the year 1645.

Figure 8
The 1644 portrait of Nathaniel Nye by Wenceslaus Holler

D.G.R. Taylor claims[43] that Nye observed a solar eclipse from Coventry in 1640, implying that Nye was one of Foster's students. However, there are some anomalies. Foster and Twysden do not mention Nye in any of their eclipse accounts, nor indeed anywhere else, to my knowledge. Moreover, although there were two solar eclipses between 1 January 1640 and 25 March 1641, neither was visible from England.

In an attempt to resolve this discrepancy, I consulted copies of Nye's almanacs, held on microfiche and digitally as part of the Early English Books Online digital resource in Cambridge Uni-

versity Library[44]. Each almanac contains predictions of planetary positions for the year, for astrological usage (the 1643 almanac styles these *The Caracters of the Seven Planets and their Aspects*), a catalogue of stellar positions, and a prognostication of eclipses for the forthcoming year. The year is deemed to begin in January, so presumably the almanacs were printed at the end of the previous year. Other common tables are *A necessary and Perfect Table to know the beginning and end of every term* and *A short description of the four quarters of the year*. For variety, individual almanacs contain sections such as *A Chronology of Memorable Things*, *A brief description of the naturall causes of watery Meteors, as Snow, Hale, Raine etc*. and *Observations for Husbandmen*. The 1645 almanac also contains a long and detailed commentary on the progress of the English civil war. Not surprisingly, Nye was passionately interested in the tumultuous events of the time.

The 1643 *new almanacke and prognostication for the year of our Lord God, 1643, being the third from the leap year, calculated exactly for the town of Birmicham [Birmingham] in Warwickshire…"* is the only one to record Nye's astronomical observations in depth. There are several sections of interest. *Certaine Observations and new discoveries made in the Celestial Regions* (see Appendix 2) establishes Nye's credentials as a serious astronomer. He recounts Galileo's observations of the moons of Jupiter, the phases of Venus and mountains and other features on the Moon. He states that the Earth rotates around the Sun, and the Sun has spots. Other of Nye's claims are less valid but reflected contemporary beliefs:

> "The Sea is caused to ebb and flow by the Earth's motion about the Sun", "…That no planet is bigger than the Earth (the Sun excepted) but lesser many hund. [hundred?] times, and this is easily proved, the Moon must then be bigger than any of the other planets, being but less than the Earth 42 times."

Nye then goes on to describe *Certain Observations made by me and others of my friends, in the place of the Planets.* This is his account in full:

> " Because those that hath astronomical tables may calculate the places of the Planets for these times, as I have observed, which I know will be to their content, however it cannot be amisse to set down such observations which I have faithfully observed.
>
> " 1640 upon the 8 of August Jupiter in the 10 deg:36 min:?? the lati. of Jupiter about one min and a half fourth, just at eight at night.
>
> " 1639 upon the 22 of May the eclipse of the Sun began at the City of Coventry just 2 min after 4 after noone the greatest obscurity just at 5 a'clock and 9 min; and the end most exactly at 6 & 5 min: the whole duration was 2 hour and 3 min; & the quantity obscured was 9 dig & 23 min;
>
> " 1639 upon the 23 of Novem Venus came just under the Sun at 3 aclock and 30 min; & continued upon the Sun half an hour the true place of the Sun; Venus were in [symbol for Sagittarius] 10 deg; and 19 min. This observation doth not agree with Landberg's table, but the eclipse of the Sun commeth somewhat nearer the truth, for [by these tables?] the Sun was Eclipsed 8 dig & 50 min; for the time of the beginning and ending, he differs much from observation.
>
> " Upon the 26 of March 1640 just at 9 aclock at night I observed Moon's Placce to be in the 8 deg of Libra & 32 min; & in this observation I considered the Paralax, Refraction & Lati[tude]"

The first and last of these entries seem to be routine astronomical observations. The second suggests that Nye observed from Coventry the solar eclipse of 22 May 1639, as seen by Foster and Twysden from Old Bayly in London. Figure 9 illustrates the maximum eclipse as seen from Coventry (1 June 1639 corresponds to 22 May Old Style). Nye's figure of 9 digits and 23 minutes (out of 12) obscured is consistent with a 73% eclipse. It is also consistent with Foster and Twysden's estimate of 9 digits 24 minutes obscured as seen from London, although their estimate of the eclipse duration (2 hours 28 minutes) is 25 minutes longer than Nye's for what was a very similar eclipse depth at both locations.

Figure 9

Maximum extent of the solar eclipse of 22 May 1639 (Old Style), as viewed from Coventry
Graphic by Sheridan Williams.

At face value, Nye's observation on 23 November 1639 is sensational. Can we possibly add Nye, perhaps only 15 years old, to Horrocks and Crabtree as the only people to view the 1639 transit of Venus? It seems barely credible, especially as Foster left no record of having viewed it.

Elsewhere in the 1643 almanac, in a separate section entitled *Of the Eclipses*, Nye expands on the transit observation:

> " And in the Year of our Lord 1639 upon the 23 of Novem the planet Venus came just under the Sun at halfe an hour after 3 noone and went of about 4. The like will happen upon the 12 of November 1643 about 11 before noon for at the instant Mercury comes just under the Sun and about 2 after noon lies nearer the center of the Sun and goes off the Sun about Sun setting … let me entreat all those who affect these arts to observe it."

He then detailed *How to behold an Eclipse of the Sun or when Venus and Mercury come under the Sun* (see Appendix 3). This involved projecting the Sun's image onto a screen in a darkened room, just as Horrocks and Crabtree had done.

A number of questions spring to mind immediately. Why did Nye wait for three years before documenting his observations? In particular, why did he not report his observations in the 1642 almanac? Moreover, there are several very troubling errors in Nye's account. The Venus transit of November 1639 did not occur on the 23rd, but on the next day, Sunday 24 November. Nye also diverges from Horrocks on the start time of the transit; however this is not necessarily a major discrepancy, because there was no standard time in England in 1639. More seriously, the transit did not last for half an hour, but for several hours. Sunset interrupted the transit as seen from England, so that only the first 30 or so minutes were visible; the Sun set with Venus still crossing the disk. Finally, there was no transit of Mercury in 1643, although there was one in November 1644.[45]

If Nye really did see the 1639 Venus transit, convoluted and unconvincing explanations are required to answer the questions. For example, perhaps Nye observed the event but did not understand what he had seen until he came to compile his almanacs, and compute the dates of transits, three years later.

On re-reading Nye's text it is noticeable that he does not use the first person for the transit observation, as he does for the 1640 observation of the Moon. Perhaps, despite his claim to have "faithfully observed" the event, this observation was by "others of my friends". Who might those friends be? One possibility is Foster, or his colleagues Palmer and Twysden, but as we have seen, they left no known records of the event. Alternatively, perhaps his friends were friends by correspondence. In many respects, Nye's account reads like a garbled version of Horrocks's account, written as *Venus in Sole Visa* in 1640. For example, Horrocks wrote that he began observing on 23 November, even though he expected the transit to occur the next day. The mention of the Belgian astronomer Philip Landsberg, is also telling; Horrocks disparages Landsberg's tables at length.

The contrast in the quality of Horrocks's and Nye's accounts is stark. *Venus in Sole Visa* is a substantial document, tightly argued, showing how Horrocks came to predict the Venus transit and what conclusions he drew from his observations. Nye simply (and incorrectly) reports the bald facts of his supposed observations, without any attempt at context or interpretation. It is this lack of supporting detail that fails to convince me that Nye really saw the event he reported. At best, if we assume that Nye really did see the 1639 transit, he failed to exploit his observations (perhaps not surprising given that he was only about 15 years old).

Of course, Nye's apparent knowledge of *Venus in Sole Visa* is of interest, as Horrocks's work did not initially receive a wide circulation outside interested parties in the north of England. Horrocks died in January 1641, shortly after completing *Venus in Sole Visa.* The day he died he was due to meet Crabtree. Crabtree took possession of Horrocks's papers after his death. When Crabtree died in 1644, many of his and Horrocks's papers were rescued by Jonas Moore and Christopher Towneley[46]. Towneley's student Jeremy Shakerley published some of Horrocks's work (though not the transit observations) in 1651. Other papers of Horrocks, including *Venus in Sole Visa*, were purchased from William Gascoigne's estate by John Worthington in 1658, and published by Johannes Hevelius in Danzig[47], before finally being published in England by John Wallis in 1661. In his introduction Wallis said:

> " I cannot help being displeased that this valuable observation, purchasable by no money, elegantly described, and prepared for the press, should have laid hid for two-and-twenty years, and that no one should have been found to take charge of so fair an offspring at its father's death, to bring to light a treatise of such importance to astronomy, and to preserve a work for our country's credit and the advantage of mankind." [48]

This does not imply that before 1661 Wallis was unaware of Horrocks's observations. Unpublished copies of *Venus in Sole Visa* were circulating in England well before then; three such copies are in the Cambridge University Library[49]. However, it does suggest that Wallis was unaware that an account of the transit, albeit seriously flawed, had been published by Nye eighteen years earlier.

Much though I would like to acclaim Nye as a child prodigy and transit observer, I can do no better than to describe him as a capable astronomer and mathematician, who was surprisingly well in touch with the new discoveries of the day. As to Nye's relationship with Foster, my guess is that Nye was at best a peripheral figure in Foster's circle – an enthusiastic youngster, perhaps. Later in his career Foster did have a student – Thomas Rice, who was also a gunner, at the Tower of London[50]. By then, Foster had been re-elected to the Gresham Professorship.

A return to Gresham College

By 1641, Mungo Murray was becoming an embarrassment to Gresham College. Fortunately, perhaps, the College were "credibly informed" that he had neglected to inform them that he had got married, in violation of the statutes of the college[51]. Moreover, Archbishop Laud had been impeached in 1640, and was now held in the Tower of London. Ward simply writes that the "professorship being vacant again by the marriage of Mr. Murray, he [Foster] applied for it, and was rechosen May the 26th of that year." Adamson reports that his opponents were the same two candidates as previously, Mr Bourman and Mr Merest, but this time, Foster was elected unanimously[52].

As recorded above, Foster and his colleagues, Palmer and Twysden, were engaged in a program of observation and measurement. I assume that the London observations were primarily by Foster, and the Northampton ones by Palmer. The esteemed instrument maker Anthony Thompson was also based at Gresham College, and he provided Foster with quadrants and other instruments built to Foster's designs. In addition to his weekly lecture commitments, Foster engaged in research into a wide variety of topics. Foster's *Miscellanies*[53] includes a catalogue of star positions; a comparison of the relative sizes of Sun, Moon and Earth; and a table of sinusoidal values, from which Foster deduced a value of pi accurate to 10 decimal places (but wrong for a further 5 digits). Foster's comments on the 'New Astronomy' are of interest. In a paper on "how the theorie of the planets are made", he explains:

> " The way I goe is (in general) agreeable to Copernicus his frame of the world; and in particular, to that which Kepler useth in his Rudolphian tables. Onely this difference there is: Kepler makes the Orbits of the Planets to be Ellipses, which is the better way, and I here doe make them to perfect circles, which is the easier way."

However, the larger part of Foster's researches were in spherical trigonometry, in particular the mathematics of dialling, or the efficient and artful construction of sundials. Unfortunately ill-health prevented him from publishing most of this work during his lifetime. The only work Foster published whilst he was Gresham Professor was on spherical trigonometry, sent to, and published by, John Wallis[54].

Four treatises of dialling were published posthumously in 1654, with the titles:

Elliptical or azimuthal horologiography.

Circular horologiography.

Rectilineal or diametrical horologiography.

Elliptical, by spherical and not projective horologiography.

There were two other posthumous works: *Posthuma Fosteri – containing the description of a ruler, upon which are inscribed divers scales, etc.* (published 1652), and *The sector altered and other scales added, with the description and use thereof.* (published 1672). All six of these six works were published by William Leybourne.

Although he was not the first to think of the idea (de Vaulezard of Paris had first suggested the concept in 1640[55]), Foster greatly developed the mathematics of analemmatic sundials. These are dials where the markers for the hours are in fixed positions, and spaced evenly around a circular dial, just as hours on a clock face are. For ordinary sundials this cannot work, as the progression of the shadow of the gnomon around the dial depends on the hour and on the season. However, in an analemmatic dial, it is the position of the gnomon that changes day by day, in such a way as to ensure an even progression of the shadow. The easiest way to manufacture such a gnomon is to leave the job to the observer, and so analemmatic sundials often come with instructions as to where the observer should stand so that their own shadow indicates the time. Figure 10 shows two examples of analemmatic sundials: at Ryton Gardens, near Coventry, and at the Norman Lockyer Observatory in Sidmouth, Devon.

Figure 10

Two examples of analemmatic sundials

The sundial in the upper photograph is at the Henry Doubleday Research Association, Ryton Gardens, Coventry. The sundial in the lower photograph is at the Norman Lockyer Observatory, Sidmouth, Devon.

Photographs by the author 2006.

A second mathematical construction employed by Foster was the nomogram, a calculating device, which in his case consisted of a circle divided diametrically in two segments. One quantity was placed on a scale on one semi-circular arc; a second quantity on the other arc; and a third quantity was placed on a scale along the diameter between the two segments. The quantities are arranged in such a way such that by placing a ruler across the circle, the three points on the scales that it intersects were in the required mathematical relationship. His nomograms thus formed an easy way to solve complex equations by a graphical, not an arithmetic, technique. The interesting thing about nomograms is that some authorities date their development to 1905 – some two and a half centuries after Samuel Foster was using them[56]. In the days before fast desktop calculators and computers, they were a versatile and rapid method of solving complex numerical relationships. The real skill was not in using them, but in designing them.

"We did by agreement, divers of us, meet weekly ..."

The 1640s were hardly an ideal time for studying natural philosophy, as England lurched into civil war. For example, Aubrey reports that William Gascoigne "… was killed at the battle of Marston Moor, aged 24 or 25 at most." [57] Nathaniel Nye supervised the defence of Worcester, and planned the fortification of Birmingham and Coventry[58]. Mungo Murray was caught in possession of a letter from King Charles to the French ambassador in Scotland[59]. John Wallis deciphered Royalist codes for the Parliamentarians[60].

Fortunately, Gresham College was relatively unaffected. Ward writes[61]:

> "… upon the breaking out of the national troubles, which soon followed his [Foster's] return to Gresham College, he was one of that worthy and learned society of gentlemen, who met in London for cultivating the new philosophy, of which an account has been given in the preface."

The account referred to in the final two lines of this quotation is by John Wallis:

> " About the year 1645 while I lived in London, I had the opportunity to be acquainted with divers worthy persons, inquisitive in natural philosophy, and other parts of human learning, and particularly what hath been called the new or experimental philosophy. We did by agreement, divers of us, meet weekly, on a certain day, to treat and discourse of such affairs. Of which number were Dr. John Wilkins, afterward bishop of Chester, Dr. Jonathan Goddard, Dr. George Ent, Dr. Glisson, Dr. Merret, doctors in physic; Mr Samuel Foster, then professor of astronomy at Gresham College; Mr Theodore Haak, a German of the Palatinate, and then resident in London (who, I think, gave the first occasion, and first suggested the meetings) and many others. These meetings were held …sometimes at Gresham College" [62]

This group, which was increasingly active in Oxford in the years 1650 to 1660, became the nucleus of the Royal Society when it was founded in 1660. Everybody on the list except Foster became an Original Fellow of the Royal Society. In the more relaxed years of the Restoration, the Royal Society prospered, providing the stage on which the 'greats' of British Science, men such as Newton, Hooke, Boyle, Halley and many others, were able to flourish. Unfortunately, Foster did not live long enough to see the foundation of this most eminent and prestigious of societies. Ward tells us that he was "*disabled by his great and long infirmities"* during his professorship[63]. In 1652 Foster succumbed and was buried at the church of St Peter le Poer, in London.

Samuel Foster's will is known[64]. Foster left £80 to Martha Beyes, (probably) mother of the watchmaker who provided Aubrey with biographical details. He left the same sum jointly to his cousin, Thomas Martin and to John Palmer, to be used for the benefit of his sister Elizabeth Poyner. Foster says in his will:

> " I would have given her as much as to ye rest, but ye wickedness of her husband is such, that what ever shee hath, he will spend, therefore I give her nothing at all."

He left Martin and Palmer 20 shillings each, to buy a book or whatever else would please them.

Elizabeth Poyner's feckless husband was Christopher Poyner, of Northampton. Christopher Poyner's will, granted 22 March 1686/7, is also known[65]. Poyner made out his will to his sister, Elizabeth Poyner, spinster, of London.

Over the next few years, John Twysden and Foster's lawyer, Edmund Wingate, presided over the publication of many of Foster's works. There was an urgency to this. Ward reported Twysden as complaining[66] that:

> " some persons having got into their hands on some things of Mr. Foster's, which out of that diffusive goodness and candour of disposition, that was in him, he communicated to others; had under a disguised face vented them as their own."

On his death, Foster had been lecturing on astronomy at Gresham College for eleven years, but publishing very little. There must have been a great temptation for his students to publish his work with minimal or no attribution. Conversely, Twysden took the opportunity to attach Foster's name to his own observations and discoveries, perhaps to add authority. For example, Emmanuel College library contains a work on reflexive dialling (i.e. mirror-based sundials) that is titled as being by Foster. However, an inspection of the text reveals that the work is actually by Twysden[67].

The other members of Foster's circle

Ward's biography contains brief details on Walter Foster:

> " He [Samuel Foster] left a brother, whose Christian name was Walter, and by the dates of his degree at Cambridge seems to have been somewhat older. He was of the same college, admitted batchelor of arts in the year 1617, master in 1621, and batchelor of divinity in 1628, and was also a fellow of the college. Dr Samule Ward, in a letter to archbishop Usher, dates from Sidney College in Cambridge May the 25th 1630, speaks very well of him in the following passage, 'As for the Latin copy of Ignatius's Epistles in Caius college library, I spoke also with Mr Foster of Emanuel Colledge, who, it seemeth, hath taken some pains already in it; but then he was to go into the country. I am informed by some fellows in that colledg, that being shortly to depart from the colledg by his time allotted, finding in himself some impediment in his utterances, he could wish to be employed by your lordship in such like business. He is a good scholar and an honest man.' But notwithstanding what is said of the impediment in his utterance, he continued to prosecute his duties in divinity, and was afterwards rector of Allerton in Somersetshire (Mr Baker). Dr Twysden commends him for his skill in mathematics, and sais, he communicated to him his brother's papers, which are published in his miscellanies." [68]

John Palmer was born on 18 November 1612, the first son of Joseph Palmer, gentleman, of Cropredy, Oxfordshire. He was admitted to Emmanuel College on 7 May 1629, received his B.A. 1632-3, and M.A. 1636; his degree was incorporated at Oxford in 1657. He was the Rector of Ecton, Northamptonshire, from 1641-1679, and the Archdeacon of Northampton 1665-1679. He married Bridget, daughter of Clifton Catesby of Ecton, and had two sons, John and Thomas, who also attended Cambridge University. He was buried at Ecton 12 December 1679[69]. Ecton is a beautiful Northamptonshire village, 8 km east of Northampton, on the northern slopes of the Nene Valley. Three kilometers to the south-west, across the river, is the parish of Little Houghton, where Foster's cousin, Thomas Martin, was rector. Palmer's family is well known in Ecton; his son John and grandson Thomas succeeded him as Rector, and Thomas Palmer built the village 'school for poor children', which still bears a memorial to him.

John Twysden was born in East Peckham, Kent, in 1607, the fourth son of Sir William and Lady Anne Twysden. He never married. He was educated at University College, Oxford, the Inner Temple, and qualified in medicine at the University of Angers. Among his non-astronomical publications were a defence of the College of Physicians, and a treatise in defence of Christianity. He was also famous for his "viper powder". He died in 1688, and was buried in St Margaret's, Westminster[70]. I hope to write a further paper on John Palmer and John Twysden.

Conclusion

As with many figures from the 17th century, some much more famous than Samuel Foster, there are a great many questions still remaining about his life, not least most of the ones I set out to answer. Where was he born? What was his family back-

ground? How strong were his ties to Coventry? I have perhaps provided a few more clues, but I am sure there is more evidence to be uncovered.

It would be wrong to over-emphasise Samuel Foster's contribution to astronomy, or his place in its history. He was a competent, but not a great, observer. Although he appreciated the importance of Kepler's 'New Astronomy', he did not master his theories well enough to be able make discoveries of his own, in contrast to his correspondent Horrocks. Foster's major theoretical contribution was to the theory of sundials, something of a backwater in the river of astronomical history. Yet it was in this subject that he was at his most impressive; I think he deserves to be remembered for his developments of spherical trigonometry.

Finally, I was surprised and rather proud that so many of the people covered in this account – Samuel Foster, Jeremiah Horrocks, John Palmer, John Bainbridge, John Wallis – were educated at Emmanuel College. Quite why one small establishment should be so productive during this period is a matter for conjecture, especially as the Cambridge curriculum at that time contained almost no astronomy. It is tempting (if perhaps a little simplistic) to suspect that the radical Protestant ethos of Emmanuel played some part in this remarkable flowering of talent.

Acknowledgements

I am especially grateful to:

Fred Sawyer, of the North American Sundial Society, who provided a large amount of material on Foster, both biographical and on the mathematics of sundials.

Chris Hicks, a work colleague, who provided much useful information about Foster's family background.

Sheridan Williams, author of *UK eclipses from the Year 0*, for checking the circumstances of solar eclipses in 1639 and 1640.

Allan Chapman, the referee for this paper, offered several pages of insightful comment and encouragement. I am very grateful for both.

I also gratefully acknowledge the assistance of the following establishments:

Warwickshire County Record Office (Mr G.M.D. Booth and others).

Northamptonshire County Record Office.

Coventry City Archive (Mr M.J. Hinman).

Emmanuel College Library (Helen Carron, Janet Morris).

St John's College Library (Jonathan Harrison and Alan Purviz).

Cambridge University Library (Adam Perkins and many others).

Material quoted from Samuel Foster's *Miscellanies, or mathematical lucubrations* Edited by John Twysden. London, 1659 is by kind permission of the Master and Fellows of St John's College, Cambridge.

Notes and References

1. Detail on the instrument makers of the time can be found in: D.G.R. Taylor. *The Mathematical Practitioners of Tudor and Stuart England*. London: Cambridge University Press. 1954. Pages 221-222. Allan Chapman discusses Horrocks's usage and development of commercial instruments in: Jeremiah Horrocks, The Transit of Venus, and the 'New Astronomy' in seventeenth century England. *Quarterly Journal of the Royal Astronomical Society*. 1990, 31, 340-343.
2. See, for example, Mike Frost. Some transit tales from history: A very curious astronomer. *Journal of the British Astronomical Association*. June 2005, 115, 132-134.
3. John Aubrey. *Brief Lives*. Oxford: Anthony Wood. 1680. The edition used was: Richard Barber (Editor). First Person Singular. 2004. Page 114. Referred to hereafter as: Aubrey. *Brief Lives*.
4. John Ward. *Lives of the Professors of Gresham College.* London: J. Moore. 1740. Pages 85-88. (Copy held in Cambridge University Library, Classmark Oo.1.32.) Referred to hereafter as: Ward. *Lives of the Professors of Gresham College*. The full text of Ward's entry for Samuel Foster is given as Appendix 4 to this paper.
5. Letter to the author from Mr G.M.D. Booth, Senior Archivist of Warwickshire Record Office, The letter is referenced: 310106/GMDB/lib, and dated 8 February 2006.
6. Foster's Will is Prerogative Court of Canterbury, Public Record Office, London, Prob II 22, Prob 10/746, proved 18 May 1652. Details were supplied by Fred Sawyer of the North American Sundial Society.
7. Mr Chris Hicks.
8. Sarah Bendall, Christopher Brooke and Patrick Collinson. *A History of Emmanuel College Cambridge.* Woodbridge: The Boydell Press. 1999. Pages 76-77.
9. Peter Aughton. *The Transit of Venus – The Brief, Brilliant Life of Jeremiah Horrocks, Father of British Astronomy*. London: Weidenfeld & Nicolson. 2004. Page 33. Referred to hereafter as: Aughton. *Life of Jeremiah Horrocks*.
10. John Venn. *Dictionary of Cambridge Alumni*. Cambridge: Cambridge University Press. 1922.
11. Ward. *Lives of the Professors of Gresham College.* Reference 4. Pages 85-88.
12. Cambridge University Matriculation Register. Held by Cambridge University Library.
13. Venn. *Dictionary of Cambridge Alumni*. Reference 10.
14. Joseph Foster. *Alumni Oxiensis*. Oxford: Clarendon Press. 1892.
15. The author is indebted to Mr Rob Phillips, assistant archivist, King Henry VIII School, Coventry for his help. The extract given is from a letter from Mr Phillips to the author, dated 6 February 2006.
16. Benjamin Poole. *Coventry: Its History and Antiquities.* London: John Russell Smith, 36 Soho Square; Coventry: William Frederick Taunton. 1870. Page 528.
17. Edmund Gunter. *The Works of Edmund Gunter, Containing the Description and Use of the Sector, Cross-Bow, Staff and other instruments, to which is added The description and use of another sector and quadrant both of them invented by Mr. Sam Foster, Late Professor of Astronomy in Gresham College London, furnished with more Lines, and differing from those of Mr Gunters both in form and manner of working.* London: 5th Edition, 1675. A copy is held in Cambridge University Library, Classmarks M.3.57 and CCD.13.23.
18. These documents are located in Coventry City Archives, at Classmark BA/H/K/9-1-3.

19. Ward. *Lives of the Professors of Gresham College*. Reference 4. Pages 85-88.
20. Frederick W. Sawyer III. The 1996 Andrew Somerville Memorial Lecture - Samuel Foster of Gresham College. *British Sundial Society Bulletin* 97.1. January 1997 Page 1.
21. The Gresham College website is www.gresham.ac.uk.
22. I.R. Adamson. *The foundation and early history of Gresham College, London, 1596-1704*. (PhD Thesis. Cambridge University. 1976. Page 145. Referred to hereafter as: Adamson. *History of Gresham College.*
23. Adamson. *History of Gresham College.* Reference 22. Page 87.
24. Adamson. *History of Gresham College.* Reference 22. Page 88.
25. Ward. *Lives of the Professors of Gresham College*. Reference 4. Pages 85-88.
26. Samuel Foster. *The Art of Dialling*. London: 1638. A copy is held in Emmanuel College library at Classmark 17.2.88/ 326.5.102.
27. Foster *The Art of Dialling*. Reference 26. This is the title of the Appendix.
28. Foster. *The Art of Dialling.* Reference 26. Conclusion of the Appendix.
29. Ward. *Lives of the Professors of Gresham College*. Reference 4. Pages 85-88.
30 Ronald G. Hatton and Revd Christopher H. Hatton. Notes on the family of Twysden and Twisden. *Archaeologica Cantiana.* 1945. 58, Page 45.
31. Samuel Foster. *Miscellanies, or mathematical lucubrations*. Edited by John Twysden. London: 1659. A copy is held in St John's College library at Classmark 2.47.24; accessed by kind permission of the Master and Fellows of St John's College, Cambridge. Referred to hereafter as: Foster. *Miscellanies*.
32. Foster. *Miscellanies*. Reference 31. Introduction.
33. David McGrory. *The Illustrated History of Coventry's Suburbs.* Derby: Breedon Books. 2003. Page 91.
34. Mike Frost. A Warwickshire Eclipse. Society for the History of Astronomy, *Newsletter*. Issue 5. November 2004. Pages 7-10.
35. Ronald G. Hatton and Revd Christopher H. Hatton. Notes on the family of Twysden and Twisden. *Archaeologica Cantiana.* 1945. 58, Page 53.
36. E-mail from Mr M.J. Hinman, Coventry City Archives, dated 10 April 2006.
37. Aughton. *Life of Jeremiah Horrocks.* Reference 9. Page 148.
38. Foster. *Miscellanies*. Reference 31. Observationes Eclipsum.
39. Sheridan Williams. *UK Solar Eclipses from Year 1.* Leighton Buzzard: Clock Tower Press. 1996. Section 5.11.
40. Aughton. *Life of Jeremiah Horrocks.* Reference 9. Page 147.
41. Aughton. *Life of Jeremiah Horrocks.* Reference 9. Page 107.
42. H.K Higton. Nathaniel Nye in: *Oxford Dictionary of National Biography*. Oxford: Oxford University Press. 2004. Page 301.
43. Taylor. *The Mathematical Practitioners of Tudor and Stuart England*. Reference 1. Pages 221-222.
44. The following Nathaniel Nye manuscripts are held either digitally or on microfiche in Cambridge University Library (C.U.L.):

    A new almanacke and prognostication for the Year of Our Lord God, 1642, by Nathaniel Nye. Held on microfiche in C.U.L. at Classmark B125:2.9, Reel 340.9.

    *A new almanacke and prognostication for the year of our Lord God, 1643, being the third from the leap year, calculated exactly for the town of Birmicham [Birmingham] in Warwickshire ... by Nathaniel Nye, Mathematitian and Practitioner of Astronom*y. Two copies held digitally, and on microfiche in C.U.L. at Classmark WING/B125:2.9, reel 1517:21 and reel 908:35.

    A prognostication for the year 1645, by Nathaniel Nye. Held on microfiche in C.U.L. at Classmark B125.2.9 Reel 1517:21 and Reel 1539:5.
45. A catalogue of Mercury transits can be found at http://sunearth.gsfc.nasa.gov/eclipse/transit/catalog/MercuryCatalog.html Mercury transits are far more common than those of Venus. Those calculated to have occurred between 1631 and 1677 are (dates are New Style):

    1631 Nov 07 observed by Gassendi and others (the first recorded Mercury transit).

    1644 Nov 09 not observed, to my knowledge

    1651 Nov 03 observed by Jeremy Shakerley from India.

    1661 May 03 observed by Huygens and Hevelius.

    1664 Nov 04 not observed, to my knowledge.

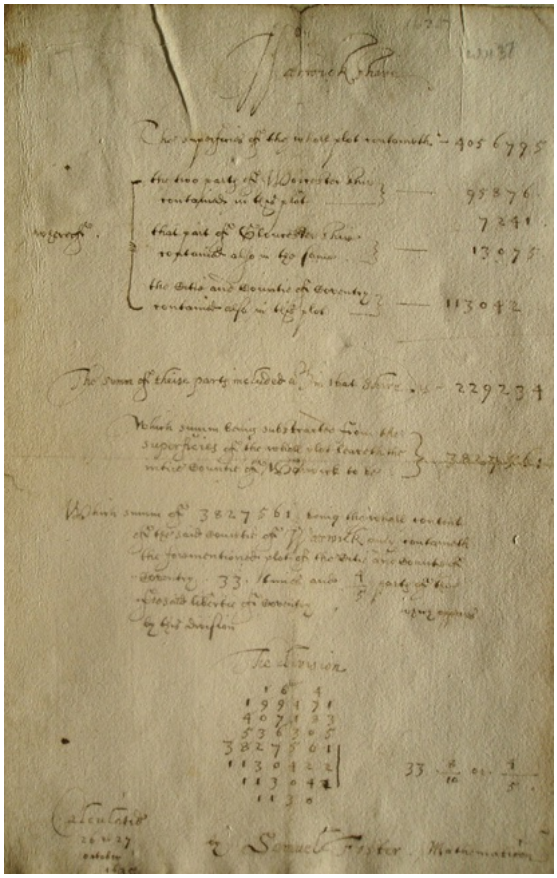
    1674 May 07 not observed, to my knowledge.

    1677 Nov 07 observed by Halley (from St Helena).
46. E.G. Forbes. *The Gresham College Lectures of John Flamsteed*. 1975. Pages 8-9.
47. Aughton. *Life of Jeremiah Horrocks.* Reference 9. Various pages in Chapter 1.
48. Aughton. *Life of Jeremiah Horrocks.* Reference 9. Page 2, quoting John Wallis's introduction to the 1661 edition of Horrocks's *Venus in Sole Visa*.
49. Contemporary copies of the manuscript of *Venus in Sole Visa* (Jeremiah Horrocks, 1640) are held in Cambridge University Library at Classmarks RGO 1.68 C, RGO 1.76 and Add 9320.
50. Taylor. *The Mathematical Practitioners of Tudor and Stuart England*. Reference 1. Page 222.
51. Adamson. *History of Gresham College.* Reference 22. Page 93.
52. Adamson. *History of Gresham College.* Reference 22. Page 88.
53. Foster. *Miscellanies*. Reference 31. Papers on An epitome of Aristarchus of Samii, Proposition XVII; Problemata Geometrice Varia; and how the theorie of the planets are made.
54. Ward. *Lives of the Professors of Gresham College*. Reference 4. Pages 85-88.
55. Frederick W. Sawyer III. The 1996 Andrew Somerville Memorial Lecture - Samuel Foster of Gresham College. *British Sundial Society Bulletin* 97.1. January 1997. Page 11.
56. Fred Sawyer. The Further Evolution of Samuel Foster's Dialling Scales. North American Sundial Society *Compendium.* September 2001, 8 (3), 28-31.
57. Aubrey. *Brief Lives*. Reference 3. Page 115.
58. H.K Higton. Nathaniel Nye in: *Oxford Dictionary of National Biography*. Oxford: Oxford University Press. 2004. Page 301.
59. Adamson. *History of Gresham College.* Reference 22. Page 146.
60. Aubrey. *Brief Lives*. Reference 3. Page 314.
61. Ward. *Lives of the Professors of Gresham College*. Reference 4. Pages 85-88.

62. Ward. *Lives of the Professors of Gresham College*. Reference 4. Preface, Pages x-xi.
63. Ward. *Lives of the Professors of Gresham College*. Reference 4. Pages 85-88.
64. See Note 6.
65. Poyner's Will is in Northamptonshire Archdeaconry Admons 1677-1710, granted 22 Mar 1686/7. I am grateful to Chris Hicks for providing me with this information.
66. Ward. *Lives of the Professors of Gresham College*. Reference 4. Pages 85-88.
67. Samuel Foster (John Twysden). *The Whole Art of Reflex Dialling.* London: 1658. A copy of this book is held in Emmanuel College Library at Classmark Ss.6.9 / 333.3.89.
68. Ward. *Lives of the Professors of Gresham College*. Reference 4. Pages 85-88.
69. John Venn. *Dictionary of Cambridge Alumni*. Cambridge: Cambridge University Press. 1922.
70. Ronald G. Hatton and Revd Christopher H. Hatton. Notes on the family of Twysden and Twisden. *Archaeologica Cantiana.* 1945. 58, Page 53.

Appendix 1

Foster's calculations of the acreage of Coventry and Warwickshire



Source:
Coventry City Archives, Classmark BA/H/K/9-1-3

Appendix 2

Certaine Observations and new discoveries made in the Celestial Regions

by Nathaniel Nye

"Many singular inventions and discoveries have proceeded from the Astronomers of late times, as first M.Galileus Mathematician to the Duke of the Medicis a principall furtherer of the Perlyeatyue [??] glasses he hath observed by them, that the fixed stars do not borrow their light of the Sun as other wandering and inferior stars, which observe their motion about the Sun, but to glitter in their own light as the Sun doth. That the Planet Jupiter hath 4 moons circling about his body, as the globe of the Earth hath one. Saturn is of a Triquetrallforme [i.e. three parts, Galileo and Nye being unable to distinguish the rings of Saturn]. That Venus both borrows her light of the Sun as the moon doth, appearing sometimes full of shape as the Moon doth at the full and sometimes halfe light, and sometimes more or less just as the moon doth alter her motion, being about the Sun. That the Moon hath divers Mountains, Vallies, Sea and Land, and an Atmosphere of Aire, encompassing her body as hath our Earth. That as we receive light from the Moon, so the Moon receives light from us. That the Sea is caused to ebb and flow by the Earth's motion about the Sun. That there are no solid orbs. That the Sun hath divers spots as well as the Moon and observes a revolution about his own centre in 28 days. That the Sun moves not about the Earth but the Earth about the Sun once a year and about its own centre every 24 hours. That the Refraction maketh the Sun to seeme about its sitting halfe a deg: more above the horizon, than indeed it is, and therefore under both the Poles they have day a long time together. That no planet is bigger than the Earth (the Sun excepted) but lesser many hund. [hundred?] times, and this is easily proved, the Moon must then be bigger than any of the other planets, being but less than the Earth 42 times "

Source:
Extract from: *A new almanacke and prognostication for the year of our Lord God, 1643, being the third from the leap year, calculated exactly for the town of Birmicham [Birmingham] in Warwickshire* ... by "Nathaniel Nye, Mathematitian and Practitioner of Astronomy" (1643). Copies held digitally and on microfiche in Cambridge University Library at Classmark WING/B125:2.9, reel 1517:21 and reel 908:35.

Appendix 3

How to behold an Eclipse of the Sun or when Venus and Mercury come under the Sun

by Nathaniel Nye

" Take a good perspect glasse and draw it out to its markes, then go into some darke room where

> the Suns-light frequents and make a hole to put your glasse out at just before the Sun, so as the Sun may shine through your glasse, and be sure that the Sun shine not on each side of your glasse, the plain glasse must be next the Sun, and the concave glasse must be within. Then take a piece of paper about a quarter of a sheet, and the Sun shining through the perspect and nowhere on each side of it, hold your paper about halfe a yard from the end of the glasse and upon the paper you may see the body of the sun and its spots, and if Venus or Mercury come under the Sun, you may observe their diameter and continuance upon the Sun, and when an Eclipse begins and ends."

Source:

Extract from: *A new almanacke and prognostication for the year of our Lord God, 1643, being the third from the leap year, calculated exactly for the town of Birmicham [Birmingham] in Warwickshire* ... by "Nathaniel Nye, Mathematitian and Practitioner of Astronomy" (1643). Copies held digitally and on microfiche in Cambridge University Library at Classmark WING/ B125:2.9, reel 1517:21 and reel 908:35.

Appendix 4

John Ward's Account of Samuel Foster

> " Samuel Foster was born in Northamptonshire, and admitted a sizar at Emmanuel college in Cambridge on 23 of April 1616, where he took the degree of batchelor of arts in the year 1619, and that of master in 1623. The following year he published his treatise, called "The Use of the Quadrant". He never had a fellowship, and is therefore placed by Mr. Fuller among the learned writers of the college, who were not fellows (Fuller, History of the University of Cambridge, p. 147).
>
> " His inclination led him chiefly to the mathematics, and upon the death of Mr. Gellibrand, astronomy professor in Gresham College, he was chosen in his room, upon the 2 March 1636; but quited the place again on the 25 of November following, and was succeeded by Mr. Mungo Murray.
>
> " After the surrender of his professorship, he continued to pursue his mathematical studies, and in the year 1638 published his Art of dialling. But in the year 1641 that professorship being vacant again by the marriage of Mr. Murray, he applied for it, and was rechosen May the 26th of that year. And upon the breaking out of the national troubles, which soon followed his return to Gresham College, he was one of that worthy and learned society of gentlemen, who met in London for cultivating the new philosophy, of which an account has been given in the preface. In 1646 Dr. Wallis, who associated with them, received from Mr. Foster a theorem De Triangula Spherico, which he afterwards published. The happy effect of these meetings, both at London and Oxford, in laying the foundation of the royal society, has been shewn already, tho Mr. Foster did not live to see it, for he died in Gresham college in the moth of July 1652, and was buried in the church of St. Pete the Poor in Broadstreet.
>
> " Dr. John Twysden gives his character of "a learned, industrious and most skilful mathematician" the truth of which he has abundantly shown by his works. Not only did he excel in his own faculty, but was likewise well versed in the ancient languages, as appears by his revising and correcting the Lemmata of Archimedes, which had been translated into Latin from an Arabic manuscript, but not published, by Mr. John Greaves. He made several curious observations of the Sun and Moon, as well as at Gresham College, as in other distant places (see his Miscellanies). And he was particularly famous for inventing and improving many planetary instruments. He published little himself, but many treatises written by him were printed after his death. Tho, as Dr. Twysden and Mr. Wingate say (to whom the public is obliged for them) "being disabled by his great and long infirmities to fit them for the press, as he desired and intended, they must needs want very much of the accomplishment, which otherwise they would have had." And Mr. Twysden complains "That some persons having got into their hands some things of Mr. Foster's, which out of that diffusive goodness and candour of disposition, that was in him, he communicated to others; had under a disguised face vented them as their own."

Source:

This extract is from: John Ward. *Lives of the Professors of Gresham College.* London: J. Moore. 1740. Pages 85-88. The material quoted is on pages 85-87.

Reverend Doctor William Pearson in South Kilworth, Leicestershire

Mike Frost
Past-Chairman, Coventry and Warwickshire Astronomical Society

William Pearson (1767-1847) was a 19th-century astronomer, renowned for his work in positional astronomy and the design of astronomical instruments, both practical and instructional. He was a co-founder in 1820 of the Astronomical Society of London, which later became the Royal Astronomical Society, where his portrait hangs. For 30 years of his astronomical career he was the Rector of South Kilworth, a village in Leicestershire, England, where he erected several observatory buildings, as well as extending the village church and building the village schoolroom. This paper documents his activities in South Kilworth.

In 2003 I was invited by friends to visit their house – the Observatory, South Kilworth, England. The house was built in 1834 by the Reverend Doctor William Pearson (1767-1847), who was Rector of South Kilworth from 1817 to 1847. From this quiet south Leicestershire village, Pearson carried out a decades-long programme of stellar observation.

From information supplied by the owners of the Observatory, I wrote a brief article about Pearson's life, which was published in July 2006[1]. The principal sources for that article were a biographical article from the *Quarterly Journal of the Royal Astronomical Society*[2], and Pearson's obituary in the *Monthly Notices of the Royal Astronomical Society*[3], fleshed out with detail from articles in the South Kilworth parish magazine[4].

The purpose of this paper is to record some of the additional material relating to Pearson's life in South Kilworth that I have identified.

The Life of William Pearson

William Pearson was born in Whitbeck, Cumbria, England on 23 April 1767. He attended Hawkshead Grammar School. William Wordsworth, three years his junior, was a fellow student. In later years they had correspondence over a boathouse on the shores of Grasmere that Pearson built, of which Wordsworth disapproved. Wordsworth wrote[5]:

> " His manners when he came to Hawkshead were as uncouth as well could be, but he had good abilities, with skill to turn them to account."

Pearson's early career was as a schoolmaster, first at Hawkshead Grammar School, then in 1793 in Lincoln. He was owner of preparatory schools in Parson's Green, London (1800) and East Sheen, London (1811). In parallel, he became, in 1793, curate of St Martin's church, Lincoln; and was Rector of Perivale, near East Sheen, between 1810 and 1812.

Perhaps his most lasting achievement was the foundation, in conjunction with Francis Baily and others, in 1820, after several attempts, of the Astronomical Society of London. This society, of which Pearson was the Treasurer between 1820 and 1827, became the Royal Astronomical Society (R.A.S.) in 1831. A family portrait (Figure 1) of Pearson, his first wife Frances and his daughter, also named Frances, hangs in the Council Room of the R.A.S. in Burlington House, London.

Figure 1

William Pearson and family

Also visible is one of the orreries that Pearson designed.
By courtesy of the Royal Astronomical Society.

Pearson was famous as a designer and manufacturer of instruments such as orreries, satellitia and planetaria. He began to build these during his time in Lincoln, probably as demonstration

Figure 2

A satellitium designed by William Pearson and built by J Fayrer

Top image: The Fayrer satellitium and its accessories. The two candle holders to the bottom left probably represent the Sun and the Earth. The circular brass disk contains zodiacal markings. **Centre image**: A detail of the satellite model itself. It measures approximately 12 x 8 x 2 inches. The handle turns a crank at the bottom right-hand corner of the mechanism. **Bottom image**: The satellitium in its carrying box.

These photographs are published by courtesy of the Museum for the History of Science, Oxford.

aids for his public lectures. However, from 1802 he was designing instruments for Thomas Young at the Royal Society. He also designed clocks, one of which is in possession of the Royal Astronomical Society. Surprisingly few of Pearson's other instruments seem to have survived, but one that has is a satellitium, shown in Figure 2. This was built to Pearson's design by James or John Fayrer of Pentonville, London. It demonstrate the movements of the Galilean satellites of Jupiter. I viewed the satellitium in 2005, and am pleased to report that it is still in good working order.

Pearson began his career as an observational astronomer at the observatory which he built in East Sheen. However, his major work was done once he had moved to South Kilworth in 1821. In his early years in the village, Pearson wrote the magisterial, two-volume work *An Introduction to Practical Astronomy*[6], for which he was awarded the Gold Medal of the R.A.S. for 1829.

His first wife died in 1831, and he remarried shortly after to Eliza Sarah, a woman 35 years old, the same age as his daughter. He died in 1847, out-lived by his daughter and second wife.

The Rectory Observatory

According to *White's Leicestershire Directory* for the year 1846[7]:

> " Kilworth (South) is a pleasant village, on the northern declivity of the river Avon, and on the Rugby and Market Harborough road, 3 miles W.N.W. of Welford, and 4½ miles E.S.E. of Lutterworth. Its parish has 478 inhabitants and 1418 acres of fertile land, mostly having a gravely soil."

The major landholders are listed as: "The Baroness Bray, lady of the manor … Pearson, … and a few smaller freeholders." It states that the rectory has 257 acres of glebe land, mostly allotted to the church in lieu of tithes at the time of enclosure in 1789. Figure 3 is taken from the ordnance survey map of South Kilworth (second edition 1901) since when the village has expanded little.

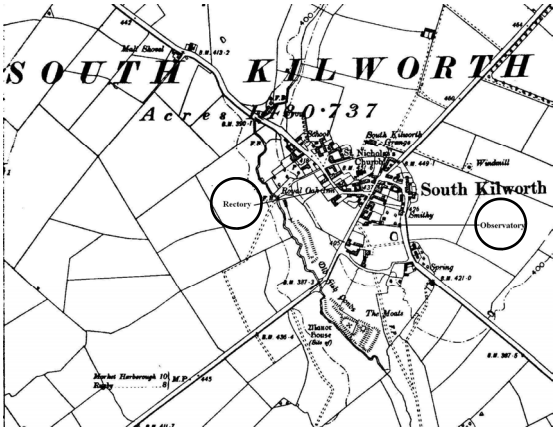


Figure 3

South Kilworth in the year 1901

This detail is from the Ordnance Survey Leicestershire Sheet LIII. Scale 1:10560. North is at the top. The indicators showing the position of the Rectory and of the Observatory are additions by the author.

Figure 4

St Nicholas church, South Kilworth, in 1821

This view, from the north-west, shows how the church looked when William Pearson first occupied the rectory.
County History of Leicestershire

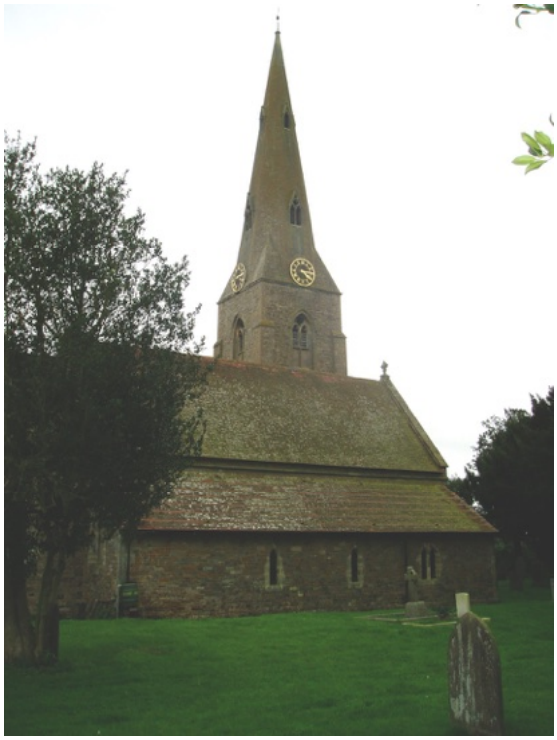


Figure 5

St Nicholas's church, South Kilworth, in 2006

Photograph from the north-east by the author.

William Pearson was made Rector of St. Nicholas's church in 1817, through the benefice of Lord Chancellor Eldon (whose grandson had been one of Pearson's pupils at East Sheen)[8]. However, he did not move to the village until 1821, after selling his very successful East Sheen preparatory school. Figure 4 shows how the church appeared when he first arrived in the village[9]. He substantially remodelled the church in 1840, building a new north aisle, which incorporated the Norman arches visible in Figure 5. *White's Leicestershire Directory* also mentions work on the south aisle in 1836. Unfortunately, his modifications were not successful and the nave had to be rebuilt by his nephew in 1868/9. Figure 6 shows a modern view of the church, with its much more substantial nave.

Figure 6

The southern aspect of the east wing of the South Kilworth rectory

Photograph by the author, September, 2006.

The Rectory stands immediately to the south of the church. Pearson built a new east wing to act as an observatory. Two sturdy brick pillars were bedded five feet into the ground, extending up to an upstairs observatory, to act as stands for Pearson's main two telescopes: a transit telescope probably by one of the father and son instrument makers, Thomas Jones of London (not yet confirmed), and an altitude and azimuth circle by Edward Troughton (1753-1835). The two pillars still stand within the east wing, but are not photogenic. However, the south-facing windows, through which the two telescopes were pointed, are clearly visible in Figure 6. Shutters in the roof gave each instrument a 180 degree view in the meridian, but neither the shutters nor the north-facing windows are now present.

In the gardens of the rectory, Pearson built a summer-house observatory, fitted with a conical revolving roof, running on rollers. There is now no clear evidence of where it stood. The roof was originally built in 1788 by John Smeaton (1724-1792) for the observatory of Alexander Aubert in Highbury. Pearson purchased it in 1806, after Aubert's death[10]. Revolving roofs for observatories were not common at the time. The flexibility afforded by such a roof meant that the telescopes in the summer-house could be used easily for plane-

tary observations rather being limited to the meridian. Pearson used a Tulley 6.8 inch refractor[11].

Martin Lunn of the Yorkshire Museum traced the history of the summer-house roof, and the telescopes held within. He wrote[12]:

> " The Rev William Pearson was very instrumental in the creation of the York Observatory. As you probably know, the York Philosophical Society built the Yorkshire Museum in 1829. In 1831 they hosted the very first meeting of the British Association for the Advancement of Science at the Yorkshire Museum. At that meeting the BA suggested that if the YPS would construct an observatory, members of the BA including Pearson would donate equipment.
>
> " Pearson donated a telescope, clock, plus books and charts. Unfortunately the telescope disappeared in the 1950s. We still have the original clock, which is a Barraud of 1811, which is still in perfect working order. There are some star charts, which we have recently discovered buried deep in our library; they had been lost for at least 50 years. These quite possibly were the ones donated by Pearson.
>
> " We have in the observatory a picture of the summer house roof that Pearson was offering to the YPS. However it was never used. A conical roof instead was used. It is unclear whether that was given by Pearson or was built here in York."

Figure 7 shows the original design for the York observatory, and the design as implemented. The former is clearly far too ornamental for practical use by York Observatory or by Pearson; perhaps this was the original roof of Pearson's summer-house. The practicable design bears a much closer resemblance to the design of roof from East Sheen, as shown in Volume 2 of *An Introduction to Practical Astronomy*. In particular, note the use of rollers immediately beneath the conical dome.

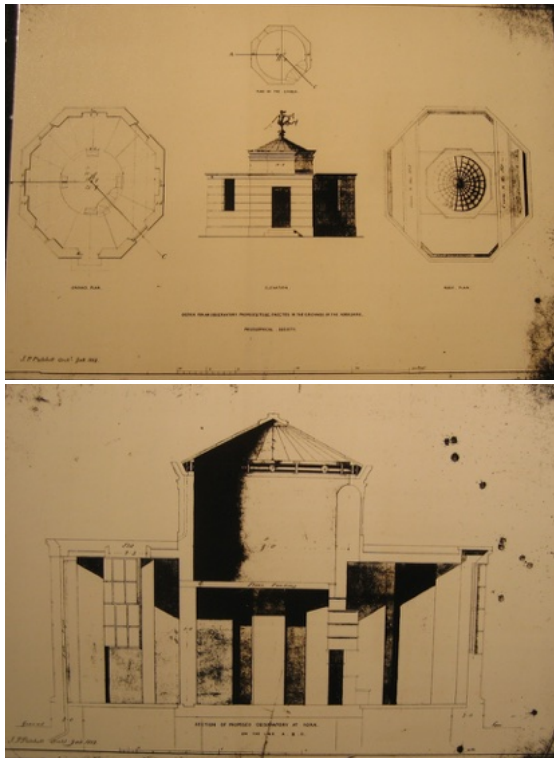


Figure 7

Plans of York Observatory

The original design is shown in the top image. The bottom image shows the observatory actually built.

Images courtesy by of Pip Strang, Yorkshire Museum, June 2006.

The South Kilworth Observatory

In 1834, Pearson decided that his observations were being spoilt by smoke from the houses to the south of the rectory[13]. He resolved to build a new observatory on the southern edge of the village, on glebe land. Figure 8 shows a plan and elevation of the new observatory.

The main structure is a two-storey octagonal building. Single-storey side rooms are attached to the west, east and north. The north room acted as a vestibule for the observatory. Presumably the side rooms allowed Pearson's assistants to time and record observations without allowing stray light into the main observatory. The upper stories are fitted with floor-to-ceiling, which therefore acted as the openings for the telescope(s). It appears that Pearson did not build instrument stands as he did in the rectory summer-house observatory.

The roof, like the observatory, had an octagonal structure (Figure 8), and was likely to have been tiled with either copper or lead tiles. The roof was topped by a copper boss, recently removed. There is evidence inside the roof of iron tie-bars holding it together. Ties went to each of the octagonal corners, and to the centre of each of the eight panels, except for those facing south and facing north. Horizontal, threaded, iron tie-bars held the octagonal shape. There is no evidence of a ceiling between the upper storey and the roof. This is similar to arrangements in the rectory east wing, allowing a 180 degree view along the meridian, with the north and south panels of the octagon being openable or detachable. There is no evidence that the roof could be rotated.

Due north from the rectory, was marked by a line painted on a nearby wall[14]. For the meridian from the new observatory, Pearson built a farmhouse 400 yards to the south, with a meridian mark built in. Unfortunately, this is now obscured.

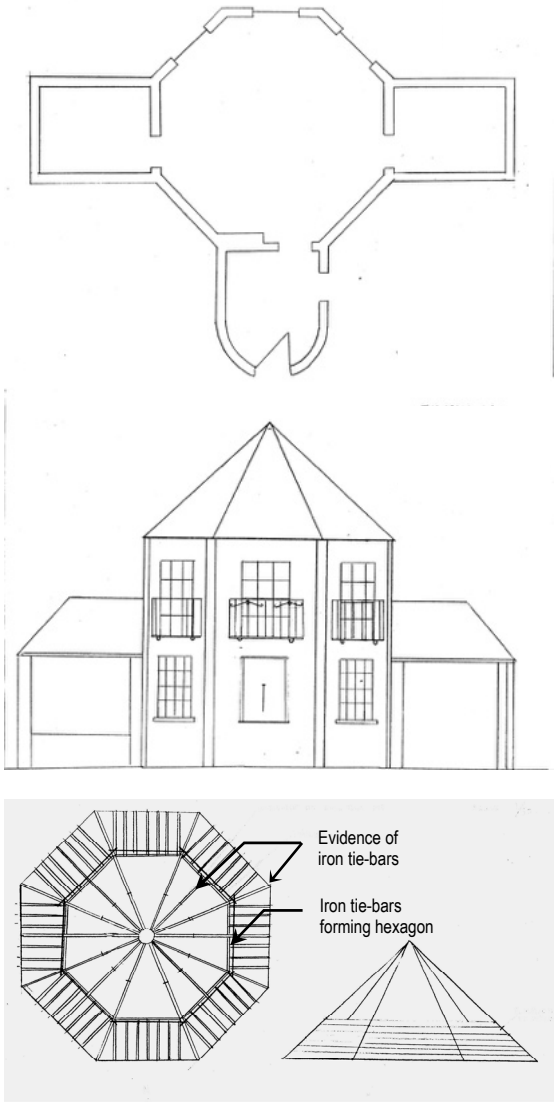


Figure 8

Pearson's South Kilworth observatory

The top and middle panels show, respectively, the plan and north elevation of the observatory. The bottom panel shows detail of the roof construction. In the plan, north is at the bottom. The scale in all panels is 1:50.

Two major observing programmes spanned Pearson's occupancy of the rectory and the observatory[15]. Between 1830 and 1838 he repeatedly observed and catalogued 520 stars capable of being occulted by the Moon. The second programme, carried out between 1828 and 1838, consisted of a series of observations of the Sun's altitude at noon, from which Pearson deduced an estimate of the obliquity of the ecliptic. Pearson's chief assistant for these observations was Ambrose Clark, who had earlier been studying mathematics privately. Village schoolmaster, Thomas Pooley, had been an earlier assistant.

After Pearson's death, the observatory went into decline. It was used first as a granary and then as a cowshed. However, in 1960 it was renovated and converted into a private dwelling. Figure 9 shows photographs, taken by the original renovator, and now in the possession of the current owners, of the Observatory as it appeared in 1960. On the south elevation (top panel) a sundial can be seen, mounted in the blocked off lower window. Figure 10 shows the dial in detail. At the top the geographical coordinates are given as: "N. Lat. = 5° 26' 47". - W. Long. 4' 26"." It was removed to the Snibston Discovery Park, Leicester, where it remains in storage; my attempts to view it have so far been unsuccessful. Figure 11 shows the Observatory as it appeared in 2004. Pearson's observatory is now a modern, comfortable home. The current owners are further renovating and extending the property, but we can be reassured that as it is in the hands of Pearson admirers, the work will be sympathetic to the building's heritage.

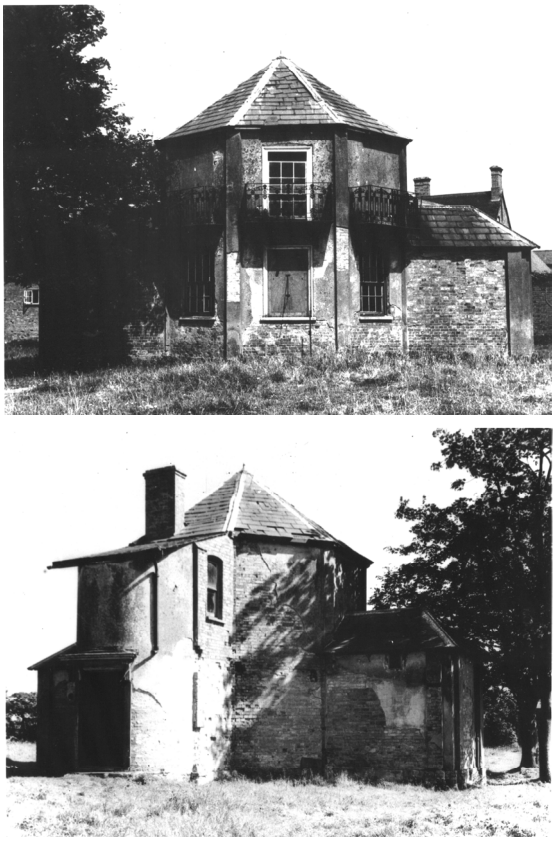


Figure 9

The Observatory in 1960

The top panel shows the south elevation.
The bottom panel is taken from the north-east.
These photographs are published courtesy of
David and Sue Dilks.

Figure 10

The sundial on the Observatory in 1960

This photograph is published by courtesy of David and Sue Dilks.

Figure 11

The Observatory in 2004

Photograph taken by the author from the south-east.

Pearson's Legacy in South Kilworth

It is difficult to form a definitive impression of Pearson's character. It is possible to trace a development of self-confidence and social standing, from the "uncouth" farmer's son studying at Hawkshead Grammar School; to the enthusiastic lecturer on astronomical matters in Lincoln and then London, designing his own orreries; to the owner of a thriving and profitable school, hobnobbing with the aristocracy. To my eye, the R.A.S. portrait shows a man confident in his career and circumstances.

Yet in 1817, even as he used his influence in London to assist in the founding of a Society for astronomers, Pearson accepted the Rectorship of a quiet, south Leicestershire village; and in 1821, whilst he was Treasurer of that very same society, and visitor to the Royal Observatory, Greenwich, he sold his profitable business in East Sheen and moved permanently to the Midlands. However, he continued to visit London on a regular basis.

Certainly Pearson threw himself enthusiastically into an observing programme. The suspicion must be that he wanted to reduce external commitments so as to concentrate on his observations, and the production of his magnum opus - *An Introduction to Practical Astronomy*. Yet, after four years as an absentee Rector, he also became a valued member of the South Kilworth community. He was a Justice of the Peace, sitting in nearby Lutterworth, and a freeman of the Borough of Leicester[16]. And, perhaps because of his earlier career as a schoolmaster, Pearson was determined to build a schoolhouse in South Kilworth.

A history of the South Kilworth schoolhouse reveals a campaign by Pearson during the early 1830s to secure funding for the erection of a new building, through the auspices of the National Society for Promoting the Education of the Poor in the Principles of the Established Church[17]. A letter dated 20 December 1833 reads:

> " I thank you for your obliging communication on the subject of the Assistance to be afforded in erecting a school by the committee of the National Society. I have looked over the printed Papers sent me at different times but cannot find the form of the Petition you allude. I think it was used on a former occasion when I made my first application."

The second application still exists, dated 29 January 1834. In a letter dated 11 March 1834, Pearson made clear the extent of his personal support for the scheme:

> " The Lord Bishop of Lincoln has been so good, as to inform me, that he forwarded my application of last month for pecuniary assistance towards building a school house. I recollect however that I omitted to state, that I propose to erect a school house for the Master and Mistress at my own expense as an appendage to the school; and if this addition be not recognised by the National Society, I shall certainly subscribe £30; the farmers not being able to advance any money by way of subscription. I have the honour to be, sir, your very humble servant W.Pearson."

South Kilworth was one of the first schools in the country to receive a grant. The schoolrooms opened later in 1834. However, like Pearson's building activities in the church, the construction of the school was not a complete success. A letter[18] from Assheton Pownall, Pearson's successor, to the National Society, in 1851, reveals that:

> " Seventeen years ago, my predecessor built a schoolhouse here, but unfortunately it was badly built, not large enough for our wants. I therefore very much wish to build a new school room more suited to our present requirements, and if I could succeed in this propose giving up one of those now in use, to the teachers, while I retain the other as a classroom."

Another insight into Pearson's character comes from two books bought at auction by the current owner of South Kilworth Rectory. They come from Pearson's personal library and bear his name plate: *Martial Biography, or Memoirs, of the Most Eminent British Military Characters* and *Lives of Illustrious Seaman*. Both were published in 1803 by J. Cundee of Ivy Lane, London. The titles suggest civic pride, patriotism, and perhaps a sense of self improvement.

Pearson observed from South Kilworth almost until his death in 1847, although the pace of his life slowed following a fall from his horse in 1844. Pearson is buried in the graveyard of St. Nicholas's church (Figure 12). The grave is in poor repair and the inscription on the headstone is illegible. There are two memorials to Pearson within the church. One is a wooden plaque recording his gifts to the parish:

> " The Revd Dr Pearson gave in 1846 the interest on L200. to Trustees for the education of ten poor Children of this Parish. Also a finger-organ by GRAY with two barrels for psalmody to the Rector and Churchwardens of this Parish for the time being. Also a service of new Plate for the Communion."

The second memorial at higher level (Figure 13) is carved in marble. This memorial is surmounted by a telescope, globe and books.

Figure 12

William Pearson's grave,
St Nicholas's church, South Kilworth

(Photograph by the author, June 2004)

Figure 13

The memorial to William Pearson
St Nicholas's church, South Kilworth

" To the Memory of the Rev^{d} W^{m} Pearson, L.L.D. F.R.S. Rector of South Kilworth Who Departed this life on the 6th September 1847 in his 81st year of his age. Universally Beloved and Regretted."

(Photograph by the author, June 2004)

Pearson's legacy to astronomy was the body of his observations; the instruments he built; his mammoth guide to serious observing, *An Introduction to Practical Astronomy*; and above all his rôle in the founding of the Royal Astronomical Society. In South Kilworth, he is perhaps better known for the work he carried out, unsuccessfully, on the church, and rather more successfully to The Rectory; his new observatory to the south of the village; and perhaps most importantly, the erection of a village schoolhouse. Those who care about the history of the village have made sterling efforts to preserve the memory of his achievements.

Acknowledgements

Peter Hingley and Reg Withey for encouragement to write this article. Peter Gill, the independent reviewer, for his helpful comments and suggestions. Chris Hicks, my colleague, and a member of Rugby Local History Research Group, who provided material from *White's Leicestershire Directory* and the 1901 Ordnance Survey map of South Kilworth. Martin Lunn and Pip Strang, from the Yorkshire Museum, for providing information on Pearson's summer-house roof. Jim Bennett, from the Museum for the History of Science, Oxford, gave permission to use the photographs of the Fayrer satellitium. I am especially grateful to David and Susan Dilks of The Observatory, South Kilworth, and to Jacky Harrison of The Rectory, South Kilworth. These owners of Pearson's houses in the village have collected a huge amount of information on Pearson, and were kind enough to help a fellow Pearson enthusiast.

Notes and References

1. M.A. Frost. The Rector of South Kilworth. Society for the History of Astronomy *Newsletter*. Issue 11. July 2006. Pages 11-14.
2. S.J. Gurman and S.R. Harratt. Revd Dr William Pearson (1767-1847): a Founder of the Royal Astronomical Society. *Quarterly Journal of the Royal Astronomical Society*. 1994, 35, 271-292. Referred to hereafter as: Gurman and Harratt. *Pearson*.
3. Anonymous. Revd William Pearson, from the Report to the Twenty-eighth Annual General Meeting of the Royal Astronomical Society. *Monthly Notices of the Royal Astronomical Society*. 1847, 8, 69-74.
4. D.A.L.Harrison. The Life and Times of a former Rector." In three parts in: *Parish Magazine of St Nicholas's church, South Kilworth*. Dates not known.
5. William Wordsworth. *Poetical Works*. Oxford: Clarendon Press. 1949. Pages 456-457. Reproduced in: T.W.Thompson. *Wordsworth's Hawkshead*. London: Oxford University Press. 1970. Page 359. Fletcher Christian, the Bounty mutineer, was also a student of Hawkshead Grammar School around this time, although as he was three years older than Pearson, and Pearson attended the school late in his childhood. There is no record of any contact between the two.
6. Rev. W. Pearson. *An Introduction to Practical Astronomy: Containing Tables, Recently Computed, for Facilitating the Reduction of Celestial Observations and a Popular Explanation of their Construction and Use*. Volume I. London: Privately printed for the author, and sold by Messrs Longman, Hurst, Rees, Orme, Brown, and Green, Paternoster Row. 1824. A second volume was published later: Rev. W. Pearson. *An Introduction to Practical Astronomy: Containing Descriptions of Various Instruments, that have been Usefully Employed in Determining the Places of the Heavenly Bodies, with an Account of the Methods of Adjusting and Using them*. Volume II. London: Privately printed for the author, and sold by Messrs Longman, Rees, Orme, Brown, and Green, Paternoster Row. 1829.
7. *White's Leicestershire Directory*. 1846. Page 394.
8. Pauline Martin. *The moles have been at it again - a history of South Kilworth School*. Privately produced in South Kilworth. 2001. Page 5. Referred to hereafter as: Martin. *South Kilworth School*.
9. This image is taken from un unreferenced and undated leaflet available in St Nicolas's Church, South Kilworth: S.W.Doggett, M.A. Rector, Amner Turnbull and John Richards, Churchwardens. *A History of South Kilworth Church*. May 1986. The source of the image is said in the leaflet to be Nichols's *County History of Leicestershire*.
10. Gurman and Harratt. *Pearson*. Page 281.
11. For details of Pearson's instruments at South Kilworth, see: Derek Howse. The Greenwich list of observatories: A world list of astronomical observatories, instruments and clocks, 1670-1850. *Journal for the History of Astronomy*. Number 51. November 1986, 17 (4), i-iv, 1-100. Page 81.
12. Martin Lunn (Yorkshire Museum staff). Personal communication (e-mail) dated 13 September 2006.
13. Gurman and Harratt. *Pearson*. Page 287.
14. Gurman and Harratt. *Pearson*. Page 287.
15. Gurman and Harratt. *Pearson*. Page 287.
16. Gurman and Harratt. *Pearson*. Page 288.
17. Martin. *South Kilworth School*. Pages 2-4.
18. Martin. *South Kilworth School*. Page 5.

Comet Halley 1910: A Local Experience

Bruce Harper
Coordinator, West Moreton Astronomy Network

This paper deals with the 1910 approach and passage of Comet Halley as reported in the *Queensland Times* in Ipswich, Queensland, Australia. Readers of the newspaper were given regular reports on the comet, as well as scientific and historical background information. While reports of superstition and panic came from other countries, the local scene was apparently one of calm. In the opinion of the author of this paper, that was due in part to the way in which the newspaper coverage was handled. It was also consistent with anecdotes of the comet that he had heard from his grandparents and other local people.

In 1910, the small Australian city of Ipswich, in southeast Queensland, was home to the author's four grandparents, then in their early twenties. They saw Halley's comet — as it was called in those days — and during the course of the next half-century, naturally told their descendants about it. The same sort of thing happened in families throughout the world, adding personal dimensions to the long wait for the 1986 return.

It is well-known, however, that the 1910 approach of Comet Halley had been awaited with a certain amount of apprehension in some quarters. The story is familiar: Astronomers had determined that Earth would pass through the tail. Many people, despite assurances that nothing was going to happen, were swept up in a mood of doom and gloom. Yet the recollections of the author's grandparents, and other local people, suggested that nothing of the sort had happened locally. Was that true, or just stoic concealment of the truth?

Other questions came to mind. How were the approach and passage of the comet reported locally? What kind of information about the phenomenon was available in the local newspaper? What kind of general astronomical information was published in the press in those days, and what kinds of scientific and technological developments were in the news? Furthermore, it is scarcely remembered today that Comet Halley was preceded by a spectacular comet discovered early in 1910. Had that made local news?

Curiosity demanded some investigation, which was conducted from July 2004 to May 2005, primarily at the Local History Room of the Ipswich Library and Information Centre. There, microfilm copies of the local newspaper, the *Queensland Times*, were available back to its establishment in 1859, as well as books and compilations on various aspects of the history of the Ipswich district. The research mainly covered the period 1909-1910. That enabled a picture to be built up of the kind of information that had been available to newspaper readers. There were, as will be seen, reports of events such as meteors, eclipses, and earthquakes, and numerous articles about developments in aviation and wireless communications. There were reports, too, of the "other" comet in January of 1910, and of the return of Brook's Comet later in the same year.

Regular reports of the position and visibility of Comet Halley were published, along with general-interest articles that went into considerable detail about the nature of comets. A small amount of what might be termed sensationalism was found with regard to comets and superstition, as well as reports of panic in other places. On the whole, however, the *Queensland Times* appeared to have published mostly sober, factual material, including what, in some instances, seemed intended to counter or allay any fear of the comet's return.

This suggested the possibility that perhaps information from other sources had been circulating in the district: magazines, other newspapers, or information received from overseas by means such as personal letters. That information from other sources might have been coming into the author's own family was suggested by the surprise discovery, in the *Queensland Times*, that his great-grandfather was sent by a relative in England a photographic postcard of the comet. We should never fail to remind ourselves that a fascination with natural phenomena is not a clinical, academic property but a living treasure shared by lay-person and scientist alike.

The Local Setting

From its beginnings in the 1820s as a source of limestone dug by convict labour, Ipswich grew to become the centre of a wider farming district, and major industries in coalmining and railway workshops. In the first decade of the 20th century, it could boast state and private schools, a technical college and diverse cultural activities.[1]

Thanks to the telegraph and overseas cables, the local newspaper kept its readers informed of current affairs such as the increasing militarism in Europe, polar expeditions, and the deaths of King Edward VII and the writer Mark Twain.[2,3] In the various fields of science, there were articles on subjects as diverse as earthquakes and mammoths.[4] From closer to home, there was coverage of a Summer School of Geology[5], while a report of the annual meeting of the Literary and Scientific Club told of a talk given by a Mr P.L. Weston, B.Sc., B.E., an instructor at the Ipswich Technical College, on the subject of electricity and its applications.[6] We also find reports on allied topics such as the spread of wireless telegraphy[7], as well as what must have been mind-boggling at the time: news of wireless telephony and the broadcast of music.[8]

Articles about astronomy, sometimes quite lengthy, dealt with such subjects as stars and their distances[9], the composition of the Sun[10] and something which must be regarded as in keeping with those times: Martian canals. In an article entitled, *Martian Engineering,* on 26 May 1910, Percival Lowell was reported as having discovered two new canals. However, Mr E.W. Maunder, of the Royal Observatory, Greenwich, was said to hold the opinion that the canals were optical illusions.[11]

Reports of unusual phenomena included a spectacular display from what was believed to be an exploding meteor over a nearby rural centre[13], and various strange lights. In August 1909, strange lights in the night sky were reported in various parts of southern Australia and New Zealand12, part of what was possibly a worldwide phenomenon often encountered today in 'UFO' books.[14] A year later, the *Queensland Times* again reported on unusual lights, seen this time from a coastal steamer off South Australia and said by one of the officers to be "like German airships flying about." [15]

In a different category were reports which, like those of aerial phenomena, would not be out of place in a newspaper today. In the article *False prophets: The end of the world* on 12 February 1909, the *Queensland Times* related how a recent prediction by three Americans had failed to occur[16]; while in May 1910, another article told how an Italian medium had been trapped and revealed to be a fraudster.[17]

Times do change, though. Back then, in an article entitled, *Australian pervert*, it was considered outrageous that "a young and good-looking woman" should renounce Christianity in "a novel ceremony" that saw her embrace the Hindu faith.[18]

Waiting for the Comet

For the period researched, the first mention of Halley's comet in the *Queensland Times* was in an article, *Man's debt to the comets*, on 22 February 1909. More than one thousand words in length, the article contained a summary of what was known about comets. However, the article began like this:

> " The announcement that a new comet has been discovered awakes in the man in the street little emotion beyond a transient curiosity. It affects him merely as it offers the possibility of a spectacular display. Reassured by astronomers that the comet will not collide with the earth and that, even if it did, it would work him no harm …" [19]

To this researcher (although he might be quite wrong) such statements seem contrived to reassure the reader. By 1909, the comet, its history and its impending return were probably well-known by the public, but lingering doubts about what might happen could well have been in circulation. What better way to reassure 'the man in the street' than by complementing his understanding of comets? Of course, not every man in the street could read in those days, and in fact, three of this author's great-grandparents were not literate. However, 'street' news and views would probably have circulated much as they can, and do, today.

With Halley's comet not yet visible in telescopes, the same article could argue that there was, in any case, no guarantee that the comet would return as predicted, because it was known that comets disappeared. The idea embodied in the title, *Man's debt to the comets*, became clearer as the article moved into a discussion of the connection between the disappearance of comets, the appearance of meteor showers, and the discovery of meteoritic iron particles in melted snow. In the view of Arrhenius, the article explained, the "primal germs of life" are dispersed through space, and fall onto planets, where, if conditions are right, "the germ is set free and the age long processes of Evolution are begun."

This researcher had been well aware of the hypothesis, known as panspermia, that had been

put forward by the Swedish chemist, Svante Arrhenius (1859-1927), but as a child of his own times had never grasped the simple fact that it had been a dynamic part of his grandparents' times. It had always simply been something in books, mentioned in passing along with the ideas of more recent scientists such as Hoyle and Wickramsinghe. To see it in the context of popular science, 1909, was truly an eye-opening experience.

On 4 August 1909, the *Queensland Times* published a short report, "Where is Halley's comet?" [20] It drew on material from a Yorkshire newspaper (unfortunately, the title was illegible on the microfilm), in which a Professor J. Elgie had suggested that the comet had, perhaps, broken up. At that stage, it had not been sighted, and the article went on to discuss the likely fate of comets, such as Biela's. That article was, so far could be ascertained, the first dealing specifically with Comet Halley in the *Queensland Times* during that apparition. The next would not be until 10 January 1910, when the newspaper gave the Ipswich district the following announcement:

> " It is estimated at Greenwich Observatory that the transit of Halley's comet across the sun will occur on May 19. The transit will be visible in Australia and America. though it is not probable that the comet will be of sufficient density to be seen against the sun's disc with the naked eye. A spectroscope or a spectroheliograph may, however, detect its presence." [21]

Would readers in those days have understood much of that? It is doubtful whether many, even today, would have more than a hazy notion. Most likely, the newspaper simply printed what came in the cable from London. Be that as it may, while many subsequent reports were found to be presentations of the bare facts, general articles about comets gave far more in the way of explanation.

However, the long-awaited return of Comet Halley to naked-eye visibility was trumped by the discovery of a new comet (that became known as the 'Daylight Comet'), announced in the *Queensland Times* on 19 January, with further reports on 20 January, 29 January, and 2 February.[22]

On 10 March 1910, the *Queensland Times* published *About comets*[23], an article of several hundred words in which the occasional appearances of comets at times of momentous events were dismissed as "mere coincidences". It went on to discuss the long orbital periods of various comets, and asked:

> " Does the reader, however, realise that profound as are these incomprehensible spaces, in every inch of its celestial path, the comet, large or small, and every atom of its tenuous substance is obeying that law which but to guess a Newton made immortal?"

A brief discussion of gravitation ensued, followed by another on the size of cometary tails, with the size of Earth's orbit as a comparison. Then,

> "... a theory of Clerk Maxwell's that when particles of matter are of microscopic size, say two or three hundred-thousandths of an inch in diameter, the sun's light would repel such particles more than the mass of a comet would attract them."

Such an action on the "fine, gauzy" composition of a comet was invoked to account for the "sickle-shaped outline" of cometary tails, and part of the reason why some comets apparently broke up. It was thought possible that "the comet of 1910" - Halley, presumably - might throw "further light on this remarkable light force." The article concluded with opinions from several astronomers that to pass through the tail of Halley's Comet would not pose a danger to Earth.

On 17 March, in *Halley's Comet*, with a subtitle, *Do comets cause floods?*, the *Queensland Times* presented a dichotomy which, nearly a century later, seems almost incredible.[24] A weather forecast for Queensland, for the period 16 to 23 March, predicted heavy thunderstorms, and advised that Halley's comet would be visible to the naked eye, before sunrise. The article continued:

> " This curious scientific problem, "Do comets cause floods?", is raised by a correspondent to the "Express", who calls attention to a series of curious coincidences. The floods in France in this year of two great comets, he says, add another example to the many recorded coincidences of such events."

Yet rather than necessarily representing a descent into sensationalism for its own sake, the tone of the article seemed to suggest more of an "I wonder if ..." feeling about floods and comets that left this researcher wondering if many people actually did believe in the link. Then, on 26 March, in another article, which commenced with details about the transit and how astronomers planned to study it, attention was drawn to "a curious parallel" the cometary visits of 1835 and 1910 and the fact that in each year there had been general elections in England in which the numbers of Liberal and Opposition seats before the dissolutions, and the numbers after, had been almost identical.[25]

Scepticism, however, was never far away. For example, in *Collision with the comet*, on 9 April 1910, the *Queensland Times* presented Sir

Robert Ball's opinion, originally in a letter in *The Times* (of London), that a rhinoceros in full charge would not fear collision with a cobweb, and nor need Earth be afraid of a collision with a comet.[26]

> " In 1861 we passed through the tail of a comet and no one knew anything about it at the time...
>
> So far as I can learn we may be in the tail of Halley about May 12, and I sincerely hope we shall."

Also on 9 April, a reflection of the general interest in the comet was evident in a brief announcement[27] that Mr W.S. Lye (the present writer's great-grandfather), had received, from his brother in England:

> "... a post-card ... bearing a very fine photographic view of Halley's comet and the planet Venus, as seen in Oxford on the 20th January last.... The tail of the comet is distinctly shown, and the planet Venus stands out very clearly."

In that time, photographs in newspapers were not as common as they would soon become. No photographs of the comet appeared in any of the articles that were found in the period researched.

The Local Experience: April 1910

It seems that the first reported sighting was that of on Mr G. Reginald Piggott, of Harlin Road, Ipswich on Monday, 11 April 1910, at about 5:15 in the morning:[28]

> " It was then clearly seen ... at a point east by north.... [It] had very little "tail" — it was more like two stars joined together. It was visible ... until almost 9 o'clock in the morning.

Other reports soon followed, of sightings from the nearby rural area of Laidley, from where it was viewed telescopically[29], and by more residents in Ipswich with the naked eye: one person reported the tail as "seeming to be about 2ft long." [30]

Meanwhile, on 14 April, a lengthy article, *Halley and his comet*, drew on a lecture, reported in the London *Daily Telegraph*, by Professor H.H. Turner, of Oxford University.[31] It explained the cometary work of Edmond Halley, and gave a considerable amount of information about the orbit of the comet: including influences attributed to the gravitational attraction of the planet Jupiter.

Reports or articles continued to appear every almost every other day, either telling where the comet had been seen, or, in the case of *Fifty million comets*, published on 21 April, presenting an array of general information.[32] The message changed, however, in a brief report from London, published in the *Queensland Times* on 25 April[33], which is worth reproducing here in full.

> " Tidings of the approach of Halley's comet has [sic] aroused intense excitement amongst the inhabitants of parts of China. The Christian Literature Society, with a view to allaying those fears, is distributing a poster, showing that the comet visited the neighbourhood of the earth of previous occasions, and that the consequences were harmless."

On the following day, an article by Walter F. Gale, F.R.A.S.[34], published originally in the *Sydney Morning Herald*, informed readers that those looking forward to seeing the comet might be disappointed, because it would:

> "… probably not afford a spectacle anything like the great comets of last century. [because] … its substance is so wasted by repeated expenditure that it is becoming bankrupt of vaporisable elements."

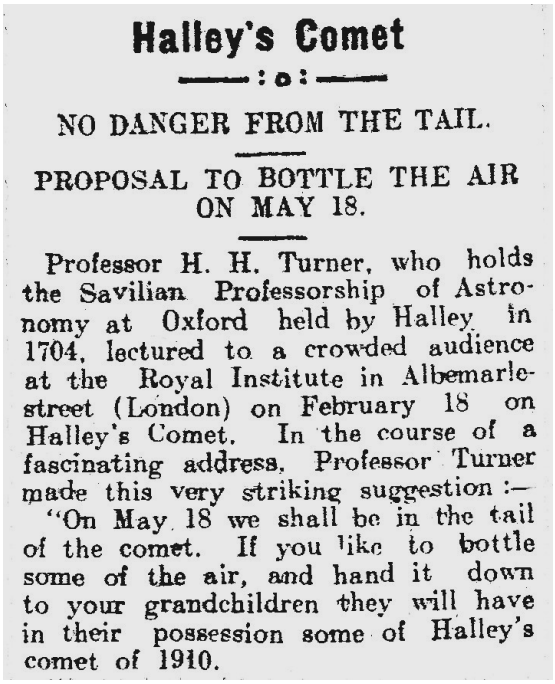
Gale pointed out that many of the short-period comets were devoid of tails, and that he was convinced that such comets represented "an effete stage in the life-history of these curious bodies." "What purpose comets may serve in the economy of the universe," he wrote, "is at present quite unknown." He added that the principal interest in Halley's comet was a result of the intimate knowledge of its motion, and therefore its identification with previous great comets:

> " The exhaustive computations of Messrs. Cowell and Crommelin, of the Greenwich Observatory staff [1909] ... enabled them to forecast the comet's return to perihelion ... with an error of less than four days.... [The] intellect of man is capable of following the comet ... with such precision that the point ... where it would again become visible ... was indicated with an error of less than one-fourth the apparent diameter of the moon."

By such means, Gale had been able to locate Halley's comet on 21 November 1909, and he now gave projections of where it would be in the near future. The final week of May, he suggested, would be the best time to see it (in the evening) because it would be close to Earth and, as an additional factor that favoured observation, there would be no moonlight. "At that time," he suggested, "Halley's comet will make its most lasting impression on the public mind."

It would seem, however, that another impression had been made upon the public mind, in some places, at least. For on 30 April, the *Queensland Times* ran a short article[35] in which Professor H.H. Turner, from Oxford University was again quoted (Figure 1). He is reported as saying that on 18 May, the Earth would be passing through the tail of comet, and that:

> " If you like to bottle some of the air, and hand it down to your grandchildren, they will have in their possession some of Halley's comet of 1910."



Halley's Comet

—:o:—

NO DANGER FROM THE TAIL.

PROPOSAL TO BOTTLE THE AIR ON MAY 18.

Professor H. H. Turner, who holds the Savilian Professorship of Astronomy at Oxford held by Halley in 1704, lectured to a crowded audience at the Royal Institute in Albemarle-street (London) on February 18 on Halley's Comet. In the course of a fascinating address, Professor Turner made this very striking suggestion :—

"On May 18 we shall be in the tail of the comet. If you like to bottle some of the air, and hand it down to your grandchildren they will have in their possession some of Halley's comet of 1910.

Figure 1

Bottling the comet's tail

Extract from the *Queensland Times* of 30 April 1910

By courtesy of the Local History Section, Ipswich Library and Information Service

According to the article, Turner believed that only one hundred-thousandth part of the air would be "comet's tail", and dismissed any fear of the consequences of passing through the tail. He did say, though, that attempts should be made to analyse the air on that night, to "find out what is really in the comet's tail." Turner also referred to the work of Professor A. Fowler, of the Royal College of Science, South Kensington, with regard to the composition of the tail, but, perhaps due to poor editing, what appeared in the article probably left many readers scratching their heads.

> "... [The] contents of the tail are similar to some substance which is present in a tube which has contained hydrogen when the hydrogen is extracted. What that substance is Professor Fowler has not yet been able to determine. but it has the same spectrum as the comet's tail …"

Perhaps the substance was carbon monoxide, produced in the process in which hydrogen is produced from steam and methane. At any rate, the further information given about the tail of the comet was probably fascinating to readers, for it described how a comet may seem to lose its tail because the tail is temporarily behind the comet and, temporarily, invisible. Then, the tail might appear on one side or the other, depending upon the position of the comet with respect to the Sun:

> "... apparently blown outwards by some force from the sun. This force ... is either electrical or the light of the sun itself, which has a force of its own. The dissipation of the tails ... is now accepted as fact, and ... leads to the conclusion comets gradually grow smaller until they "probably break up into small meteors."

As Halley's comet passed perihelion, which occurred on 20 April, it became more readily visible.

The Local Experience: May 1910

The comet had become visible to the naked eye and was steadily increasing in brightness, according to a brief report on 7 May, which noted that the tail was much longer.[36] On the same day, a notice was given that on the following Monday (9 May), a partial eclipse of the Sun would be visible from Ipswich during the mid to late afternoon.[37] That apparently stimulated the article that appeared on 12 May[38], entitled, *Eclipses and comets*, which spoke of the importance of understanding such occurrences, and briefly recapitulated how Halley, with "the Newtonian theory", undertook his investigation of comets. It reminded readers that where comets came from was still unknown.

Figure 2

Comet Halley on 6 May 1910

This image was taken at Melbourne Observatory at 1910 May 6.315 using a 6-inch doublet.

The time quoted is that of mid-exposure using the time convention used at the 1910 apparition namely Greenwich Mean Time in Astronomical Time, which began at noon. The lens had an aperture of 15.0 cm, and a focal length of 106.7 cm.

Image by courtesy of the Royal Astronomical Society

Sir Robert Ball was quoted in that article as saying that it was impossible to give more than conjecture, and while perhaps they came from outside the solar system, perhaps they had originated

inside it, perhaps even as "fragments driven off from the sun himself." What was certain, however, was that comets were "obedient to the great laws of gravitation", and that modern science had cleared away the fear and superstition that comets had once attracted.

Was there a need to remind readers that the comet would be harmless? Were rumours of doom and gloom circulating? On 8 May, an article had mentioned a comedy sketch, about the comet, by university students in Sydney[39], but on 15 May, in *Coincidences of the comet*, the *Queensland Times* saw fit to recall that comets had once been thought of as heralding of disasters and great events.[40] If there were any misgivings in the district, it seems that they could not have been of great significance.

On 17 May, there were two reports. One was of plans by the International Commission on Aeronautics to launch a balloon in an attempt to collect air samples for analysis; it also reported that observations made in Madrid had found no trace of the poisonous gas, cyanogen.[41] The other report, from a German steamer that had visited ports in New Guinea, said that the natives regarded the comet as "an aerial demon come to destroy the world, and were performing many weird dances to drive it away." [42]

When 19 May arrived, the *Queensland Times* reminded readers that Earth would pass through the tail that morning.[43] Mr Cooke, the government astronomer in Perth, Western Australia, was quoted as saying there was no cause for alarm because the matter in the tail was "extremely attenuated". He did warn of possible disturbances to magnetic instruments, and of possible auroral displays, but concluded that "in all probability nothing out of the ordinary will be noticed."

Not so, however, in the opinion a Mr Clement Wragge, who in a letter received in Brisbane (40 km from Ipswich), was reported in the same article as advising that:

> "... the earth will pass through the comet's tail between 12.22 p.m. and 1.22 p.m. on the 19th, [and] it might be just as well to remain indoors between noon and 2 o'clock p.m. ... with doors and windows shut, in case cyanogen gas may make you feel temporarily upset. I don't anticipate any danger yet, but be careful."

Wragge was a meteorologist well-known in Australia at the time.[44] The article does not state to whom the letter was addressed, but perhaps it was a relative or close friend. Whether his advice was heeded was not, so far as this researcher could find, subsequently noted in the newspaper. Nor, it seems, was any coincidence between the presence of the comet and the death of King Edward VII on 18 May. In fact, on 20 May, the *Queensland Times* carried a report on the comet and an article about the King[45], in adjacent columns.

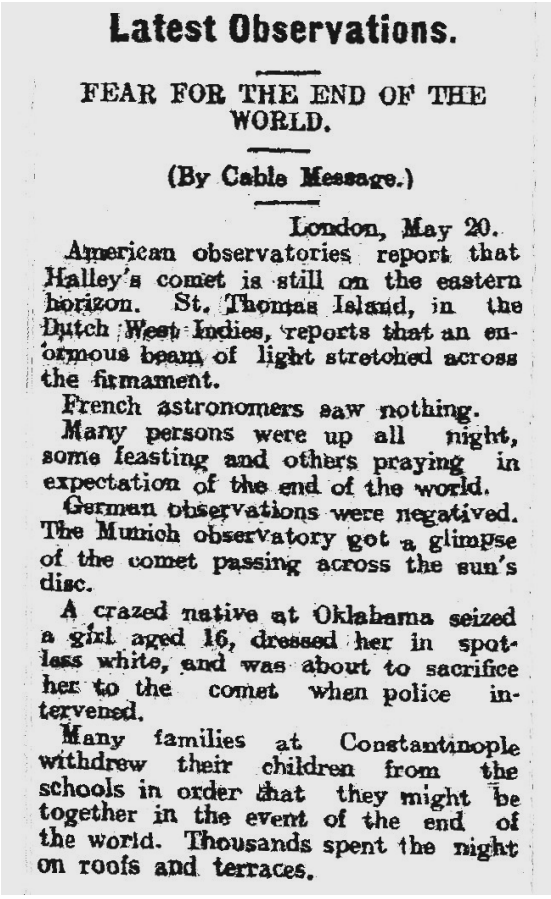
The article on the comet[46] was, however, full of news. From Germany it was reported on 19 May that scientists were not anticipating electrical storms as a result of Earth being in the tail, but the Royal Prussian Meterological [sic] Society was arranging for thirty-eight balloons to be sent up, with trained observers and "chemical and electrical meteorological apparatus." However, the article then proclaimed, "Halley's comet monopolises the American newspapers." Balls and breakfast parties were being arranged on the roofs of hotels in New York, while in the southern states, "negroes" were suffering from "comet panic". They had stopped working, the article continued, and were devoting their time to prayer meetings: "Many of them are half-crazed with fear, and are hiding in cellars." Then, concluding with an oddly mixed bag, the article reported that insurance agents were reaping a rich harvest; Professor Dounard of Yerkes Observatory said that the tail extended for 107º, and up to 5 or 7 in width; while in St Petersburg, Russia, many people were spending the night in churches.

On the following day, 21 May, reports of astronomical observations from around the world were accompanied by news that in some places overseas, people had been up all night, "some feasting and others praying", and in Oklahoma, "a crazed native" had been about to sacrifice a sixteen-year-old girl to the comet when police intervened (Figure 3). In Constantinople, families had taken children from school so they could be together if the world ended. "Thousands," said the article, "spent the night on roofs and terraces." [47]
And in Ipswich? To judge from the rest of the *Queensland Times*, life had gone on as usual. Nor were there reports of parties or prayer sessions from elsewhere in the nation; just astronomical observations from various places, a list of recommended viewing times for the next few days, and a note in the same article that there had not been "the slightest sign of the earth having passed through the tail of Halley's comet." From Launceston, Tasmania, the same article reported that Wragge had recently made "a careful observation with a special solar telescope":

> "... the only indication of the comet's transit was a magnetic glare all round the solar edge. The observation shows that the nucleus of the comet

> was not what would be termed solid, but evidently consisted of an aggregation of cosmical electrons in violent motion."

No elaboration was made on what "cosmical electrons in violent motion" might be. On 23 May it was reported that Professor Hale had made interesting observations from the Mount Wilson Observatory, which showed that the comet "was disappearing in the distance." In Scandinavia, a Professor Birkeland had suggested that the tail "is principally electric rays". From Melbourne electrical engineers in Victoria, Queensland, and Tasmania were reported to have said that "no unusual earth currents were received on the telephone or telegraph" in the period when Earth was in the tail.[48]



Latest Observations.

FEAR FOR THE END OF THE WORLD.

(By Cable Message.)

London, May 20.

American observatories report that Halley's comet is still on the eastern horizon. St. Thomas Island, in the Dutch West Indies, reports that an enormous beam of light stretched across the firmament.

French astronomers saw nothing.

Many persons were up all night, some feasting and others praying in expectation of the end of the world.

German observations were negatived. The Munich observatory got a glimpse of the comet passing across the sun's disc.

A crazed native at Oklahama seized a girl aged 16, dressed her in spotless white, and was about to sacrifice her to the comet when police intervened.

Many families at Constantinople withdrew their children from the schools in order that they might be together in the event of the end of the world. Thousands spent the night on roofs and terraces.

Figure 3

Comet Halley causes bizarre behaviour

Report from the *Queensland Times* of 21 May 1910.

By courtesy of the Local History Section, Ipswich Library and Information Service

On 25 May there was a brief report that a steamer, just arrived after a voyage from New York, had afforded a fine view of the comet. It was also noticed that on the previous Thursday, several hundred persons at Bairnside, Victoria, had observed, in line with the Sun, "particles like snow, scintillating and very bright." [49]

The fuss, if there had ever been one in Ipswich, was over. On 30 May appeared an article[50] based on that by Professor Edward C. Pickering of Harvard in the April edition of *Century* that covered similar territory to other articles that the *Queensland Times* had carried. The final word on the local experience appears to have been on 4 June, in an article that drew on one from the London *Daily Telegraph*, in which various opinions from Sir Robert Ball had been presented.[51] Again, it was, in effect, stale news from when the comet had still been approaching the Sun. The return of Brooks's comet was noted later in the year,[51] by which time Halley's comet was long gone. However, let us give that master of communication, Sir Robert Ball, the final word:

> " The light haze that ever floated in a summer sky is cast-iron compared with the spiritual tenuity of the tail of a comet."

Conclusions

The 1910 approach and passage of Comet Halley were well-covered by the *Queensland Times*, with regular information presented in such a way that most readers would have been able to keep abreast of what was happening. In a general background context of reporting news and development in science and technology, the information on the comet, and other astronomical topics, reflected the state of knowledge at the time.

The reports of fear, superstition and panic from other countries made a strong contrast with the absence of such reports from the local district. Sensationalism for its own sake seems largely to have been avoided, and that indicates to the author that any local disquiet had been, at most, minimal.

The possibilities for further research do, however, suggest themselves. It would be extremely interesting to consult the archives of other newspapers. Those of the *New York Times*, for instance, are available electronically.[52] It ought to be possible to compare and contrast the local experiences in a way that future generations, at the time, for example, of the next return of Comet Halley, may find illuminating.

Acknowledgements

The author wishes to thank the staff of the Local History Room at the Ipswich Library and Information Centre for their patience, kindness, and unfailing courtesy. He also wishes to thank the Editor of *The Antiquarian Astronomer* for his patience while the paper was being prepared.

Notes and References

1. A useful book for information about Ipswich in the early 1900s is: Buchanan, Robyn. *Ipswich in the 20th Century*. Ipswich: Ipswich City Council. 2004.
2. The death of the King. The *Queensland Times*. 19 May 1910. Page 5.
3. The death of Mark Twain. The *Queensland Times.* 23 April 1910. Page 9.
4. Searching for mammoths. The *Queensland Times*.3 May 1909. Page 3.
5. Summer School of Geology. The *Queensland Times*. 8 January, 1910. Page 2.
6. Literary and Scientific Club. The *Queensland Times*. 16 February 1909. Page 2.
7. Radio-Telegraphy: Australia and Pacific Islands. The *Queensland Times*. 12 February 1909. Page 5.
8. Music and telephony: Wireless apparatus in New York. The *Queensland Times.* 13 January 1910. Page 5.
9. About stars: Stupendous distances. The *Queensland Times*. 15 January 1910. Page 2.
10. Concerning the sun. The *Queensland Times*. 12 May 1910. Page 6.
11. Martian Engineering: The New 'Canals'. The *Queensland Times*. 26 May, 1910. Page 2.
12. Unexpected aerial visitor: Supposed bursting of a meteor. The *Queensland Times*, April 21st, 1910. Page 5.
13. There are three articles of interest regarding the mystery lights of 1909, all in the *Queensland Times*: Mysterious Light. 11 August 1909. Page 4; A Glen Innes mystery. 16 August 1909. Page 2.; Elusive lights. 17 August 1909. Page 2.
14. See Airships reports 1909, in Spencer, John. *The UFO Encyclopaedia*. London: Headline (Hodder). 1997. Page 9. For more about the airship sightings in Australia and New Zealand, also see Chalker, Bill. *The Oz Files*. Potts Point, New South Wales: Duffy & Snellgrove. Pages 29-32.
15. Strange light at sea. The *Queensland Times*. 8 August 1910. Page 6.
16. False prophets: The end of the world. The *Queensland Times*. 12 February 1909. Page 3.
17. Notorious Italian medium trapped. The *Queensland Times*. 14 May 1910. Page 11.
18. Australian Pervert. The *Queensland Times*. 7 July 1909. Page 7.
19. Man's debt to the comets. The *Queensland Times*. 22 February 1909. Page 2.
20. Where is Halley's comet? The *Queensland Times*. 4 August 1909. Page 8.
21. Halley's Comet: Expert Opinion. The *Queensland Times*. 10 January 1910. Page 5.
22. There were four reports about the new comet in the *Queensland Times*: Comet close to sun: Interesting Sydney discovery. 19 January 1910. Page 6; Comet near to sun. 20 January 1910. Page 5; The new comet: Vividness maintained. 29 January 1910. Page 9; and, The new comet: Photographed at Greenwich. 2 February 1910. Page 5.
23. About Comets. The *Queensland Times*. 10 March 1910. Page 3.
24. Halley's comet: Do comets cause floods? The *Queensland Times*. 17 March 1910. Page 3.
25. Comet Halley. The *Queensland Times*. 26 March 1910. Page 13.
26. Collision with the comet. The *Queensland Times*. 9 April 1910. Page 3.
27. Halley's Comet. The *Queensland Times*. 9 April 1910. Page 13.
28. Halley's Comet. The *Queensland Times*. 12 April 1910. Page 5.
29. Halley's Comet. The *Queensland Times*. 16 April 1910. Page 11.
30. Halley's Comet. The *Queensland Times*. 19 April 1910. Page 4.
31. Halley and His Comet. The *Queensland Times*. 14 April 1910. Page 2.
32. Fifty Million Comets. The *Queensland Times*. 21 April 1910. Page 2.
33. Halley's Comet: Excitement in China. The *Queensland Times*. 25 April 1910. Page 5.
34. Halley's Comet: Its Path Described. The *Queensland Times*. 26 April 1910. Page 7.
35. Halley's Comet: No Danger from the Tail. The *Queensland Times*. 30 April 1910. Page 10.
36. Halley's Comet. The *Queensland Times*. 7 May 1910. Page 9.
37. Eclipse of the sun. The *Queensland Times*. 7 May 1910. Page 9.
38. Eclipses and comets. The *Queensland Times*. 12 May 1910. Page 4.
39. Way for the comet. The *Queensland Times*. 8 May 1910. Page 7.
40. Coincidences of the comet. The *Queensland Times*. 15 May 1910. Page 3.
41. Halley's comet: Observations in Madrid. The *Queensland Times*. 17 May 1910. Page 4.
42. Halley's comet: Regarded as an aerial demon. The *Queensland Times*. 17 May 1910. Page 3.
43. Halley's comet: Earth to pass through tail this morning. The *Queensland Times*. 19 May 1910. Page 2.
44. Brief biographical details of Wragge are given in Bernard, J.R.L. (General editor). *The Macquarie Dictionary of People and Places*. Sydney: The Macquarie Library Pty Ltd. 2nd edition 1995. Page 788. A search of the world wide web would probably find a wealth of detail - he was a controversial figure.
45. The separate, but adjacent, articles about the comet [Reference 46] and King Edward VII are in The *Queensland Times*. 20 May 1910. Page 3.
46. Halley's comet: Interests of scientists. The *Queensland Times*. 20 May 1910. Page 3.
47. Halley's comet: World observations. The *Queensland Times*. 21 May 1910. Page 9.
48. Halley's comet: Interesting observations. The *Queensland Times*. 23 May 1910. Page 5.
49. Halley's Comet: Observations on a Steamer. The *Queensland Times*. 25 May 1910. Page 5.
50. Composition of comets. The *Queensland Times*. 30 May 1910. Page 6.
51. Halley's comet: Views of Sir Robert Ball. The *Queensland Times*. 4 June 1910. Page 11.
52. Brook's comet. The *Queensland Times*. 13 October 1910. Page 7.
53. The web-site for the archive of The New York Times was accessed on 31 March 2006 at: http://www.nytimes.com/ref/membercenter/nytarchive.html

The Reverend John Michell: A Letter from his Great-grandson

Eric Hutton
Fellow of the Royal Astronomical Society

Very little is known about the life of John Michell (1724-1793), apart from his various published papers. The writer of a letter to the *English Mechanic* newspaper, under a *nom de plume*, claiming to be Michell's great-grandson, has now been identified as being written by Andrew Thomas Turton Peterson. Peterson reports that "hearsay and family tradition" places Michell as the person who inspired William Herschel to take up astronomy, and who tutored him in making specula. Some of the claims made in the letter can be substantiated by independent documentation; others can be shown to be exaggeration or erroneous.

Of the many letters written to the *English Mechanic and World of Science*, a weekly newspaper published in England between March 1865 and October 1926, one written under the mysterious nom-de-plume KHODA BUX, claimed to be from the great-grandson of the Reverend John Michell (1724-1793) has been an enigma for a long time[1]. It was written in 1871, prompted by the death in May of Sir John Frederick William Herschel (1792-1871).[2]

By examining other letters[3] written by KHODA BUX to the *English Mechanic*, I have determined that the author can be identified uniquely as being Andrew Thomas Turton Peterson[4]. In the 1880s, Petersen designed and built in the village of Sway, on the southern edge of the New Forest, Hampshire, England, the so-called Sway Tower. Having six stories and a height of 200 feet, it can claim to be the first concrete 'tower block' in Britain and Ireland. Now a Grade II listed building, it has recently been renovated and converted into high-class 'bed and breakfast' accommodation.

The letter

The full text of the letter is given below.

" SIR WILLIAM HERSCHEL.

[2103.] – As in these days of practical science a lively interest is taken in the doings and belongings of its great apostles, the following information anent [concerning] the late Sir Wm. Herschel may be interesting to most of your readers. Your correspondent "G.M.D.," quoting from Miller's "History of Doncaster," says he (Dr. Miller) first drew Herschel from obscurity in inducing him to start as a candidate for the office of organist to Halifax Church, which he succeeded in obtaining. He gives, however, no clue as to the quarter from whence William Herschel laid the foundation of his great fame as an astronomer and telescope constructor. I am in a position to give a clue as to how and when he got his first instruction and his taste for astronomy. After Herschel's appointment as organist of Halifax he became acquainted with the Rector of Thornhill (a village about nine miles from Halifax and six from Wakefield), whose name was John Michell – a man of fortune, whose whole life was devoted to science, and whose writings are to be found in considerable numbers in the journals of the Royal Society during the latter half of the last century, one of the most prominent papers being that on the great Lisbon earthquake in 1756. John Michell may perhaps be better known as the builder of the mathematical bridge across the Cam, at Queen's College, Cambridge. He was no mean violinist in his day, and his soirees – where not only the first musical talent, but also the first scientific men of the day, such as Cavendish, Black, and Priestley, used to meet occasionally – were well known in the West Riding of Yorkshire, and to which Wm. Herschel used to come to perform on the violin. At the period of these visits Michell was and had been long engaged in the making what was at that time a large telescope-a ten-foot reflector. The proper combination of metal for a perfect reflector, and the grinding the same, had long occupied Michell's attention, in which he at last succeeded, and I believe I am correct in saying that Herschel there became a willing and able pupil, and obtained the germs of his great astronomical renown. At the death of John Michell all his scientific apparatus were sent to Queen's College, Cambridge, save and except his large reflecting telescope, which, by purchase or gift, came into the possession of Wm. Herschel. I have been told by the only child of Michell, who died about thirty-five years ago, at the age of upwards of eighty, and was intimate with Herschel, that he told her that the principal part of his observations had been made with her father's telescope, which he found more convenient than his own larger one. The Rev. John Michell (not Mitchell), I have also been informed, was the inventor of an apparatus for as-

> certaining the weight of the world, which is known as that of Cavendish. Your readers may probably ask how I come to know anything about what I a writing? My answer to that is, from hearsay and family tradition. I am the grandson of Michell's only daughter, from whom I heard much, and I was also a pupil more than fifty years ago of an old clergyman who had in early life been for several years the curate of Thornhill under Michell. As a matter of course, I feel a pride in being a descendant from John Michell, only equalled by that of thinking that he afforded a nursery for such a genius as the older Herschel, to be followed by that of his equally illustrious and more highly educated son. Perhaps this may among your readers reach the eye of some one who may know what has become of Michell's reflector, and as to whether it has passed through the hands of the auctioneer, or whether it still remains a time-honoured instrument in the hands of the Herschel family.
>
> KHODA BUX."

John Michell

It is appropriate here to introduce the person of prime interest in this story - John Michell[5]. He was born on Christmas Day 1724. He entered Cambridge University on 17 June 1742, and graduated (in mathematics) as fourth wrangler in 1748. He was a lecturer in the university in various subjects to 1760, and became Woodwardian Professor of Geology in 1762. He was elected to Fellowship of the Royal Society on 12 June 1760.

Michell published work on a variety of topics: on magnetism (in which he stated the inverse square law of magnetic force), earthquakes, the use of Hadley's quadrant for surveying, and the determination longitude. His published astronomical works included observations of the comet of January 1760, and in 1767 a seminal paper on stellar parallax and magnitude of the 'fixed' stars[6]. This was described in his entry in the *Oxford Dictionary of National Biography* as being:

> " … arguably the most innovative and perceptive contribution to stellar astronomy to be published in the eighteenth century."

In the paper he discussed in particular the true binary nature of some stars, the existence of 'secular' parallax, caused by the movement of the Earth in its orbit, and the topic that is making him noticed in modern times - his speculation that there could be stars of so great a mass that their gravitational force prevents light from leaving them.

There is no known likeness of Michell, so the pen-picture that follows is usually substituted in order to bring an image to mind:

> " John Michell. BD is a little short Man, of a black Complexion, and fat; but having no Acquaintance with him, can say little of him. I think he had the care of St. Botolph's Church [Cambridge], while he continued Fellow of Queens' College, where he was esteemed a very ingenious Man, and an excellent Philosopher. He has published some things in that way, on the Magnet the Magnet and Electricity." [7]

This, then, is the man whose descendent, Peterson, is the author of the letter and its claims, which are the subject-matter of this paper.

KHODA BUX's claims

What can be made of the various claims within KHODA BUX's convincing-sounding letter? I will address four of the main ones, but many remain unverifiable, or await further research and discoveries, to prove or disprove them.

First, KHODA BUX says: "I am the grandson of Michell's only daughter ...". This is verifiable. Mary Michell (baptised 3 September 1675 at Newark, Nottinghamshire) was the only child of the Reverend John Michell and Sarah Williamson, who died seven weeks after giving birth.[7] Mary Michell is recorded as marrying Sir Thomas Turton, Bart. of Starborough Castle, Surrey on 2 September, 1786. Their only son, Sir Thomas Edward Michell Turton, Bart. is not Peterson's father.[8,9] However, there is a separate record[9] of Sir Thomas (senior) having a daughter, Anna, born 14 September 1787; the name of the mother is not recorded. Anna married Henry Peterson. Our author is the first son of their six children. He was named Andrew Thomas Turton Peterson.

Second, KHODA BUX claims that "After Herschel's appointment as organist of Halifax [in the early 1760s] he became acquainted with the Rector of Thornhill … whose name was John Michell ...". This is erroneous. It is known that Michell did not arrive at Thornhill until 1767, having previously been in the parish of Compton in Hampshire. However, Herschel had left Halifax for Bath in December the previous year. So they were certainly not near neighbours at any time. Even as late as 1781 they had not met, as evidenced by what Michell writes at that time[10]:

> "… with Comp. to Mr Herschel though I have not yet the pleasure of a personal acquaintance of him...".

This comment also makes unlikely to be accurate, KHODA BUX's assertion that Herschel got "his first instruction and his taste for astronomy" from Michell during visits to the Thornhill Rectory.

Third, KHODA BUX's claim that Michell's "large reflecting telescope, which, by purchase or gift, came into the possession of Wm. Herschel" is true. How Herschel came to acquire it, and some details of the telescope, can obtained from a letter written to Herschel after Michell's death by his son-in-law, Sir Thomas Turton (Junior)[11]:

> "...but for one article we have been at a loss to know where we can look to for the disposal of it & that is the large telescope which occupied for the space of some years, a great deal of Mr Michell's time and attention … If you could in any degree assist me with your advice, as to the best mode of disposing of it ...
>
> "The dimensions & state of the telescope are nearly as follows. A Reflecting Telescope Tube 12ft long made of Rolled Iron painted inside and out, & in good preservation. The Diameter of the large Speculum 29 inch. Focal length 10 feet, its weight is 330 lbs. it is now cracked. There are also 8 concave small mirrors of different sizes viz of 3 ¼ 4 & 5 inch diam. and 2 convex mirrors 3 ¼ inch diam they are polished, there are also [?] sets of eye glasses in brass tubes & cells. The weight of the whole is about half a tun ..."

Herschel paid £30 for the telescope, little more than the £26 offered to Sir Thomas by a Rotherham iron-master. It is possible that Herschel recycled the speculum metal from Michell's mirror into his later telescopes. The only clue as to when Michell built his large telescope, is a short passage in a letter written by him in January 1781[12]:

> "It is but very lately that I have got my great speculum cast & its not yet ground or polished."

As there are no known published observations in which Michell's telescope was used, the question has to be asked: Was it usable? Its short focal ratio of 4, is considered difficult to grind and figure even today. Herschel's two large telescopes, the 20-foot and 40-foot reflectors, had much longer focal ratios - 13 and 10 respectively, and required two people to operate them. So KHODA BUX's claim that Herschel "found [Michell's telescope] more convenient than his own larger one", would certainly be true. But as the speculum was reported to be cracked, then KHODA BUX's claim (the fourth I examine) that:

> "… the principal part of … [Herschel's] observations had been made with … [Michell's] telescope ..."

cannot be true (unless the crack was inconsequential or Herschel was prepared to use the speculum even if it had degraded optical performance).

Mary Michell died on 28 January 1837, when KHODA BUX (Peterson) was 19 years old. This is consistent with his statement:

> " I have been told by the only child of Michell, who died about thirty-five years ago, at the age of upwards of eighty ..."

Conclusions

I have shown that many of Peterson's claims do not stand up to known facts. Peterson himself says:

> " Your readers may probably ask how I come to know anything about what I am writing? My answer to that is, from hearsay and family tradition."

I suggest that in the 100 years between the writing of the letter, and the events it purports to describe, family tradition made more of the connection with Herschel than ever existed.

However, the letter does leave many questions unanswered: Who was Peterson's tutor - the "… clergyman who had in early life been for several years the curate of Thornhill under Michell."? What was Michell's ability as a musician? (I can find nothing about it.) What is the origin of the family belief that Michell tutored Herschel in astronomy? These, and many other aspects of the letter are the subject of my continuing research.

Acknowledgements

I wish to acknowledge, with thanks: Richard Crossley (fellow member of the Society for the History of Astronomy) for introducing me to Brian Wallis; and Brian Wallis for supplying copies of his detailed local research into the family trees involved.

Notes and references

1. See, for example: Zdenek Kopal. Entry for Michell, John in: *Dictionary of Scientific Biography*. New York: Charles Scribner and Sons. 8-volume edition 1981. Volume 9 and 10, Pages 370-371.
2. KHODA BUX. Sir William Herschel. Letter published in the *English Mechanic and World of Science*. Volume XIII. Issue 325, Friday 16 June 1871. Pages 309-310. The [2103] at the beginning of the letter is the number given to the letter by the newspaper's Editor. This numbering sequence did not start until Volume 11, Issue 276, published on 8 July 1870. It ended at the end of Volume 75 (in Issue 1950, published on 8 August 1902) when the letter number had reached 46,149. Beginning in Volume 76 (Issue 1951, published on 15 August 1902) letter numbers restarted at 1 with each new six-monthly volume.
3. See, in particular: KHODA BUX. Concrete. *English Mechanic and World of Science and Art*. Issue 910. 1 September 1882. Pages 597-598.
4. After reaching this conclusion, I learnt that Brian Wallis of the Yorkshire Archaeological Society had come to the same conclusion in May 2005. He announced his findings in an unpublished letter dated 20 May 2005 to Russell McCormmach, copied to Richard Crossley. Wallis, personal communication to the author. 17 August 2006.
5. A[gnes] M[ary] Clerke. Michell, John (1724/5-1793). Revised by Michael Hoskin. Entry in the *Oxford Dictionary of National Biography*. Oxford University Press. 2004. Consulted online at http://www.oxforddnb.com/view/article/18657. Accessed 4 December 2006.

6. Rev. John Michell, B.D. F.R.S. An Inquiry into the probable Parallax, and Magnitude of the fixed stars, from the Quantity of Light which they afford us, and the particular Circumstances of their Situation. *Philosophical Transactions of the Royal Society*. 1767, 57, 234-264.
7. Quoted in: Richard Crossley. Mystery at the Rectory: Some Light on John Michell. This article was originally published in four parts in *Yorkshire Physics News* (the news-sheet of the Yorkshire branch of the Institute of Physics): Issue 17, January 2000; Issue 18, April 2000; Issue 19, October 2000; Issue 20, January 2001. It can now be accessed via the internet at www.yorksphilsoc.org.uk/files/michell.pdf . Crossley gives the source of the quotation used as: "Cole MSS XXXIII, 156, British Library". I have not yet verified this information.
8. Anonymous. Obituary of Sir T. E. M. Turton, Bart. *The Gentleman's Magazine.* July to December 1854. XLII, new series. Page 190.
9. Entries in RootsWeb's WorldConnect Project. This can be found at http://rootsweb.com (accessed March 2006). Search for "Anna Turton" born 1787, and "Thomas Turton" born 1764.
10. Extract from a letter, dated 23 February 1781, from Michell to W. Watson. Royal Astronomical Society MSS Herschel W.1/M101.
11. Extract from a letter, dated 1 July 1793, from Turton to Herschel. Royal Astronomical Society MSS Herschel W.1/T10(1).
12. Extract from a letter, dated 21 January 1781, from Michell to W. Watson. Royal Astronomical Society MSS Herschel W.1/M99.

The Society for the History of Astronomy Survey of Astronomical History

Roger Jones
Council Member, Society for the History of Astronomy

The Society for the History of Astronomy was formed to encourage research into astronomical history at the local level. To aid this research, the Society has created the Survey of Astronomical History as a way of collating findings and making them available to others. The Survey is a database in which information is recorded on web-pages that have a geographical basis - the 120 historic counties of Britain and Ireland. The systematic structure of these pages makes them easy to use both to record data and to search existing data. This paper describes the Survey and advises on resources available to researchers.

One of the main aims of the Society for the History of Astronomy (S.H.A.), as set out in its Constitution, is[1]:

> " To encourage new research into the history of astronomy, especially amateur research at the local level."

The Society has created a means to aid such research, and to record its results - The Survey of Astronomical History. What prompted the Society to embark on the Survey? Prior to the Society's formation, Stuart Williams, now our Secretary, had been researching local astronomers, in particular W. Henry Robinson[2], in his job as Senior Archives Assistant at Walsall Local History Centre. It was this research that led to his contact with Dr Allan Chapman. Realising the huge gaps in the local history of astronomy revealed especially by Chapman's book *The Victorian Amateur Astronomer*[3], Williams proposed to set up a national survey of such astronomy, and to encourage similar, coordinated research across Britain. Chapman suggested the formation of a specialist society to organise this, which Williams undertook to establish. This initiative culminated in the formation of the Society for the History of Astronomy. Many of the amateur astronomers who contributed information to Chapman's book subsequently became members of the Society.

In recent years a great deal has been written about amateur astronomers, from Chapman's book to the many papers submitted to astronomical journals, including the Society's journal *The Antiquarian Astronomer*. Local societies have contributed a great deal too, with articles in their own magazines. Nevertheless much of the astronomy that went on locally in the past still awaits discovery by local historians and amateur astronomers.

The need for the Survey

A typical example of the local astronomy history that awaits recording for the first time is shown by a case of mine (Figure 1)[4]. Who was this smart, young gentleman with the fine Grubb telescope?

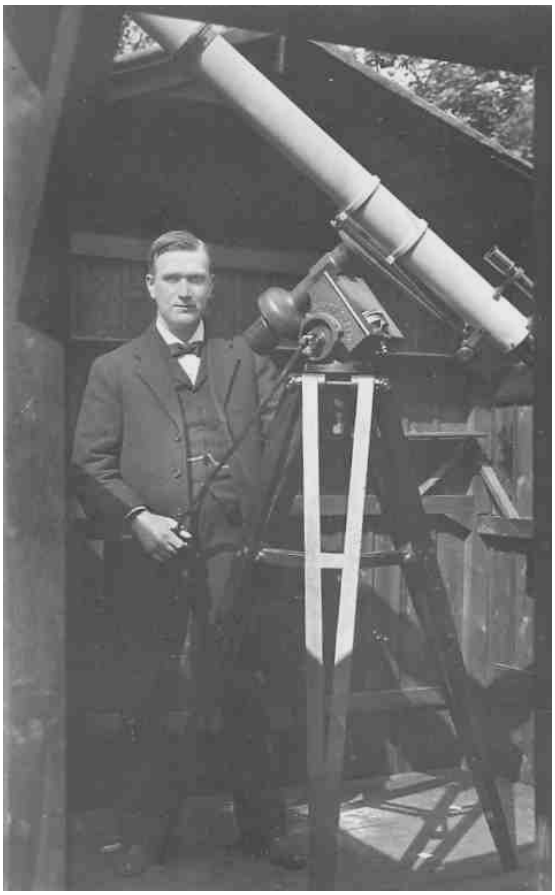


Figure 1

An unidentified, bygone amateur astronomer

From a postcard in the author's collection.

He was probably a very dedicated amateur, as testified by having his own small observatory. This is a photographic postcard from my own collection. The man is not identified, but is one of the many unknown amateurs about whom the S.H.A. is trying both to discover more and to record permanently. Of course, if we had his name we may have a better chance of discovering more about him. Perhaps he was a member of the British Astronomical Association, or a Fellow of the Royal Astronomical Society (R.A.S.). If so, he might have contributed to one of their journals; there may even be an obituary of him. We may never discover anything about this particular person, but if we do, the Survey will help to preserve that knowledge for the benefit of future historians.

Many individuals will, no doubt, have researched people and places of astronomical interest on their own account; but it is possible that the fruits of their research will never have reached a wide audience. This is where the S.H.A. has a vital rôle to play. The main vehicle for recording and disseminating the results of research is 'The Survey of Astronomical History' - an on-line repository of information about people, places, equipment and information connected with astronomy. Naturally, we should focus our efforts on subjects that are not already well researched and well documented - hence the emphasis on amateur astronomers and local history.

To the best of our knowledge, a Survey of this kind has never been attempted. We are therefore encouraging all our members to contribute to the Survey in any way that they can. It can be both exciting and rewarding to discover on your doorstep an unrecorded fellow astronomer. Ideally, we would like well researched and referenced contributions to include in the Survey. Whilst this is one of the Society's long-term aims, we would be delighted if, in these early stages, members would submit anything of interest; details can always be added at a later date. For example, simple lists of names and places associated with astronomy in your local area would make an encouraging start.

Setting up the Survey

As a new society, founded only in June 2002, we started the Survey with a blank sheet[5]. The S.H.A. Council asked me to be its coordinator. I therefore sought an easy-to-follow method of recording information that would lend itself to on-line use, both to add data and to view and 'mine' existing information on the Survey database and in other databases linked electronically via the internet. Where did I look for inspiration? I immediately thought of my own research into family history, and remembered the many useful genealogy sites I had found on the internet. In Britain and Ireland, many of these were based on the county structure, and contained numerous links to archives, libraries and local record offices. It seemed sensible to follow the 'county' route in setting up the Survey. Because the Survey is concerned mainly with the 'history' of astronomy, I decided to disregard the new administrative areas, and base the Survey on the centuries-old county structure as it existed before the large-scale re-organisations in 1974[6]. The Survey therefore uses as its basic components the 120 ancient counties of England, Wales, Scotland, Northern Ireland and the Republic of Ireland.

Progress of the Survey

The county pages for England, Wales and Scotland can now be viewed on the Society's website at www.shastro.org.uk (Figure 2). These pages were designed to fulfil several functions. As an aid to doing research, links on the pages connect to some of the repositories in each county where relevant records are held. These include local history centres, county record offices, local astronomical and historical societies, universities and observatories. As an aid to recording the results of research, space is allocated to enter details of local astronomers and places of interest. This allows new researchers to go to the Survey pages, click on a county and discover what, if any, research has been carried out on the locality. It must be emphasised that the Survey database constantly changes; at the moment, many counties carry only minimal information. One of the main aims of this paper is to encourage readers to add more information, and so help to build the database.

What is included in the Survey?

We have given ourselves a wide remit and intend to cover anything and everything astronomical. We want to know where astronomers and people involved in associated work or study, both amateur and professional, lived and worked in the past. (Not just the distant past; the 20th Century spans a period of very great activity amongst amateur astronomers.) What was their occupation? Did they have their own observatories? Are there any remains of these buildings today, and can they be found on old maps? Are there photographic or artists' images of these buildings? Did these people

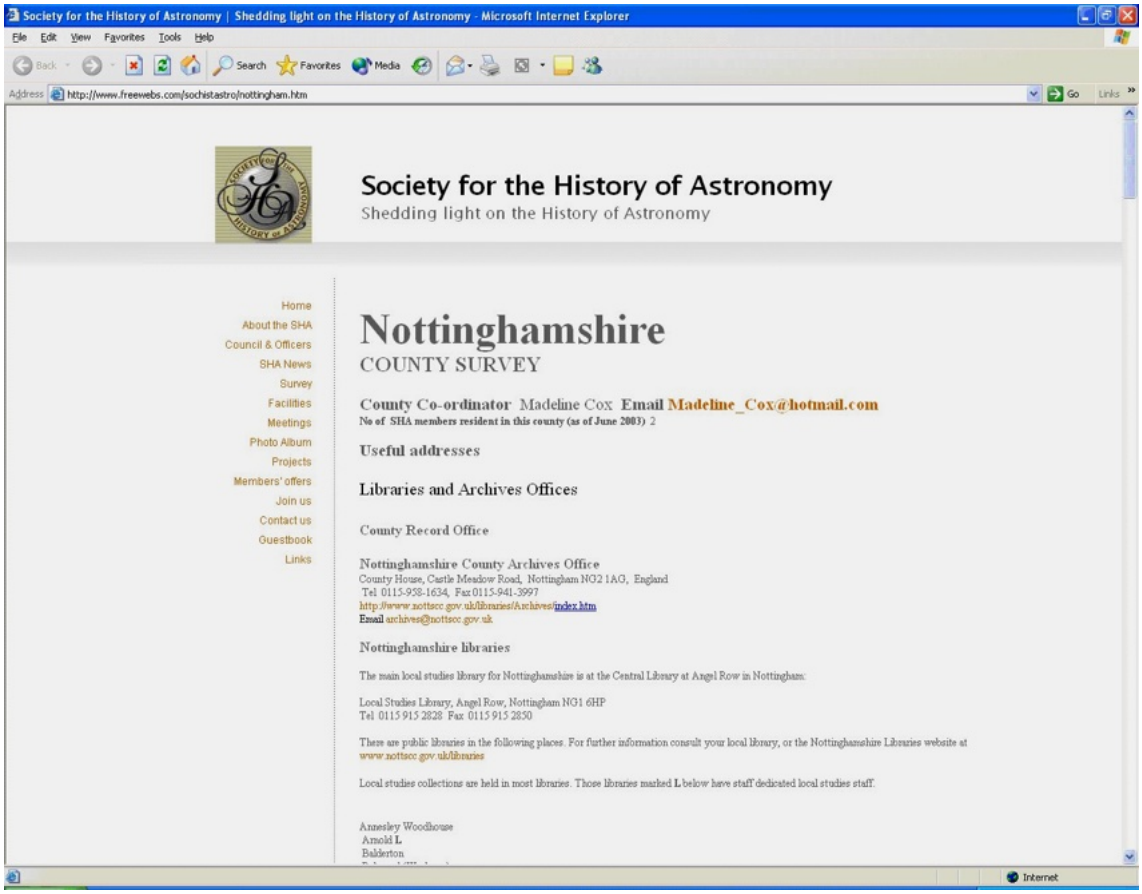


Figure 2

One of the county pages in the Survey of Astronomical History

The content of these pages is wholly dependent on contributions from researchers.

leave records such as observing books, star charts, diaries, business records, publications in journals *etc*? Do the census records tell us anything about their astronomical activities? A search through the online 1881 census of Great Britain[7] produces many results from queries using the words 'astronomer' and 'observatory'. An example will show how the census information can aid research. Where was Howard Grubb, the Irish telescope maker, on census night? We know that he was not in Dublin making telescopes, but in London at the Tavistock Hotel, an establishment as I understand it, suitable for bachelors; room rate 1 shilling and 6 pence per night. What was he doing there? A perusal of the other hotel guests entered on the census return reveals no-one who had an obvious connection with Grubb. Perhaps, then, he was attending a meeting of the Royal Society or of the R.A.S., or he could have been in London *en route* to Vienna to report on the progress of the new 27-inch refractor which had just seen first light at his Dublin works[8].

Where does one start?

Starting the research is often the main problem. As Williams wrote[9]:

> " In researching local astronomical history, luck, dedication, hard work and the skills of a veritable Sherlock Holmes are needed as local records are often patchy and rarely indexed for astronomy or astronomers. Members can however make worthwhile and unique discoveries simply by visiting local history centres and applying that most advanced of research tools … the brain."

Nowadays we have two additional tools at our disposal - the personal computer and the internet. So do not leave home without first doing some desktop research. First, check the Survey pages for what is already entered. Then, type into a search engine the locality of interest (county, town *etc.*) and words such as: 'astronomer, observatory or telescope'. You will get dozens of links. Also try the county name and 'local history'. This will give you contacts for local societies with members who may know about the lives of local astronomers.

Next, visit your local history centre, county record office or library[10]. All will have an index system, on either cards or a computer, so start by looking up keywords such as 'astronomer, observatory, telescope, comet, meteor, fireball, eclipse, transit, aurora, *etc*'. This should give some interesting leads. Search back copies of local and national newspapers, particularly around the dates of known events such as eclipses, meteor showers and comets. Newspaper editors often relied on local amateur astronomers to tell them what was going on in the night sky, and their names are often given in the article. The national astronomical societies are often excellent sources of information. For example, in the past, the membership lists of the R.A.S. included members' addresses.

Another source of information is announcements of public lectures. Most large towns and cities had venues in which such lectures were held, and these were usually well publicised. The announcements included the names of the astronomers on the lecture circuit, particularly in the late 19th and early 20th centuries. For example, when I was carrying out research on Sir Robert Ball I discovered that he had lectured in Walsall where I live. So I searched in back copies of local newspapers held at the Walsall Local History Centre. He visited the town on nine occasions, at the request of W. Henry Robinson, who was Secretary of the Walsall Literary Institute. I have found announcements and reviews of all his lectures there, and in many other towns.[11]

When the names of astronomers have been found, the real investigations can start. For example, occupations can be checked in census records[12] (see the Section on censuses below). For towns and cities these are usually held in the local history centre; for the whole county by the county record office. The Survey county pages already include excellent examples of research, including Ken Goward's work on Suffolk and Madeline Cox's on Nottinghamshire. Between them they list almost 40 astronomers, some well known, such as G. B. Airy, but many previously unknown to most historians of astronomy.

Other Electronic Resources

The internet is the fastest growing source of information, and it can supply the researcher with numerous leads. It hosts several excellent sites for astronomy historians. The NASA Astrophysics Data System (A.D.S.) site[13] is an invaluable tool in that it contains scanned images of thousands of astronomical documents including *Monthly Notices of the Royal Astronomical Society*. Typing 'obituary + fellow' in its search engine brings up more than 800 obituaries published by the R.A.S. A2A or Access to Archives[14] is another online catalogue with impressive search facilities. Typing in the word 'observatories', returns, for example:

> " John Smeaton, the 18th century engineer famous for the 3rd Eddystone lighthouse and the Forth canal also designed Observatories."

Here is another example, from a search on A2A using the word 'planets':

> " Astronomical sketches by Gideon Turner Davis of Reading and others ... Volume compiled in 1891 by G[ideon] Turner Davis of 13 Donnington Gardens, Reading, as a guide for novice astronomers, 'to show what a small telescope can show in Reading'. Includes sketches of observations of the Moon, planets, comets, sunspots, stars and a nova in the Andromeda nebula, made 1877-1891, with additional observations, 1896-1897."

The words 'observatory' and 'telescope' give results such as:

> " At Broomhill, Southborough, Kent, Sir D L Solomons built a water tower surmounted by a telescope. He was an able scientist and installed electricity in the 1880s."

> " At Cragside, Northumberland, William Armstrong built an observatory on his house with a glass dome."

Naturally, all such information must be confirmed by using other resources. This is because errors are not uncommon, such as this reference to Sir Robert Ball:

> " FILE - Volume of papers - ref. Accession 618 - date:1798-1905. item**:** Letter from Robert S Bath at the Observatory, Co Dublin, to Sir Henry Barkly as Secretary of the Royal Institution at Finsbury Circus, agreeing to give two lectures at the London Institution on the subject of the Astronomical Theory of the Great Ice Age - ref. Accession 618/101 - date**:** 9 July 1886."

For researchers with interests in the London area, A1M25 gives detailed descriptions of archives in and around the capital[15]. In addition, there are the many genealogy and local history sites, discussion groups and message boards, which may be of use to find the ancestors or living relatives of your subject. Several local authorities use a search system called DScovery[16]. This does a combined search of all a local authority's library, museum and archive holdings. Just enter a single word, for example, 'astronomy', and it will produce a list of results for the whole authority.

Census data

Data from the seven censuses between 1841 and 1901 is now available online, though some information can be obtained only by subscription or pay-per-view. Try your local library or local history centre, as they may allow free access via their library account. The 1881 census is free online, and in more detail than any other. Many local history societies have transcribed and indexed census data onto their websites. It is worth mentioning that some census data can be unreliable and there are many enumerator and transcription errors. For example, in the 1881 census Howard Grubb is listed as Grubby. Edwin Dunkin is listed as Junkin.

Maps

The website at www.old-maps.co.uk is an ideal source for late 19th century maps of the British Isles, which can reveal actual or suspected observatory sites. The site lists 51 addresses containing the word 'observatory' (Figure 3). Type in 'Hakin' and you will be taken to a spot just outside Milford Haven where the word Observatory is printed. S.H.A. member Bryn Jones tells us that although a building was erected here for astronomical purposes, it never operated as an observatory.

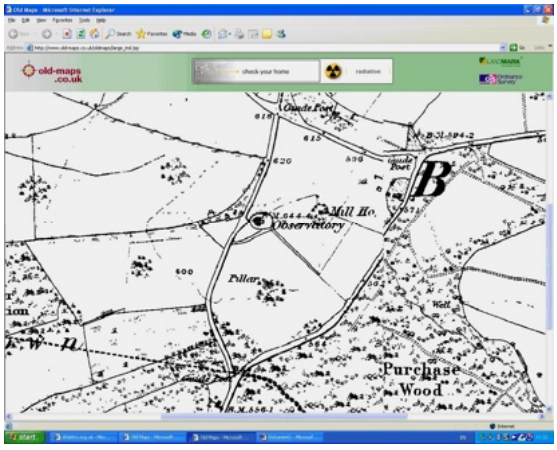


Figure 3

An example of information available on maps

This screenshot is from www.old-maps.co.uk.
It shows the site of the early 19th century observatory of 'Mad' Jack Fuller at Brightling, East Sussex, England.

S.H.A. Newsletters

In Issue 1 of the S.H.A. Newsletter (November 2002), Sir Patrick Moore, Stuart Williams and Ken Goward all wrote introductory articles on local astronomy. Williams also wrote an article about researching the history of local astronomy. My own article on A2A states that it contained 4 million catalogued items. Today, just four years later, the site contains 10 million items. It is a real treasure trove for the researcher. An amusing reference occasionally turns up, such as:

> " Herefordshire, a wealthy gentleman, Henry Southall purchased a telescope. His son remarked … 'its principal use will be to astound the ignorant gentry of Ross with Papa's great scientific knowledge and attainments.'"

Diaries, Journals and Letters

Many diarists and men of letters wrote about the night sky in their journals. Gilbert White, for example, is best remembered for his *Natural History and Antiquities of Selborne*, but his journals[17] contain many astronomical references, including:

> " 25 October 1769 - A vast aurora borealis which like a broad belt stretched across the Welkin from east to west. This extraordinary phenomenon was seen the same evening in Gibraltar.
>
> " 9 February 1774 – Jupiter and Venus approximate very fast – Venus is bright and makes strong shadows on the floor and walls.
>
> " 1 March 1783 – Mercury was visible all the first half of the month, but partly the bad weather and partly for want of an horizon, I never was to get sight of him."

Collecting Astronomical Ephemera

Hidden gems are still to be found that relate to astronomy. I include here news cuttings, advertisements and brochures for telescopes and accessories. I collect postcards, and have found many depicting telescopes and observatories. Some of the most interesting are those of solar eclipses taken in the early part of the 20th century. I have one fine example of a partial eclipse taken from my home town of Malvern in 1905.

Contributing to the Survey

There are a number of ways in which researchers can contribute to the Survey. First, they can become the co-ordinator for a particular county. This will involve acting as a liaison between the S.H.A. Council and researchers of the chosen county; supporting those researchers; and collating information to build the Survey database. The rate and direction in which each county develops will depend on the contributors. At first, co-ordinators might have to work alone, doing the ground-breaking work themselves.

Researchers not wishing to take responsibility for a whole county can still make a substantial contribution. Their chosen subject or field of interest may be a single person or observatory, a

school or a college where astronomy flourished in the past, or perhaps an instrument or lens maker. Data on these subjects will always be pertinent to the Survey and we encourage you to contribute your findings to it. Anyone can view the web-site and make contributions. However, only members of the S.H.A. can become county co-ordinators. An aspect of the Survey that will need to be attention is the question of quality control of the content. The best way to do this is being considered.

The Society Archives

When research on a particular topic has been completed and written up, a copy should be deposited in the S.H.A. Archives, held at the Institute of Astronomy, Cambridge. A suitable link, and a short summary of the findings, will be entered on the county page on the S.H.A. website. Even when research is ongoing, reference can be made to it on the website, allowing others to see that work is in progress. In this way researchers will be able to collaborate and compare findings on a particular subject, whilst at the same time avoiding duplication of effort. Members are also strongly encouraged to donate further copies of their work and original documents or photographs to relevant local history centres and record offices, where they may reach a local audience, preserved under archival conditions for posterity.

Conclusion

This paper has been published at this time to encourage historians of astronomy who have completed an aspect of their research to submit their findings to the Society so that we can grow the Survey database. It is our wish to do this incrementally, as the research findings will assist other researchers. In addition, we hope that this paper will encourage every reader to engage in this very worthwhile and fulfilling pursuit. We look forward to receiving your contributions.

S.H.A. point of contact for the Survey

Comments and questions on any aspect of the Survey can be raised with the author by e-mail (roger.jones@shastro.org.uk) or by standard mail (12 Stencills Drive, Walsall, WS4 2HP, England.) Suggestions for improvements to the website will be particularly welcomed.

Acknowledgements

Specific references and credits are given below, but I could not have penned this paper had I not read and taken in what had already been written on this subject, in particular by Allan Chapman and Stuart Williams, and by the encouragement of the S.H.A. Council whenever the Survey has been discussed at our meetings. Reg Withey, of course, was most helpful with the drafting of this paper.

Notes and References

1. Constitution of the Society for the History of Astronomy. Section 2. Objects and aims. Sub-section ii.
2. Stuart Williams. W. Henry Robinson: Popularising astronomy in Victorian Walsall and Birmingham. *The Antiquarian Astronomer: Journal of the Society for the History of Astronomy*. Number 1. 2004. 44-51.
3. Allan Chapman, *The Victorian Amateur Astronomer: Independent Astronomical Research in Britain 1820-19*20. London: Wiley. 1998.
4. A postcard from the author's collection. Date and publisher are unknown.
5. The Survey of Astronomical History (formerly named The Survey of the Astronomical Geography of the UK) was launched 22 February 2003 at the Annual General Meeting of the Society for the History of Astronomy held at the Royal Observatory, Greenwich.
6. The Local Government Act (1972; effective 1974) amalgamated some existing counties and established new ones. The Survey is based on the county structure that existed prior to these changes.
7. Data from the 1881 census can be searched online, free of charge at www.familysearch.org.
8. I. S. Glass. *Victorian Telescope Makers: The Lives and Letters of Thomas and Howard Grubb.* Bristol: IOP Publishing Ltd. 1997.
9. Stuart Williams. The Dead Astronomers [sic] Society, or Researching Local Astronomy History. *Society for the History of Astronomy News.* Issue 1. November 2002. Pages 4-6.
10. Addresses for most County Record Offices and Local History Centres can be found on the appropriate pages on the Society's website at www.shastro.org.uk.
11. Roger Jones. Sir Robert Ball: Victorian Astronomer and Lecturer par excellence. *The Antiquarian Astronomer: Journal of the Society for the History of Astronomy*. Issue 2. December 2005. Pages 27-36. (See Page 32).
12. Census data for 1841, 1851, 1861, 1871 1881, 1891 and 1901 for England Wales and Scotland.
13. The NASA Astrophysics Data System (A.D.S.) website is at http://adsabs.harvard.edu/abstract_service.html
14. A2A can be searched at www.a2a.pro.gov.uk
15. This site can be found at www.aim24.ac.uk .
16. This can be viewed at www.crxnet.com/page.asp?id=228 .
17. Gilbert White's Journals were published in: Walter Johnson. *Gilbert White's Journals*. London: Routledge. 1931.

Shooting Stars: The Women Directors of the Meteor Section of the British Astronomical Association

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In the early 20th century, three women amateur astronomers – Catherine O. Stevens, Fiammetta Wilson, and A. Grace Cook – made significant contributions to the Meteor Section of the British Astronomical Association, both as observers and as Directors of the Section. This paper discusses the role each played in meteoric science in general, and the Meteor Section in particular. It will be shown that all three women made significant and historically important contributions to the Section, and that their lives and work are worthy of study because of the light such study sheds on the birth and youth of amateur astronomical societies in the British Isles.

In the late 19th century, astronomical opportunities opened up to American women, both as students at the newly founded women's colleges, and as data-analyzing "computers" on large-scale research projects at major observatories. For example, between 1885 and 1900, Harvard College Observatory director Edward C. Pickering hired at least twenty-one women, the majority for analyzing stellar spectra for the Henry Draper Memorial project[1]. Unfortunately, women in Britain were not afforded as many opportunities, as there was no counterpart to the undergraduate astronomy programs in American women's colleges, nor were many "computer" positions made available to women[2,3,4]. Two notable exceptions are Alice Everett and Annie Scott Dill Russell (1868-1947), both of whom worked at the Royal Observatory, Greenwich in the 1890s. Due to these limitations, women in Britain and Ireland who showed interest in observational astronomy were frequently limited to working with their spouse or another family member (for example, Margaret Lindsay Murray Huggins, 1848-1915), or, as in the case of those of "independent means" such as solar observer Elizabeth Brown, having a small private observatory built especially for their astronomical pursuits[3].

Access to professional societies was also largely closed to British women. The most prestigious of these, the Royal Astronomical Society, had essentially closed its doors to female members. Only three women could be counted among its rolls, all as honorary members. Caroline Lucretia Herschel (1750-1848), discoverer of several comets and long-time astronomical assistant to her brother, famed amateur astronomer and telescope maker William Herschel (1738-1822), and Mary Fairfax Somerville (1780-1872), author of several well-known books on astronomy and other sciences, had been elected to honorary membership in February 1835. Anne Sheepshanks (1789-1876) had also been granted honorary membership in recognition of her donation of her brother Richard's astronomical instruments in 1857[5]. Given the numerous doors closed to British women interested in astronomy, it is logical that they entered the field through those few remaining doors open to them, namely local astronomical societies.

The most notable among the early institutions was the Liverpool Astronomical Society (L.A.S.), founded in 1881 at the suggestion of the Reverend Thomas Henry Espinell Compton Espin (1858-1934). Its goals were to "foster a liking for astronomy, especially amongst the possessors of small telescopes". Observers were organized into various topical sections[6]. Membership was open to all interested parties (aided by the organisation's inexpensive subscriptions). By 1887 female members numbered eight out of three hundred, including the famed astronomy writer Agnes Mary Clerke (1842-1907), and Elizabeth Brown (1830-1899), who was the first Director of the Society's section for solar observing[7].

By this time, serious tensions related to monetary issues and the growing geographical scope of the Society had arisen. Although it began as a local society, the L.A.S. had grown substantially over its first decade, and had become not only national, but international in focus, much to the very public dismay of one of its most famous members, astro-photographer Isaac Roberts (1829-1904)[6,7,8]. By 1889, increasing financial problems, combined with the serious illness, death, or resignation of several officers, led some members to press for the formation of a new society.

William Henry Stanley Monck (1839-1915), a barrister and photometry expert, wrote to the Editor of the *English Mechanic and World of Science* a letter that was published on 18 July 1890, laying the groundwork for such a new, amateur society[8]. Among the reasons for the necessity of the new organization were the obvious decline in the L.A.S. and the fact that:

> "… the Royal Astronomical Society does not supply all that is needed. … [For example] … ladies (many of whom take an active interest in science, and have contributed to its progress) are practically, if not theoretically, excluded from the Fellowship of the Royal Astronomical Society."

Letters of support soon appeared in the *English Mechanic*, including one penned by Elizabeth Brown. For some time she had been urging Edward Walter Maunder (1851-1928) of the Royal Observatory, Greenwich to form such a new amateur organization, with, as Maunder termed it "the gentle persistency which characterized her" [9].

A Provisional Committee, which included four women - Elizabeth Brown, Agnes Clerke, Agnes Giberne (1845-1939), like Clerke, an astronomy writer, and Margaret Huggins - was formed. The Committee set up Objectives for the new British Astronomical Association (B.A.A.):

> "The association of Observers, especially the possessors of small telescopes, for mutual help, and their organization in the work of Astronomical observation. The circulation of current Astronomical information. The encouragement of a popular interest in Astronomy." [10]

The Constitution of the new B.A.A. stated that:

> " Ladies shall be eligible for election as Members of the Association, and no expression herein-after shall be held to debar them from exercising any right or privilege of the Association, or from filling any office to which they may be elected." [10]

By the time the first meeting was held on 24 October 1890, 283 members had joined, and from the start women held positions of authority within the organization. Brown became the first Director of the Solar Section and held that post until her death in 1899. Despite the fact that she considered herself "totally useless" to the Association. Clerke served on the Council for six terms between 1890 and 1898, and wrote two articles for the Journal of the B.A.A.[11] She remained a member of the Association until her death in 1907. Huggins served on the Council from 1890 to 1892. The wife of Isaac Roberts, Dorothea Klumpke-Roberts (1861-1942), a noted astronomer in her own right, served as a Council member in 1902-1903 and in 1904-1905. In his address of 1894, the B.A.A. President Arthur Downing noted:

> " We have a lady Director of Observing Section [Brown], a lady Secretary [Alice Everett], a lady editor [Annie S.D. Russell Maunder]. So that I think we may claim to have shown that we are quite prepared to appoint a lady to any office in our Association for which we consider that she is the most suitable member available at the time." [12]

But it was the Meteor Section that became a haven for serious women amateur astronomers. As Mary Evershed observed in 1932:

> " … the British Astronomical Association has encouraged many women amateurs to do useful observing work, and Mrs. Fiammetta Wilson, with Grace Cook's help, for some time directed the Section for Meteors." [13]

This remainder of this paper will examine the contributions to the Meteor Section not only of Wilson and Cook, but of an earlier woman member, Catharine Octavia Stevens.

Early history of the Meteor Section and Catharine Octavia Stevens

Cometary debris was not definitively established as the cause of meteor showers until Giovanni Schiaparelli's 1866 work on the Perseid meteor shower and Comet Swift-Tuttle. Once the source of meteor showers was known, observers turned their attention toward identifying as many showers as possible, and determining their exact visual radiants. The most prolific radiant hunter was William Frederick Denning (1848-1931), who noted 278 potential showers, many of which were later determined to be collections of sporadic meteors rather than true annual showers[14]. This type of meteor work was mainly done with the unaided eye, and required:

> " A good knowledge of the constellations … [v]igilance and considerable practice before one becomes proficient as an observer." [15]

In this vein, the Meteor Section of the B.A.A. under its original Director, David Booth (1890-1892), and its second Director Henry Corder (1892-1899) was concerned with observing meteors and determining radiants[16]. The Section remained small, averaging about twelve, all male, members of whom only a handful were active observers[17]. William F. Denning, Director from 1899-1900, introduced detailed meteor reports of individual showers, listing observers and meteor counts. This was carried on by his successor, Walter E. Besley (1900-1905). The first observations posted by women are observations of Leonid by

Mary Orr, in 1900[18], of 119 Perseids by Miss M. Bolton in 1901[19] and of the 1901 Leonids by Mrs Arthur Brook[20]. The Section boasted twenty-one official members in 1902, although none were women. This was to change in May 1905 with the resignation of Besley due to poor health[21]. Miss Catharine O. Stevens (Figure 1), a distinguished member of the B.A.A., became the next Meteor Section Director. The appointment is somewhat puzzling, since her background did not include meteor observing, but was focused on the Sun and atmospheric phenomena such as sun pillars.

Catharine Octavia Stevens (1864-1959) was the eighth daughter of the Reverend Doctor Stevens, Rector of Bradfield, Berkshire. In keeping with the tradition of the day, C.O.S. (as she was commonly called) was tutored in music, painting and embroidery[22]. She joined the B.A.A. in 1891 and mainly made solar observations with her 3-inch refractor and $1^{5}/_{8}$-inch spyglass. She developed a new type of stand for her spyglass, which was dubbed the "Stevens stand" in a report to the B.A.A.[23] She travelled on three solar eclipse expeditions, to Algiers in 1900, Majorca in 1905 and Quebec in 1932. Her main interest in eclipses was the study of shadow bands[24,25,26,27]. She was also generally interested in the interplay between astronomy and meteorology, observing and describing such phenomena as seeing[28,29], solar pillars, halos and glories[30,31,32], and aurorae. She believed that aurorae were related to climate and weather rather than to sunspot activity[33,] and spent a year in the Shetland Islands making observations[22]. She also published observations of Comet Perrine[34] and a discussion of the connection between Biela's Comet and the Andromedids[35]. She built a house and observatory on the top of Boars Hill, Oxford, in 1910, on the edge of the Oxford Preservation Land Trust – a permanent dark site for observing[22].

When Stevens took over the reins of the Meteor Section, she did so with the intention of improving the organization of the Section so that its observations would be more scientifically useful. She also stressed the importance of simultaneous observations of meteors from two locations, a technique that can be used to determine the height of meteors[36,37]. Despite her attempts to organize the Section, and to rally its two dozen observers behind organized simultaneous viewing sessions, the Section was fairly dormant during her directorship (1905-1911). Stevens explained her difficulties in shouldering the overwhelming responsibility of directing the Section in her 1908 report:

> " … but the duty of a Director is not merely to sweep together the 'records' of the members of his Section. Thus, that the harvest of information gathered during the last three years is only so slowly coming through the 'mill' is due to the fact that in the present instance the Director is new both to the work of directing and to the details of the subject of meteoric astronomy." [36]

Stevens was also ill during a long period of time near the end of her directorship, which further hampered her work[38]. In all fairness, it should be mentioned that several of the other observing sections suffered from a serious lack of activity during this same time frame. Stevens did, however, make a lasting mark on the observing sections of the B.A.A. – she enlarged the scope of the Meteor Section to include observations of aurorae and the zodiacal light. Although very few observations were actually reported to the Section during her directorship, the study of the latter two phenomena was continued, with a separate section for Aurorae and Zodiacal Light formed for the first time in 1911 under the directorship of Gavin J. Burns.

Figure 1

Catherine Octavia Stevens (1864-1959)

Miss Stevens was Director of the Meteor Section of the British Astronomical Association from 1905 to 1911. This image is taken from her obituary in the Journal of the B.A.A. 1960, 70 (2), facing Page 104.

By courtesy of the British Astronomical Association

Fiammetta Wilson and the golden age of meteor observing

Another woman held in high esteem by the B.A.A. was Fiammetta Worthington Wilson (1864-1920). The eldest child of F.S. Worthington and Helen Felicite Till Worthington, she was originally home-schooled by governesses. She showed a natural talent for languages, and attended schools in Switzerland and Germany. Afterwards, she spent a few years at home before studying music in Italy. Following several years of travelling, she returned to England and taught at the Guildhall School of Music, where she became successful as a conductor and musical arranger[39].

Her interest in astronomy developed after her marriage to S.A. Wilson, through attending a series of lectures by Professor Alfred Fowler at the Imperial College of Science and Technology in 1910, a curriculum that Fowler had inherited from his mentor, Sir Norman Lockyer.[40] Denning wrote:

> " This [astronomy] became an absorbing interest to her, and she gave up a great deal of her music in order to devote more time to it. Social enjoyments were relinquished so that she might the more fully indulge the passion for astronomy; but her indomitable spirit and energy occasionally led to carelessness of self, which caused suffering." [39]

Indeed, Wilson was seriously ill on a number of occasions, and was forced by doctors' orders to give up observing for a time[41,42,43,44]. She joined the B.A.A. in 1910 and quickly established herself as a driving force within the Meteor Section, teaming up with Denning on coordinated observing sessions from different locations. According to her colleague, Cook, Denning and Wilson:

> "… obtained together more duplicate paths (accordances) of meteors than has ever been known in the history of meteoric astronomy." [45]

To facilitate observing she had a wooden platform built in her garden to enable her to see over the tree-line. She had many adventures during World War I. On one occasion "special constables detected the flashlight she used for recording meteors, and severely threatened her with arrest as a German spy." [39] When she tried to convince them that she was observing for the B.A.A., "she was met with a stern rejoinder, 'But do they know what you are doing?'" [46] Another time, "falling splinters from shrapnel once made things highly dangerous, but she managed to get good records." [39] Between 1910 and 1920 she observed more than 10,000 meteors, and marked paths for most of them[39].

Wilson's work resulted in several papers. In 1918 she and Denning noted that the apparent radiant of the January Quadrantid shower had shifted by eight degrees from its normal position[47]. This apparent change in the main radiant from one year to the next was probably caused by perturbations on the meteoroid stream from the planet Jupiter[14]. Wilson also published a paper on her meteor observations from the year 1914, 1060 meteors in 450 hours of observing. She noted that:

> " Probably I would have been enabled to record several other brilliant meteors during the latter end of the year, but for my husband being unable to help me – consequently, whilst I have been writing down notes recording one meteor, another may have eluded me." [48]

In addition to her meteor observing, Wilson used her 3-inch refractor, and especially her Zeiss binoculars, to observe deep sky objects and comets. Her paper *Clusters and Nebulae Visible with Small Optical Means*[49] described sixty objects viewable in binoculars. Wilson was also a contributing member of the Aurorae and Zodiacal Light Section, and published two brief notes on her observations[50,51]. In addition, she was a member of the Comet Section, and using her binoculars independently recovered Westphal's Comet in 1913 a few days after its official discovery by Paul Delavan of the National Observatory of Argentina[39,50]. She was a member of the Leeds Astronomical Society, the Chaldean Society, the Société Astronomique de France, the Société d'Astronomie d'Anvers, and was appointed a member of the Commission des Étoiles Filantes of the International Astronomical Union[39].

Wilson was accorded two great honours during her life: receiving the Edward C. Pickering Fellowship, and election as a Fellow of the Royal Astronomical Society. The latter event was momentous: she was one of the group of the first five women to be elected to the Society. In November 1886, Elizabeth Iris Pogson Kent had been nominated for Fellowship. The daughter of Norman Pogson, the former director of the Madras Observatory, Elizabeth was a long-time assistant astronomer and meteorological observer at that observatory. A legal advisor to the R.A.S. Council opined that the Society's charter prohibited the election of women, and so her name was withdrawn. In 1892, Annie Russell, Alice Everett and Elizabeth Brown were nominated for Fellowship, but they did not receive the three-quarters vote needed to be affirmed. In December 1914, Wilson

and Mary Blagg were proposed for Fellowship. In view of the earlier legal opinion, the Fellows voted at the February 1915 General Meeting to apply for a supplemental charter to allow women to become Fellows. Thus it was that Blagg, Wilson, Ella K. Church, Cook, and Margaret T. Meyer were elected in January 1916[5].

In November 1916, the Maria Mitchell Association, which oversaw the Nantucket Island homestead and observatory of Maria Mitchell (1818-1889), the first American woman professional astronomer, presented Edward C. Pickering with $12,359.13[53]. The award was given in honour of Pickering's forty years as Director of the Harvard College Observatory, to endow a fellowship for women astronomers. The Edward C. Pickering Fellowship carried with it a stipend of $500 to facilitate "study at the Observatory, with special emphasis on stellar research" [4]. Mary H. Vann and Dorothy Block were its first two recipients. award. When Block left Harvard for Yerkes Observatory, the remainder of her term (1919-1920) was filled by Antonia Caetana de Pereira Maury (1866-1952), who was at that time engaged in a study of spectroscopic binaries[4]. The 1920-1921 award was earmarked for an English astronomer, and Fiammetta Wilson was selected from among the applicants. Unfortunately, she died on 21 July 1920, two days after her fifty-sixth birthday, before word of the award could reach her[54]. Of her death, Harold Thomson, President of the B.A.A. said:

> " She has endeared herself to all of us by her keenness and enthusiasm for her work and by her power of inspiring others with her own love of astronomy. She will be greatly missed from our Council and our Meetings and the loss of her work will be a serious blow to the Meteor Section." [55]

Grace Cook and the Meteor Section

Not much has been written about the life of Alice Grace Cook (died 1958), although her work figured prominently in the history of the Meteor Section. A resident of Stowmarket, Suffolk, she became a member of the B.A.A. in 1911 and began serious meteor observing with Wilson and Denning. She later worked with J.P. Manning Prentice, whom she trained in meteor observing, in establishing the radiants of several showers[56,57]. The famous comet discoverer George Alcock met Cook at his first meeting of the Meteor Section in 1931. Cook told Alcock that in her opinion he would, one day, take the place of Denning (who had recently died)[58].

Cook wrote several articles on other areas of astronomy, including: *Observational Methods for Meteor Observers*[59]; *Magnitudes of Meteors*[60]; *Transit of Mercury*[61]; and *Observations of Nova Aquilae*[62], where it is noted that she was one of the first to discover the nova. Under the pseudonym Mary Star she also wrote articles on astronomy for local newspapers, including the *East Anglian Daily Times*[63]. She was a member not only of the Meteor Section, but also of the Comet, Saturn, Lunar, and Aurorae and Zodiacal Light Sections of the B.A.A., and aided the Historical Section by typing two large index volumes[64].

Besides her election in 1916 to Fellowship of the R.A.S., Cook was awarded the Pickering Fellowship in 1920, after Wilson's death. The announcement in *The Observatory* explained that:

> " Miss Cook is also an ardent meteor-observer and was a close friend of Mrs. Wilson; and it would have been difficult to suggest a more appropriate revision under the tragic circumstances. The holder will carry with her all our good wishes for a prosperous year's work." [65]

An unanswered question is exactly what Cook did with the Pickering Fellowship. The 1922 *Annual Report of the Harvard College Observatory* reported that Cook had been "engaged in the observation of meteors" [66], but gives no hint of whether she actually travelled to Harvard. In fact, scrutiny of the reports of the Meteor Section of the B.A.A. show that she did not: she continued observing meteors from England during the entire period October 1920 to September 1921, and in October 1921 was elected Director of the Section. It may well be that the first Pickering Fellow from Britain actually to conduct work at Harvard was Cecilia Payne, who held that distinction in 1923-1924[4].

Cook remained active in astronomy until late in her life. She was a founding member in 1921 of the Ipswich section of the Chaldean Society, and in 1950 of the Ipswich and District Astronomical Society. Her death was reported at the meeting of the B.A.A. held on 25 June 1958, where she was lauded as "one of England's most distinguished women astronomers" [67].

The Directorships of Wilson and Cook

From 1911 to 1921 the Director of the B.A.A. Meteor Section was the Reverend Martin Davidson (1880-1968). He published detailed reports of the observations of Section members, and the calculations done by Denning on radiants and atmospheric heights and trajectories of meteors[9]. These

years saw the core of dedicated observers (Denning, Cook, and Wilson) making significant contributions to the work of the Section. In addition, a number of other women were recruited and became contributing members of the Section. For example, the 1913 roster shows that of the total of thirteen members, five were women - Cook, Mrs. Louisa P. Freeman, Miss A. Fry, Miss Helen M. Metcalfe, and Fiammetta Wilson[68].

In early 1916, the Reverend Davidson took leave from the Section to act as an Army Chaplain. Cook and Wilson were named Interim Directors until his return. In 1917 the Section had twenty members, including six women – Cook, Wilson, Freeman, Mrs. J.E. Edwards, Miss T.E. Gall, and Miss L.S. Strover[69]. Although they were named co-directors, Cook herself stated that it was Wilson who did the bulk of the work[70]. The pair carried on the work of the Section, and tried diligently to recruit new members, to replenish the ranks lost to the war effort[71]. Upon his return to the Section in 1919, Davidson wasted no time in thanking his friends for their devotion to the Section:

> " Through the untiring energy of the Acting Directors, Mrs. Wilson and Miss A.G. Cook, the work of the Section was continued during the war, and many new members were enrolled." [43]

Wilson's health was now deteriorating and she could not participate in any significant way from 1919 until her death in 1920. After that, Cook was the only active woman member of the Section.

Davidson resigned in 1922 and Cook was appointed sole Director. During her brief Directorship (just under two years), the Section saw the publication of its first Memoir since 1905, and a marked increase in the radiants determined, due in part to the work of Cook and J.P. Manning Prentice, who succeeded Cook as Director in 1923[73]. However, looking back upon this period, Prentice referred to Wilson's death as a "sheer tragedy" and used it to mark the end of the second great phase of the Meteor Section's work[9]. The Section recovered some of its momentum by 1930 when simultaneous observations were again coordinated. Prentice remarked that:

> "… the results are of a very satisfactory standard of accuracy; although in quantity they are not yet so numerous as those formerly obtained between Mrs. Wilson, Miss Cook, and Mr. Denning." [74]

Perhaps this is the most telling statement of the enduring legacy of Cook and Wilson – they had become the standard against which the work of all others would be measured.

It is, therefore, clear that Stevens, Wilson and Cook each made significant and historically important contributions to the Meteor Section of the B.A.A. Furthermore, a study of their life and work illuminates a notable period in the history of modern astronomy, namely the birth and youth of amateur astronomical societies in the British Isles.

Notes and References

1. Mack, Pamela E. Straying From Their Orbits. In: G. Kass-Simon and Patricia Farnes (Editors). *Women of Science: Righting the Record.* Bloomington, Indiana: Indiana University Press. 1990. Pages 72-115.
2. Kidwell, Peggy Aldrich. Women Astronomers in Britain, 1780-1930. *Isis*. 1984, 75 (278), 534-546.
3. Creese, Mary R.S. *Ladies in the Laboratory?* Lanham, Maryland: The Scarecrow Press. 1998. Pages 225-249.
4. Jones, Bessie Zaban and Lyle Gifford Boyd. *The Harvard College Observatory: The First Four Directorships, 1839-1919.* Cambridge, Massachusetts: Harvard University Press. 1971. Pages 383-417.
5. Dreyer, J.L.E. and H.H. Turner (Editors). *History of the Royal Astronomical Society 1820-1920*. London: Royal Astronomical Society and Wheldon and Wesley. 1923. Pages 81 and 233-234.
6. Davies, W.H. The Liverpool Astronomical Society. *The Observatory*. 1883, 6 (77), 268-9.
7. Chapman, Allan. *The Victorian Amateur Astronomer*. Chichester: John Wiley and Sons. 1998. Pages 248-251.
8. Monck, W.H.S. An Amateur Astronomers' Association. *English Mechanic and World of Science*. Number 1321. 18 July 1890. 445-446.
9. Kelly, Howard L. *The History of the British Astronomical Association*. London: British Astronomical Association. 2nd Edition 1989. Pages 7-9 and 104-110.
10. Provisional Committee. Rules of the British Astronomical Association. *Journal of the British Astronomical Association*. 1890, 1 (1), 9-14.
11. Brück, M. T. Agnes Mary Clerke, Chronicler of Astronomy. *Quarterly Journal of the Royal Astronomical Society*. 1994, 35, 59-79.
12. Duke, P.F., and A. Everett. Report of the Annual Meeting of the Association. *Journal of the British Astronomical Association*. 1894, 5 (1), 1-9.
13. Evershed, M.A. Woman Astronomers. *Journal of the British Astronomical Association*. 1932, 42, 48-49.
14. Kronk, Gary. *Meteor Showers: A Descriptive Catalog*. Hillside, New Jersey: Enslow Publishers. 1988. Pages xx-xxi, 17, 22, 155 and 172.
15. Olivier, Charles P. *Meteors*. Baltimore: Williams and Wilkins. 1925. Page 9.
16. Booth, David. Report of the Meteoric Section. *Journal of the British Astronomical Association*. 1893, 3 (11), 485-493.
17. Corder, Henry. Meteoric Section. *Journal of the British Astronomical Association*. 1898, 8 (10), 391.
18. Besley, Walter E. Meteoric Section Interim Report II. The Leonids,1900. *Journal of the British Astronomical Association*. 1901, 11 (2), 56-60.
19. Besley, Walter E. Meteoric Section Interim Report. The Perseids, 1901. *Journal of the British Astronomical Association*. 1902, 12, 60-62.

20. Besley, Walter E. Meteoric Section Interim Report II. The Leonids. *Journal of the British Astronomical Association*. 1902, 12 (4), 163-167.
21. Besley, Walter E. The Meteoric Section. *Journal of the British Astronomical Association*. 1905, 15 (7), 300.
22. J.H.D[rake]. Catharine Octavia Stevens. *Journal of the British Astronomical Association.* 1960, 70 (2), 103-104.
23. Petrie, J.G. Report of the Meeting of the Association. *Journal of the British Astronomical Association.* 1906, 16 (2), 51-53.
24. Stevens, Catharine O. The Problem of 'Shadow Bands'. *Journal of the British Astronomical Association.* 1906, 16 (2), 60-63.
25. Stevens, Catharine O. Wind Waves and Shadow Bands. *Journal of the British Astronomical Association*. 1924, 34 (5), 193-194.
26. Stevens, Catharine O. Shadow Bands. *Journal of the British Astronomical Association*. 1927, 37(7), 277-278.
27. Stevens, Catharine O. The Total Eclipse of the Sun 1932 August 31. *Journal of the British Astronomical Association*. 1932. 43 (1). 24-25.
28. Stevens, Catharine O. The Sun as a Twinkling Star. *The Observatory*. 1907, 30 (389), 407-408.
29. Stevens, Catharine O. Stellar Scintillation, *Journal of the British Astronomical Association*. 1922, 33 (3), 107-109.
30. Stevens, Catharine O. To the Editors of Knowledge. *Knowledge*. April 1902, 25, 84-85.
31. Stevens, Catharine O. The Great Sun Shaft of March 6, 1902. *Journal of the British Astronomical Association*. 1902, 12 (6), 240-242.
32. Stevens, Catharine O. Note on Halos and Rainbows. *Journal of the British Astronomical Association*. 1905, 15 (3), 137-138.
33. Stevens, Catharine O. Note on the Probably Atmospheric Origin of Aurorae. *Journal of the British Astronomical Association*. 1907, 17 (6), 279-280.
34. Stevens, Catharine O. Comet Perrine. *Knowledge.* December 1902, 25, 274.
35. Stevens, Catharine O. Note on the Physical Relation of Comets and Meteors. *Journal of the British Astronomical Association*. 1910, 20 (4), 197-199.
36. Stevens, Catharine O. Section for the Observation of Meteors. *Journal of the British Astronomical Association*. 1908, 18 (9), 358-360.
37. Stevens, Catharine O. Aurorae, Meteors, and Zodiacal Light Section. *Journal of the British Astronomical Association*. 1909, 19 (10), 436.
38. Stevens, Catharine O. Aurorae, Meteors, and Zodiacal Light Section. *Journal of the British Astronomical Association*. 1910, 20 (10), 527-528.
39. Denning, W.F. and Mrs Fiammetta Wilson. *Monthly Notices of the Royal Astronomical Society*. 1921, 81 (4), 226-229.
40. Meadows, A.J. *Science and Controversy: A Biography of Sir Norman Lockyer*. Cambridge, Massachusetts: MIT Press. 1972. Pages 115-129.
41. Davidson, M. Meteor Section Interim Report No. 11. *Journal of the British Astronomical Association*. 1913, 23 (6), 273-275.
42. Davidson, M. Meteor Section Interim Report No. 1. *Journal of the British Astronomical Association*. 1919, 29 (7), 189.
43. Davidson, M. Meteoric Section. *Journal of the British Astronomical Association*. 1919, 29 (9), 242.
44. Davidson, M. Meteor Section. *Journal of the British Astronomical Association*. 1920, 30 (10), 319-320.
45. Cook, A. Grace. And Mrs Fiammetta Wilson. *Journal of the British Astronomical Association.* 1920, 30 (10), 330-331.
46. Maunder, E. Walter and P.J. Melotte. Report of the Meeting of the Association. *Journal of the British Astronomical Association.* 1916, 26 (5), 177-179.
47. Denning, W.F. and Fiammetta Wilson. The Meteoric Shower of January. *Monthly Notices of the Royal Astronomical Society*. 1918, 78 (3), 198-199.
48. Wilson, Fiammetta. Brilliant Meteors Observed in 1914. *Monthly Notices of the Royal Astronomical Society.* 1915, 75 (5), 449-455.
49. Wilson, Fiammetta. Clusters and Nebulae Visible with Small Optical Means. *Journal of the British Astronomical Association.* 1916, 27 (2), 72-83.
50. Wilson, Fiammetta. The Zodiacal Light *Journal of the British Astronomical Association*. 1911, 21 (5), 241.
51. Wilson, Fiammetta. The Zodiacal Light as Observed April 24th, 1914. *Journal of the British Astronomical Association*. 1914, 24 (8), 408-409.
52. Delavan, Paul T. Discovery of Comet 1913d (Delavan). *Popular Astronomy*. 1913, 21, 644.
53. Pickering, Edward C. *Annual Report of the Director of the Harvard College Observatory*. 1918, 72, 1-2.
54. Anonymous. From an Oxford Note-book. *The Observatory.* 1920,. 43 (Number 556), 336.
55. Maxwell, S., and P.J. Melotte. Report of the Annual Meeting of the Association. *Journal of the British* Astronomical Association. 1920, 31 (1), 1-4.
56. Richards, Pete. *Historical Footnote on Meteor Observing in Suffolk*. 17 December 2005. http://www.ast.cam.ac.uk/~ipswich/Observations/Meteors/Meteors_historical.htm Accessed 16 October 2006.
57. Cook, A. Grace and J.P.M. Prentice. Observations of the Meteors of the ε Arietid Radiant in 1921. *Monthly Notices of the Royal Astronomical Society.* 1922, 82 (5), 309.
58. Mobberley, Martin. *George Alcock (1912-2000) Remembered*. n.d. http://uk.geocities.com/martinmobberley/Alcock.html. Accessed 16 October 2006.
59. Cook, A. Grace. Observational Methods for Meteor Observers. *Journal of the British Astronomical Association.* 1923, 33, 235-237.
60. Cook, A. Grace. Magnitudes of Meteors. *The Observatory.* 1915, 38 (Number 485), 136-142.
61. Cook, A. Grace. Transit of Mercury. *Journal of the British Astronomical Association*. 1914, 25, 84-85.
62. Cook, A. Grace. Observation of Nova Aquilae on June 8. *Monthly Notices of the Royal Astronomical Society.* 1918, 78 (8), 569.
63. Gooding, Ray. *Ipswich Section of the Chaldean Society.* 25 September 2005 .http://www.ast.cam.ac.uk/~ipswich/History/Chaldaean.htm. Accessed 16 October 2006.
64. Evershed, M.A. Historical Section. *Journal of the British Astronomical Association*. 1931, 41, 450.
65. Anonymous. From an Oxford Note-book. *The Observatory*. 1920, 43 (Number 557), 372.
66. Bailey, S.I. *Annual Report of the Director of the Harvard College Observatory.* 1922, 76**,** 2.
67. Beet, E.A. and D.A. Campbell. The Ordinary Meeting of the Association. *Journal of the British Astronomical Association.* 1958, 68, 302-303.
68. Davidson, M. Members of the Meteor Section. *Journal of the British Astronomical Association.* 1913, 24 (2), 83.

69. Wilson, Fiammetta, and A. Grace Cook. Summary of the Work of the Section, June to December 1916. *Journal of the British Astronomical Association.* 1917, 27 (3), 108-112.

70. Cook, A. Grace. Meteor Section. *Journal of the British Astronomical Association.* 1922, 32 (4), 128-130.

71. Wilson, Fiammetta, and A. Grace Cook. Meteoric Astronomy. *The Observatory.* 1918, 41 (Number 524), 127-129.

72. Davidson, M. Meteor Section Interim Report No. 7. *Journal of the British Astronomical Association*. 1920, 30 (8), 256-258.

73. Prentice, J.P.M. Meteor Section. *Journal of the British Astronomical Association*. 1923, 34 (2), 53-55.

74. Prentice, J.P.M. Meteor Section. *Journal of the British Astronomical Association*. 1930, 40 (9), 368-370.

Airy's Altazimuth

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When considering the instrumental needs of the Royal Observatory, Greenwich soon after becoming Astronomer Royal, George Airy decided that the difficulty of refining the theory of the Moon's motion required some means of obtaining accurate positional observations additional to those traditionally made with meridian instruments. His Altazimuth, completed in 1847, was to prove the most successful means of attaining this end and added significantly to our knowledge of lunar theory. The design, construction, operating procedures and results obtained with this instrument are described.

Introduction

When George Biddell Airy (1801−1891) came to Greenwich in 1835 as the seventh Astronomer Royal he took over an establishment that had become rather run down, mainly due to the ill health of his predecessor and incompetent members of staff. Positional astronomy, always one of Airy's major interests, was still the Observatory's main function, and Airy immediately reviewed the performance of the main positional instruments then in use. These were the six-foot mural circle and the ten-foot transit instrument, both constructed by Edward Troughton and in use since 1812 and 1816 respectively. In his first Report to the Board of Visitors in 1836 he confirmed that "The state of the meridian instruments is most satisfactory."[1] He was therefore able to concentrate for his first few years in office on the necessary improvements to the functioning of the Observatory, including staff restructuring, and reorganisation of the procedures for the reduction and publication of observations.

1.1 Need for lunar positions

Determinations of the Moon's position had been a major task since the foundation of the Royal Observatory in 1675, because then the only means of determining longitude at sea was by measuring the distance of the Moon from fixed stars and calculating the longitude difference from a comparison with the Moon's tabulated positions as seen from a fixed station. The task assumed by John Flamsteed, the first Astronomer Royal, and his successors was therefore the constant improvement of the co-ordinates of a large number of fixed stars, and frequent measurement of the Moon's position to facilitate the formulation of a theory to predict its future movement. Over the next 160 years the first of these tasks had been carried out very satisfactorily, but predicting the Moon's position had proved to be a different matter.

Due to the complexity and rapidity of its motion against the background of the fixed stars, circling the sky more than twelve times a year but not exactly retracing its path for about 18.6 years (230 lunations), far more position measurements were required than for any other celestial body, but paradoxically the Moon's position could be satisfactorily determined far less often than that of other bodies. For a period of about four days either side of New Moon the thin crescent cannot be observed with meridian instruments owing to its proximity to the Sun and the consequent glare; the fact that a positional measurement can be lost by the passing of a small cloud at the moment of transit is therefore much more serious in the case of the Moon. A further problem in obtaining really accurate positions of the Moon arises from the fact that due to its changing phases, except at times close to Full Moon only one limb each in Right Ascension and Zenith Distance can be observed, so that an estimated value of the apparent semi-diameter has to be applied to derive the position of the Moon's centre.

By Airy's time the lunar ephemeris was no longer needed by navigators, since the successful development of the marine chronometer and the annual publication of the *Nautical Almanac* provided better means of longitude determination. By then, however, the Royal Observatory had established itself as one of the world's leading stations for the provision of positional observations of fundamental stars as a fixed frame of reference, and of the motions of the Sun, Moon and planets for the

purposes of refining orbital theory and improving ephemerides. In other words, the requirements of the navigator had been superseded by those of the world's astronomical community. This is apparent from the huge undertaking of re-reducing all the Greenwich observations of the Moon and planets made since the introduction of improved instrumentation by James Bradley, the third Astronomer Royal, in 1750. Suggested by Airy in 1832, and involving the use of improved constants derived by Friedrich Bessel, this government-funded enterprise was now being carried out by a team of supernumerary computers under Airy's supervision, and would lead to publications a few years later which would prove to be of great and lasting value (Airy 1845, 1848a).

1.2 Airy's proposed solution

Despite his initial satisfaction with the performance of the meridian instruments, Airy was considering their eventual replacement as early as 1843 (Satterthwaite 2001a). In particular he contemplated replacing the transit instrument with one of larger aperture − prompted by the discovery of new, faint, minor planets − and of combining its function with that of the mural circle in a single instrument. This he achieved with the inauguration in 1851 of his uniquely successful transit circle (Satterthwaite 2001b). Whilst considering the matter of improved instrumentation for positional work, however, Airy was also acutely conscious of the need to provide some means of increasing the number of lunar position measurements, and so made this the first priority of his review.

In an address to a specially convened meeting of the Board of Visitors of the Royal Observatory on 1843 November 10 Airy presented his proposed solution. He summarized the lunar positions that had been determined during his seven years in charge at Greenwich, remarking that "one-fourth of the Moon's course is absolutely lost, and one-half is very imperfectly observed" and that "the uniform suppression of observations during the Moon's passage through entire portions of her orbit of great extent is, in reference to theory, extremely injurious." Noting that the number of complete observations of the Moon's position currently being made was under one hundred a year he estimated that given the means to make off-meridian observations "the number of nights of efficient observation might be made to exceed two hundred". He continued:

> "After careful consideration of the ways in which these observations might be made, I have come to the conclusion that there is but one instrument with which observations could certainly be made possessing the required accuracy, and that with it the observations certainly could be made. This instrument is the Altitude and Azimuth Instrument. No form, however, in which I have seen this instrument appears to me to be sufficiently firm for this purpose (in which the azimuths are as important as the altitudes). I should propose to construct a new instrument, with circles of three feet diameter, in general form resembling the Palermo or Dublin circle, but framed on the same principles of massiveness and strength, and with the same exclusion of adjusting power, which I have adopted in the Ordnance Zenith Sector." [2]

The Zenith Sector was a new instrument designed by Airy and used by the Ordnance Survey for star observations in connection with its on-going retriangulation of the British Isles.

The Palermo circle referred to was the highly successful 5-foot vertical circle constructed by Jesse Ramsden and used by Giuseppe Piazzi from 1789; with it, Piazzi compiled a catalogue of nearly 8000 stars, discovered the large proper motion of 61 Cygni, and in 1801 discovered Ceres, the first minor planet. The Dublin circle, also by Ramsden, was originally intended to be ten feet in diameter, but this was later reduced to eight feet. Unfinished when Ramsden died in 1801, it was eventually completed by Matthew Berge and installed at Dunsink Observatory in 1808, although observational records exist only for the period 1812−1839. These instruments are basically transit circles, but mounted so as to permit observation in azimuths other than the meridian plane. It was entirely characteristic of Airy to design his own version of the instrument, rather than to have another Ramsden copy made, and to incorporate his own carefully thought out principles of design. His instrument achieved the required stability and precision with far less interruption of its field of view that was the case with any of its predecessors.

It is worthy of note that initially the new instrument was known as the Altitude and Azimuth Instrument. This rather cumbersome title would clearly have beneffited from abbreviation, and occasional references to the 'Alt-Azimuth' are found. Airy finally resolved this himself; in his Annual Report in June 1851 he for the first time refers to the instrument as the Altazimuth, by which name it has been known ever since. A concise description of the instrument is included in the Tercentenary History of the Royal Observatory (Howse, 1975:53-5).

2. Design principles

Airy was considering the design of three instruments simultaneously at this time (the Altazimuth, the Transit Circle and the Reflex Zenith Tube), and applied the same principles to each. He believed it unrealistic to expect that a precision instrument could be so well engineered that when fully adjusted it would remain free from instrumental errors, and knew that such errors would in any case vary with ambient conditions; he therefore aimed at making the structure as massive and rigid as possible, with no provision for delicate adjustments, and relied on determining the necessary corrections for instrumental errors by measurement at the time of observation. In his own words:

> " That in all the moving parts of the instrument the fundamental principles of construction have been:— to form as many parts as possible in one cast of metal,— to use no small screws in the union of parts,— and to leave no power of adjustment in any part; it being intended that the observations shall be so arranged that every instrumental error shall be deduced from the ordinary observations, and that numerical corrections shall be applied in the reduction of the observations." [3]

This approach, unusual for the time, was to be triumphantly vindicated by the success of these instruments, and would be used as the basis for the design of a large number of instruments worldwide during the next hundred years.

Whilst the designs were entirely his own, Airy did consult with two trusted friends during their formulation: Charles May, engineering director of the firm of Ransomes & May who were to manufacture the massive parts of each instrument, and William Simms of Troughton & Simms who would be responsible for the optics, graduated circles and other precision components. It is clear that he regarded the proposed Altitude and Azimuth Instrument as the greatest priority, and following the acceptance of his proposal by the Board of Visitors he was able to report to them six months later that:

> " The Board of Admiralty at once sanctioned the principle of this proposal; and, on their application, the Lords Commissioners of the Treasury without hesitation sanctioned the estimated expense." [4]

3. Housing and support

3.1 Building

In addition to the construction of the instrument it was also necessary to provide a building to house it. Airy chose to build on the walls of the Advanced Building, in effect on the site where Flamsteed's Equatoreal Sector had once stood, a few feet to the south of the Halley/Bradley Quadrant Room. The western wall had been constructed by Flamsteed as a meridian wall for his Mural Arc, whereas the other walls aligned with the original buildings, approximately 14° off-meridian; the new building, in effect a tower, was therefore an irregular quadrilateral in section. The instrument was mounted three storeys high in order to have a clear horizon for the lunar observations. Airy records that:

> "… the Deputy Ranger of the Park consented, on my application, to cut off the top of the only tree which interfered materially with our view near the horizon." [5]

A revolving 'dome' with opening shutters, in fact a flat-topped cylinder of ten feet internal diameter, covered the instrument. This became known as the New South Dome (Figure 1).

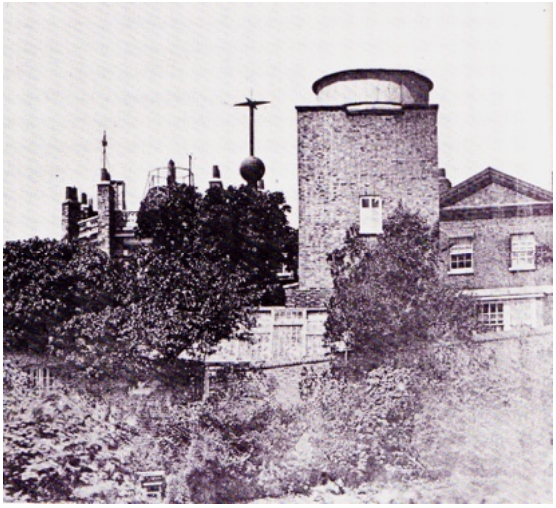


Figure 1

The Altazimuth dome, from the south in 1857.

Courtesy of the National Maritime Museum.

3.2 Supporting Pier

The proposed massive construction of the instrument required a very firm foundation; for this Airy specified a three-rayed pillar of brickwork, unconnected with the surrounding building and topped by blocks of Portland stone, rising some 26 feet above the foundation. The central part of this pillar was triangular in section, of side approximately 5 feet, with rays one foot wide extending five feet from the centre at each corner. At the centre of this structure an upward extension, a cylindrical brickwork column 3 feet in diameter and approximately

4½ feet high, was provided to support the actual instrument, the lower rayed pier providing support for the framework bearing the upper pivot bearing.

The floor of the observing room was independently supported some two feet above the top of the rayed pillar, having no contact with the mounting or any part of the instrument.

4. Design and construction

The basic design of such circles comprises a telescope mounted on a horizontal axis with a vertical circle attached, contained within a framework which can be rotated around a vertical axis and provided with a horizontal circle to measure the azimuth setting. A major difference from the design of earlier vertical circles, however, was the need for the measurements in azimuth to be made with the same accuracy as those in altitude in order for lunar positions to be computed from them; hence the horizontal circle needed to be graduated to the same accuracy as the vertical circle, and similarly read by microscopic micrometers. This imposed a further requirement, that the upper pivot of the vertical axis be very firmly supported, and engineered to maintain accurate verticality at all settings. Airy achieved this by a characteristically simple but effective design.

4.1 Upper bearing support

In addition to providing for this verticality and rigidity, it is also necessary to minimise obscuration of those parts of the sky where observations were required to be made. Airy achieved this by mounting the upper bearing at the centre of a horizontal triangular frame, which was supported by three vertical triangular frames bolted to a horizontal triangular base. These welded triangular frames, of iron rods 1½ inches in diameter, fastened together by means of strong bolts in welded supports, provide a very rigid structure without the need for massive components which would obscure more of the sky. The radial arms which locate the upper and lower bearings at the centre of the two horizontal frames are also welded, and the radial arms of the lower triangle rest in grooves cut in the stone blocks which cap the three rays of the supporting pier. Airy further provided for the framework to be orientated so as to minimise the area of useful sky obscured by the framework:

> " The single bars offer no material interruption to the telescope; the only part which deserves consideration is the angle of the upper triangle, where five bars unite, and where there are also a fork, nuts, &c. Now it was obvious that, if the frame were so placed that one of these angles should be exactly South; then the two remaining angles would be in positions in which the Moon could never pass them; and the southern angle, though it would undoubtedly interrupt the sight of the Moon, would do so in a position of the Moon which is not favourable to observations with this instrument, and in which she would infallibly be observed with the meridional instruments. That position was therefore adopted for the frame; and every arrangement of the building, staircase, &c., was made in subordination to this choice." [6]

This arrangement can be seen in Figure 2, which is extracted from the published description of the instrument (Airy 1848b). It shows the brick pillar *C* bearing the horizontal circle *Q*, and is drawn from the perspective of an observer standing north of the instrument and facing south; notice that the lower horizontal triangle is viewed from above and the upper from below. *N* is the upper bearing for the vertical axis.

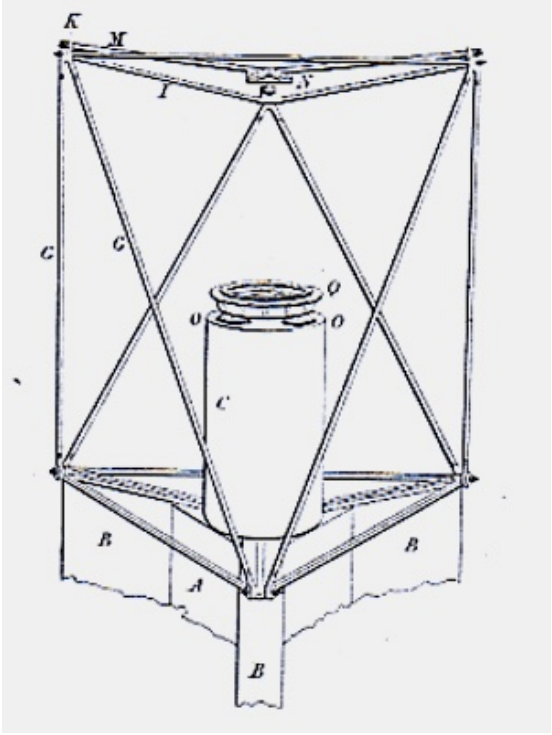


Figure 2

The supporting structure for the Altazimuth

This shows, in particular, the upper azimuth bearing *N*, and the column *C*, which supports the base plate *Q*, seated on top of the 26-foot high, three-rayed supporting pier.

This image is from Airy 1848b, Plate I, Figure 4.

4.2 The telescope and circle

The telescope and vertical circle are constructed as a single unit, comprising two gun-metal castings bolted together. One casting forms the central

drum with a set of spokes and one pivot, the objective and eye-ends of the telescope, and carries the vertical circle; the other casting forms the second pivot and set of spokes. The combined unit is supported with the axis horizontal, each pivot resting in a counterpoised bearing in the 'cheek' pieces of the rotating frame. The telescope objective is an achromatic doublet of 3.7 inches aperture, approximate focal ratio 12. This unit is shown in Figure 3.

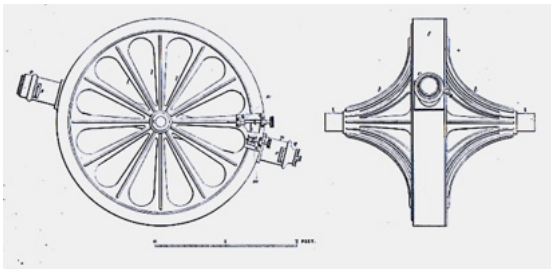


Figure 3

The telescope and vertical circle unit

This image is from Airy 1848b, Plate III, Figures 18 and 19.

4.3 The Rotating Frame

This frame is basically comprised of four parts in cast iron, two vertical side or 'cheek' pieces and upper and lower connecting plates carrying the pivots of the vertical axis. Each cheek piece is a single casting, over 4½ feet high and 2 feet wide; both carry a pivot bearing for the horizontal axis, and one carries the four microscopes for reading the vertical circle. The other cheek piece carries a toothed circle, which engages with a pinion attached to the telescope and circle drum to provide adjustment in altitude. The upper connecting plate carries the upper pivot of the vertical axis, and is bolted to the two cheek pieces. The lower connecting plate, also bolted to the cheek pieces, carries the lower pivot and also four microscopes for reading the horizontal circle. The spherical gun-metal pivot rests in a counterpoised gun-metal cone and has an oil-channel bored through it for lubrication of the bearing.

In his description of the instrument Airy gives the weights of these various components: the total weight of the rotating frame together with the telescope and vertical circle is almost 2000 lb (907 kg). That such a mass can be rotated whilst preserving verticality to the accuracy required is confirmation of the excellence of the design of the supporting framework. The massive construction of the rotating frame, with the telescope/circle unit mounted within it, is well shown in Figure 4.

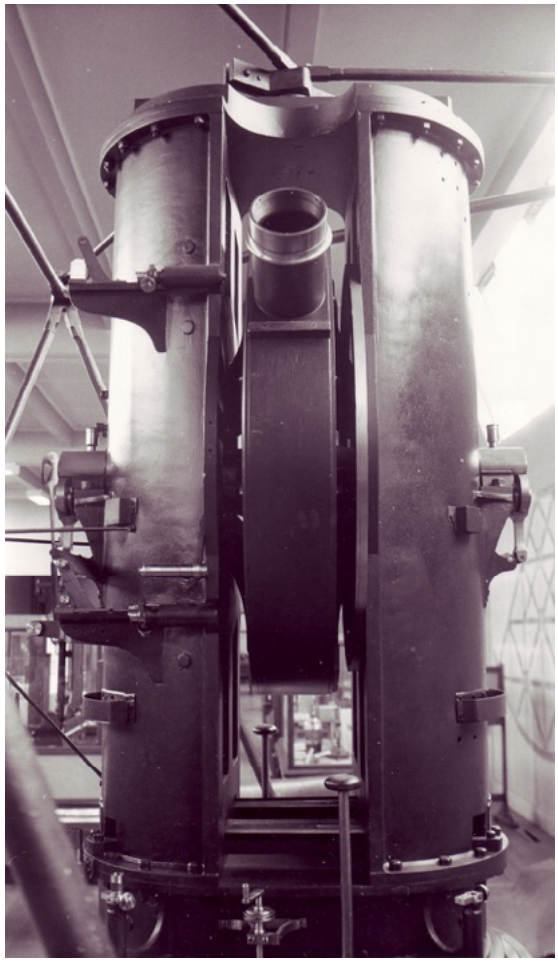


Figure 4

The rotating frame and telescope/circle unit

Photographed when displayed in the Science Museum, London, *circa* 1965.

Courtesy of the National Maritime Museum.

4.4 The base plate

The base plate is located by three of its spokes seating in grooves cut in iron blocks set in the stone capping of the brick column, each furrow being filed to the exact depth to ensure horizontality. It carries the horizontal circle, and also a toothed circle engaging with a pinion attached to the lower plate of the rotating frame, to provide for adjustment in azimuth.

4.5 The divided circles and microscopes

Both circles are of silver and 3 feet in diameter, with graduations every 5 minutes of arc. The graduations were engraved using William Simms's self-acting dividing engine, his improvement on Troughton's excellent machine. His nephew, also William Simms, who had joined the business in 1836, records in his memoirs that his Uncle had entrusted him with the graduation of several im-

portant instruments:

> " Amongst the instruments I graduated upon this machine may be named the Transit Circle at Greenwich, that at the Cape of Good Hope, … the large Equatorial at Greenwich, the Alt-Azimuth instrument there also." [7]

The circles produced by Troughton & Simms at this time were to remain some of the finest examples of machine-divided circles for many decades. Each circle has four reading microscopes with micrometers, and a low-power 'pointer' microscope for identifying the whole number of degrees.

4.6 Ancillary equipment

Additional fittings included levels to confirm horizontality of the altitude and verticality of the azimuth axes, and an illumination system enabling the circles to be read by the microscopes. This was provided by a single lamp, with a series of reflectors to direct the illumination to those parts of the circles beneath the microscopes.

At each end of the horizontal (altitude) axis was affixed a small plate bearing a small dot, and microscopes were provided to enable the position of these dots to be measured and thus to determine any pivot errors.

Some of these additional components can be seen in the drawing of the assembled instrument (Figure 5). Figure 6 shows in close up part of the base plate with the setting circle, azimuth circle and slow-motion controls.

4.7 Construction

The construction of the new instrument was not without difficulties and delays. Airy reported in 1845 that the instrument was:

> "... not yet out of the engineer's hands, but I am assured that its principle parts will be transferred to Mr Simms in a few days. It is almost unnecessary to remark, that the work was, in several respects, different in some degree from that to which engineers are accustomed, and this has caused greater delay in its construction than I had anticipated." [8]

A year later he records that construction had been delayed "by a singular accident":

> " The parts cast by Messrs Ransome and May … had been sent to Mr Simms, and several fittings of micrometers and other small parts had been adapted to them. Some levels also having been adapted, I was much surprised to find that the end of the telescope would not pass them, although the calculations of height, &c., had been expressly arranged in order to permit it to pass. On examination it appeared that, in attaching some small portions of the pattern to the principal

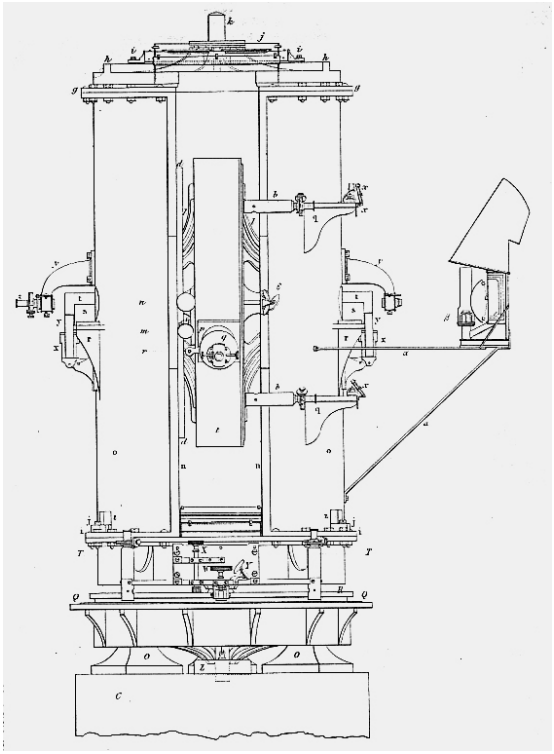


Figure 5

Drawing of the complete Altazimuth assembly

From Airy's published description (Airy 1848b, Plate IV, Figure 22). Notice the microscopes for examining the pivots of the horizontal axis, two of the microscope micrometers for reading the vertical circle, and the light source that illuminated the circles via a system of mirrors.

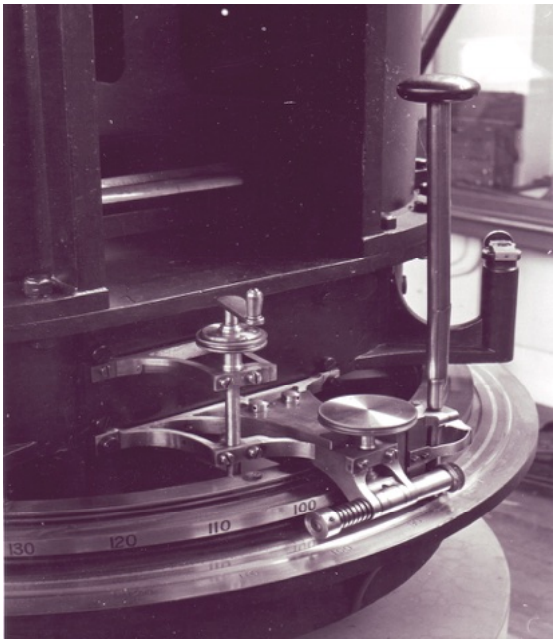


Figure 6

Close-up view of part of the base plate and horizontal circle structure

Also shown are the setting circle and slow-motion controls.
Courtesy of the National Maritime Museum.

> parts, these portions had been attached on the wrong side of the hole for the horizontal axis, so that, in the casting, what was intended for the upper part of the vertical axis became the lower part. The engineers, upon hearing of this mistake, immediately undertook to prepare new sides without expense to the Observatory, and with as little delay as possible; but as the completion of these parts requires not only skilful casting, but also careful turning and planing, there is necessarily considerable delay." [9]

In his next report, in June 1847, Airy records that "The Altitude and Azimuth Instrument has been completed several weeks." [10] In the light of the complexities of the design and the difficulties encountered in its construction, completion just 3½ years from the initial proposal seems very commendable. Airy records his satisfaction with the work of both the engineers and the instrument-maker, and especially with the graduation of the circles with Simms's dividing engine:

> "… my first care was to examine the graduations … in no instance is the mean of the four microscopes of either circle half a second in error."

(A positional accuracy better than one part in 600.) The form of the pivots of the horizontal axis was also "examined most severely", by measurement of the dots placed at each end of the axis with the micrometer microscopes provided for the purpose (see Section 4.6 above) and the effect of any irregularity "does not amount to half a second." Airy comments:

> " I think it extremely creditable to the engineers that pivots which have not been touched by the tool of the instrument-maker should possess this accuracy."

The completed instrument is shown in situ in the New South Dome in Figure 7.

5. Modifications and repairs

During its working life of half a century, normal maintenance procedures were carried out from time to time, such as repolishing pivot surfaces, replacing damaged webs, repairing or replacing levels, but few major repairs were necessary.

5.1 Major repairs

In 1856 Airy altered the bearings of the horizontal axis, which had been introducing slight errors in its orientation relative to the azimuth circle. He substituted "a pair of anti-friction wheels (carried by one frame) instead of a single wheel." [11] The original single-wheel bearing is visible in the engraving featured on the cover of this issue; the two-wheel bearing can be seen in Figure 10, on page 93, behind a tapered shutter used to control the illumination (from a lamp, which is not present in the photograph).

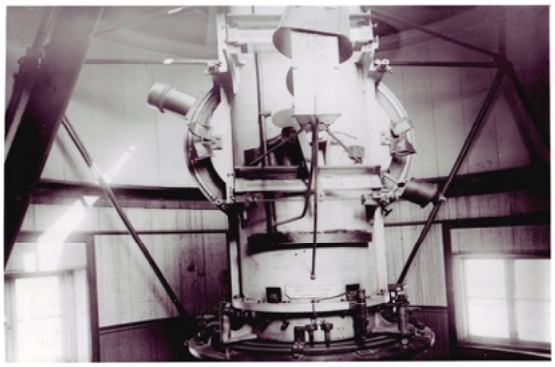


Figure 7

The Altazimuth photographed by E.W.Maunder *circa* 1900

This is the only extant photograph of the instrument in its working position.

Courtesy of the British Astronomical Association.

In 1873 Airy reports that he had become dissatisfied with the bearings of the horizontal axis, and had the Y-bearings replaced with circular segments (a system that he had used successfully in the Transit Circle). Oil-lubricators were also fitted and the pivots re-turned.[12] The instrument was out of use from 1872 September 9 to 1873 January 5 whilst this work was carried out, the only closure of such length ever allowed by Airy. In 1874 October the counterpoises of the horizontal axis were removed, "the object being to insure the stability of that axis." [13] In 1876 he reports that:

> "… a little trouble has been occasioned lately by stiffness in the azimuthal motion. As the lower bearing of the vertical axis appears never to have been cleaned since the erection of the instrument, I have had the whole instrument raised, under the superintendence of Mr. Simms, and the accumulation of oil cleaned out. Small channels are now made, to permit the oil to reach the bearing-parts more readily." [14]

Airy records in 1877 that:

> " To relieve the lower bearing of the vertical axis more effectually from the weight of the instrument a more powerful lever-counterpoise has been applied … with very beneficial results as regards the azimuthal motion of the instrument." [15]

And in 1880:

> " The horizontal circle of the Altazimuth has been regraduated by Mr. Simms, the divisions having been nearly rubbed out in course of years; and improved compound object-glasses, with adjustment for focus, have been supplied to the reading microscopes. Two supplementary microscopes have been mounted for examination of the

> division errors of the horizontal circle and of the errors of the micrometer-screws. The instrument is now in thorough working order." [16]

In 1895, W.H.M. Christie, who had succeeded Airy as Astronomer Royal in 1881August, reports that:

> " In 1894 June it was noticed that the level error of the instrument was very unsteady; on searching for the cause, it was found that the upper pivot of the vertical axis of the instrument and its bearing were much worn. The bearing was removed, and a new bearing of phosphor-bronze, made by Messrs Troughton and Simms, was inserted and the pivot was re-ground." [17]

5.2 Collimation marks

Observations of zenith distance, made with the 'altitude' circle, are of course referred to the true vertical, the zenith point being checked by means of the levels provided to confirm verticality of the axis. Observations in azimuth are less simple, unlike meridian observations the azimuth in which the instrument is set needs to be referred to a fixed datum. To provide for this it was usual to accompany lunar observations with azimuth measurements of a pair of bright stars of accurately known position, one high and one low in the sky. In 1850, however, whilst confirming his confidence in both the instrument and its methods of use, Airy reports "an occasional change … in the apparent Zero of Azimuth." [18] In order to examine if the change was real he decided to erect a collimating mark.

> " The interference of buildings has compelled me to do this in an unusual way. The 25-feet object-glass of the old Zenith Tube is fixed in the North wall of the New South Dome staircase. The mark is fixed … upon the cross wall which rises from the western side of the Computing Room, and just below the ridge of the Quadrant Room".

The 5-inch lens, by Dollond, had been the objective of Pond's unsuccessful zenith tube, dismantled in 1848 and about to be replaced by Airy's Reflex Zenith Tube (Satterthwaite 2003). The mark consisted of a metal plate with a round hole $^1/_{50}$ of an inch in diameter, illuminated by a gas flame. An image of the hole about $^1/_{300}$ inch in diameter made by a short-focus lens was then formed in the focal plane of the collimating lens; when observed through this with the Altazimuth telescope it was seen "as a beautifully defined circle, subtending an angle of 2¼".

The problem of the wandering zero point was found to affect observations with the Transit Circle as well, and remained a constant preoccupation for decades. From time to time new marks were set up, notably in 1880 when a mark consisting of a small plane mirror was set up on the parapet of the south-east building of the Royal Naval College, some 1700 feet distant. In order to observe this a circular hole was cut in the brick wall between the courtyard and the terrace of the Wren building.[19] The new mark was used successfully. After many years of study it was concluded that the variations in the azimuth zeros were caused by actual movement of the ground on which the supports of the instruments stood, small in extent but enough to be detected with such sensitive telescopic instruments, and were linked to variations in the ambient temperature.

6. Observations with the Altazimuth

To obtain accurate positions of the Moon the azimuth of the visible 'preceding' or 'following' limb, depending on the phase, and the zenith distance (Z.D.) of at least one of the 'upper' and 'lower' limbs, are measured. At, or very close to, Full Moon all four limbs can be measured, and at large gibbous phases both the upper and lower limbs can be measured in Z.D., appropriate corrections being applied for 'defective illumination' in these cases. In order to average out instrumental effects, observations are made in symmetrical pairs, the instrument being rotated through 180º in both planes between them; these orientations are defined as 'graduated face of the vertical circle facing left' (i.e. to the east) or 'right' (west). Airy laid down strict rules for the use of the instrument:

> " The Moon is to be observed if visible, and the observer is bound to watch if necessary while the Moon is above the horizon, and the Sun is not more than an hour above the horizon. One Azimuth and one Altitude are to be observed, and, if possible, two Azimuths and two Altitudes in reversed positions of the instrument: and if the night is fine, a low star and a high star are to be observed in azimuth, both in reversed positions of the instrument, and one star in altitude, in reversed positions. Thus a complete set includes ten observations." [20]

6.1 Methods of observation

In principle, the observation is similar to that made with a transit instrument. If the object is being observed in an azimuth other than the meridian plane it will of course be seen to cross the field diagonally. For azimuth, the sidereal times of passage of the object across six vertical wires[21] in the focal plane of the telescope are recorded. Between each wire the telescope is rotated slightly around the horizontal axis using a slow-motion control, so

that the object crosses each wire approximately centrally. Similarly for Z.D., the times of passage across six horizontal wires are recorded.

During its early years, observations were made by the traditional 'eye-and-ear' method, wherein the observer noted down the hour and minute, then listened to the second beats of the sidereal clock and estimated (to one tenth of a second) the time of passage over the wire. In 1854 March Airy's Barrel Chronograph came into use, enabling the observed times to be electrically recorded and subsequently measured (to about one hundredth of a second) against time pulses transmitted from the sidereal standard clock. This system increased the accuracy and considerably reduced personal errors (Satterthwaite 2001a). Both the Altazimuth and the Transit Circle were wired into the chronograph circuit, 'morse-keys' being provided to enable the observer to send the signals. Thus a typical procedure for the observation of a star might be as follows:

1. Switch on chronograph.
2. Set instrument ahead of star, circle facing east.
3. As star crosses field, tap key as it crosses each of six vertical wires, adjusting to mid-wire position for each (first azimuth observation).
4. Read four microscope micrometers and pointer on horizontal circle, read levels.
5. Reset; as star crosses field, tap key as it crosses each of six horizontal wires (first Z.D. observation).
6. Read microscopes and pointer on vertical circle.
7. Reverse instrument to face west.
8. Reset, repeat 5 and 6 (second Z.D. observation).
9. Reset, repeat 3 and 4 (second azimuth observation).

6.2 First and last observations

The first observation, of just one limb of the Moon in both co-ordinates, was made by Hugh Breen Jr on 1847 May 10 (Figure 8). The first symmetrical pairs of observations were made three days later, but were clearly experimental with two observers sharing the task; on May 20, however, routine observations began with accompanying stars observed. Airy himself did not normally observe, his responsibilities being such that regular night duties would clearly be impracticable, and in any case he suffered from poor eyesight (both myopia and astigmatism) and preferred not to observe but to delegate that task to others. Nevertheless, as with the Transit Circle (with which he had observed just three stars on a single night!) he clearly wished to try out his instrument personally, observing a limb of the Moon on May 21, and on two more occasions during that first week.

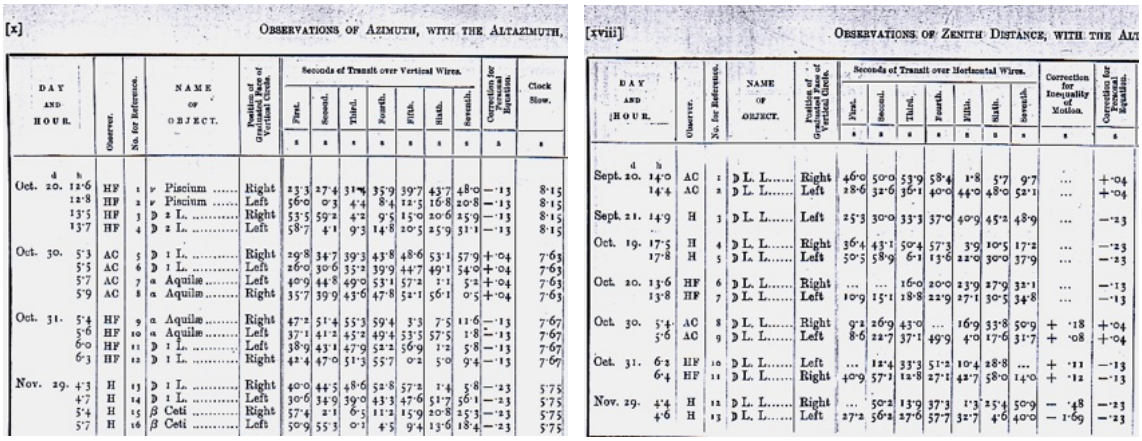
[ii] OBSERVATIONS OF AZIMUTH WITH THE ALTITUDE AND AZIMUTH INSTRUMENT

DAY.	Observer.	No. for Reference.	NAME OF OBJECT.	Position of Graduated Face of Vertical Circle.	Seconds of Horizontal Transit over Vertical Wires. I.	II.	III.	IV.	V.	VI.	Concluded Clock Time of Horizontal Transit over Mean of Vertical Wires.	Clock Slow.	Sidereal Time.	Readings of Microscopes of Horizontal Circle. a	b	c	d
					s	s	s	s	s	s	h m s	s	h m s	sec.	sec.	sec.	sec.
May 16	H B	1	☽ 1 L.	Left	24·8	47·7	9·9	32·6	55·0	17·8	12. 7. 21·30	69·15	12. 8. 30·45	5·045	5·035	5·095	5·405
May 19	D	2	☽ 1 L.	Left	25·8	47·8	9·7	31·5	53·4	15·1	12. 9. 20·55	74·26	12. 10. 34·81	7·343	7·441	7·600	7·940
	H B	3*	☽ 1 L.	,,	48·6	10·7	32·5	55·0	17·5	38·9	12. 39. 43·87	74·26	12. 40. 58·13	0·035	0·297	0·147	0·357
	H B	4*	☽ 1 L.	Right	48·8	10·5	33·4	56·0	18·2	40·5	13. 23. 44·57	74·27	13. 24. 58·84	3·510	3·594	3·700	4·013
	H B	5	☽ 1 L.	,,	14·3	36·5	58·8	21·5	43·8	6·2	13. 45. 10·18	74·28	13. 46. 24·46	4·055	4·207	4·375	4·522
May 20	H B	6	☽ 1 L.	Right	58·7	16·9	35·8	54·7	13·8	32·2	11. 6. 45·35	75·94	11. 8. 1·29	0·003	0·039	0·052	0·273
	H B	7	☽ 1 L.	,,	47·5	6·4	25·8	45·5	5·1	24·4	11. 33. 35·78	76·00	11. 34. 51·78	3·435	3·487	3·710	4·056
	H B	8	☽ 1 L.	Left	14·7	34·9	55·6	16·5	36·8	56·9	12. 19. 5·90	76·11	12. 20. 22·01	5·773	5·906	6·093	6·172
	H B	9	☽ 1 L.	,,	36·6	57·8	18·8	40·0	1·8	22·8	13. 0. 29·63	76·19	13. 1. 45·82	3·936	4·193	4·085	4·332
	H B	10	Arcturus.	,,	7·5	24·7	41·8	59·7	17·2	34·5	13. 21. 50·90	76·24	13. 26. 7·14	7·075	6·973	7·407	7·617
	H B	11	α Aquilæ.	,,	2·7	23·5	44·5	4·6	25·7	46·3	14. 50. 54·55	76·41	14. 52. 10·96	6·892	6·887	7·197	7·532
	H B	12	α Aquilæ.	Right	54·6	14·7	35·8	56·7	17 3	38·3	15. 3. 46·23	76·44	15. 5. 2·67	3·752	4·036	3·815	4·212
	H B	13*	α Lyræ	,,	40·7	13·5	47·6	22·0	55·5	29·5	15. 36. 4·80	76·51	15. 37. 21·31	7·445	7·705	7·835	7·952
May 21	G B A	14	☽ 1 L.	Right	41·5	58·2	15·0	32·2	49·6	6·7	8. 41. 23·87	78·22	8. 42. 42·09	3·901	4·050	3·865	3·974
	G B A	15	☽ 1 L.	Left	37·4	54·1	10·7	27·4	44·6	0·7	9. 19. 19·15	78·32	9. 20. 37·47	0·476	0·605	0·808	0·898
	D	16	☽ 1 L.	,,	16·1	33·8	50·9	8·8	26·0	43·2	11. 11. 59·80	78·52	11. 13. 18·32	4·265	4·438	4·492	4·669
	D	17	☽ 1 L.	,,	52·7	10·1	27·7	45·6	3·0	20·7	11. 18. 36·63	78·53	11. 19. 55·16	3·281	3·420	3·423	3·531
	D	18	☽ 1 L.	Right	37·8	55·3	13·5	31·5	49·7	7·7	11. 38. 22·58	78·54	11. 39. 41·12	3·548	3·569	3·624	4·005
	D	19	☽ 1 L.	,,	17·3	35·0	53·5	11·9	30·0	48·1	11. 47. 2·63	78·55	11. 48. 21·18	6·654	6·635	6·687	7·108
	D	20	Arcturus.	,,	50·5	8·1	25·8	44·0	2·0	19·8	13. 3. 35·03	78·61	13. 4. 53·64	4·881	4·930	4·865	5·062
	D	21	Arcturus.	Left	45·7	3·2	21·0	38·6	56·0	13·5	13. 17. 29·67	78·64	13. 18. 48·31	6·430	6·458	6·749	7·030
	D	22	α Aquilæ.	,,	46·7	7·5	28·3	49·2	10·2	30·8	13. 56. 38·78	78·67	13. 57. 57·45	1·378	1·498	1·537	1·859

Figure 8

The first observations in azimuth with the instrument (only part shown)

Observers: HB − Hugh Breen Jr; D − Edwin Dunkin; GBA − G.B.Airy.
From *Greenwich Observations 1847.*



[x] OBSERVATIONS OF AZIMUTH, WITH THE ALTAZIMUTH.

DAY AND HOUR.	Observer.	No. for Reference.	NAME OF OBJECT.	Position of Graduated Face of Vertical Circle.	Seconds of Transit over Vertical Wires. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Correction for Personal Equation.	Clock Slow.
					s	s	s	s	s	s	s	s	s
d h													
Oct. 20. 12·6	HF	1	ν Piscium	Right	23·3	27·4	31·5	35·9	39·7	43·7	48·0	−·13	8·15
12·8	HF	2	ν Piscium	Left	56·0	0·3	4·4	8·4	12·5	16·8	20·8	−·13	8·15
13·5	HF	3	☽ 2 L.	Right	53·5	59·2	4·2	9·5	15·0	20·6	25·9	−·13	8·15
13·7	HF	4	☽ 2 L.	Left	58·7	4·1	9·3	14·8	20·5	25·9	31·1	−·13	8·15
Oct. 30. 5·3	AC	5	☽ 1 L.	Right	29·8	34·7	39·3	43·8	48·6	53·1	57·9	+·04	7·63
5·5	AC	6	☽ 1 L.	Left	26·0	30·6	35·2	39·9	44·7	49·1	54·0	+·04	7·63
5·7	AC	7	α Aquilæ	Left	40·9	44·8	49·0	53·1	57·2	1·1	5·2	+·04	7·63
5·9	AC	8	α Aquilæ	Right	35·7	39·9	43·6	47·8	52·1	56·1	0·5	+·04	7·63
Oct. 31. 5·4	HF	9	α Aquilæ	Right	47·2	51·4	55·3	59·4	3·3	7·5	11·6	−·13	7·67
5·6	HF	10	α Aquilæ	Left	37·1	41·2	45·2	49·4	53·5	57·5	1·8	−·13	7·67
6·0	HF	11	☽ 1 L.	Left	38·9	43·1	47·9	52·2	56·9	1·2	5·8	−·13	7·67
6·3	HF	12	☽ 1 L.	Right	42·4	47·0	51·3	55·7	0·2	5·0	9·4	−·13	7·67
Nov. 29. 4·3	H	13	☽ 1 L.	Right	40·0	44·5	48·6	52·8	57·2	1·4	5·8	−·23	5·75
4·7	H	14	☽ 1 L.	Left	30·6	34·9	39·0	43·3	47·6	51·7	56·1	−·23	5·75
5·4	H	15	β Ceti	Right	57·4	2·1	6·5	11·2	15·9	20·8	25·3	−·23	5·75
5·7	H	16	β Ceti	Left	50·9	55·3	0·1	4·5	9·4	13·6	18·4	−·23	5·75

[xviii] OBSERVATIONS OF ZENITH DISTANCE, WITH THE ALT

DAY AND HOUR.	Observr.	No. for Reference.	NAME OF OBJECT.	Position of Graduated Face of Vertical Circle.	Seconds of Transit over Horizontal Wires. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Correction for Inequality of Motion.	Correction for Personal Equation.
					s	s	s	s	s	s	s	s	s
d h													
Sept. 20. 14·0	AC	1	☽ L. L.	Right	46·0	50·0	53·9	58·4	1·8	5·7	9·7	...	+·04
14·4	AC	2	☽ L. L.	Left	28·6	32·6	36·1	40·0	44·0	48·0	52·1	...	+·04
Sept. 21. 14·9	H	3	☽ L. L.	Left	25·3	30·0	33·3	37·0	40·9	45·2	48·9	...	−·23
Oct. 19. 17·5	H	4	☽ L. L.	Right	36·4	43·1	50·4	57·3	3·9	10·5	17·2	...	−·23
17·8	H	5	☽ L. L.	Left	50·5	58·9	6·1	13·6	22·0	30·0	37·9	...	−·23
Oct. 20. 13·6	HF	6	☽ L. L.	Right	...	...	16·0	20·0	23·9	27·9	32·1	...	−·13
13·8	HF	7	☽ L. L.	Left	10·9	15·1	18·8	22·9	27·1	30·5	34·8	...	−·13
Oct. 30. 5·4	AC	8	☽ L. L.	Right	9·2	26·9	43·0	...	16·9	33·8	50·9	+ ·18	+·04
5·6	AC	9	☽ L. L.	Left	8·6	22·7	37·1	49·9	4·0	17·6	31·7	+ ·08	+·04
Oct. 31. 6·2	HF	10	☽ L. L.	Left	...	12·4	33·3	51·2	10·4	28·8	...	+ ·11	−·13
6·4	HF	11	☽ L. L.	Right	40·9	57·1	12·8	27·1	42·7	58·0	14·0	+ ·12	−·13
Nov. 29. 4·4	H	12	☽ L. L.	Right	...	50·2	13·9	37·3	1·3	25·4	50·9	− ·48	−·23
4·6	H	13	☽ L. L.	Left	27·2	56·2	27·6	57·7	32·7	4·6	40·0	− 1·69	−·23

Figure 9

The final observations with the Altazimuth

Observations in azimuth are in the left panel; those in zenith distance are in the right panel. Only part of both is shown.
Observers: HF − Henry Furner; AC − Andrew Crommelin; H − Henry Hollis.
From *Greenwich Observations 1897*.

The final lunar observations were made on 1897 November 29 by Henry Hollis (Figure 9). The instrument thus had a working life of 50 years and six months. During most of this time it had been out of use only for brief periods of maintenance, etc., rarely exceeding a few days and normally at a time when observations of the Moon could be undertaken using the Transit Circle. Even when the dome was damaged in 1872, the roof shutter being blown off in a heavy gale, it was soon replaced and observations continued.[22]

6.3 Record of lunar observations

From an examination of the annual volumes of *Greenwich Observations* and the summaries published in the *Annual Reports of the Astronomer Royal* it is possible to see how successfully the Altazimuth achieved Airy's stated goal of increasing the number of positional observations of the Moon, especially during the period between Last Quarter and First Quarter. Whilst he remained in office Airy required the Moon to be observed, together with the necessary observations of stars and the collimation mark, on every possible occasion.

Following his retirement his successor, William Christie, did not continue this practice, being concerned to reduce the demands of positional astronomy, including staff time devoted to both observations and reductions, in favour of the development of astrophysical work. In his first *Annual Report*, in 1882, Christie comments that:

> "… important economy of force would result from the restriction of the altazimuth observations of the Moon to the period from last to first quarter. The other half of the lunation is provided for by the transit-circle" [23].

This ignores, of course, the possibility of meridian observations being lost due to passing cloud, but became the standard practice from July 1882. However, the instrument was occasionally used to measure the Moon's diameter in both co-ordinates at Full Moon.

Christie also suspended observations for 5½ months from May to October 1892 "during great pressure of longitude and other work" [24] - the longest period of inactivity in the life of the instrument.

In order to demonstrate Airy's success in achieving his aims, the statistics in the Table below are presented separately for the periods of full and reduced use.

The number of lunar diameters measured during a sample period of seven years, 1875−1882, when both instruments were being used also demonstrates the value of the Altazimuth (next page):

The number of Moon positions obtained and the average number per lunation

		With Altazimuth		With Transit Circle	
1847−1882	6549	(15.7 per lunation)	3602	(8.6 per lunation)
1882−1897	1261	(6.3 per lunation)	1784	(8.5 per lunation)
Total	1847−1897	7810	(12.6 per lunation)	5386	(8.5 per lunation)

With Altazimuth		With Transit Circle	
in Azimuth	78 (11.1)	in R.A.	17 (2.4)
in Z.D.	263 (37.6)	in N.P.D.	6 (9.0)

Figures in parentheses are the annual means.

Z.D. zenith distance; R.A. right ascension; N.P.D. north polar distance.

Airy records a quite exceptional, possibly unique, achievement in lunar positional observation:

> " The Moon was observed with the Altazimuth on every one of the 20 consecutive days from 1863, April 21 to May 10." [25]

6.4 Other Observations

The Altazimuth was also used occasionally for other purposes, such as the observation of comets, lunar occultations of stars, and Jupiter's satellite phenomena, and on 1870 April 19 it was used to observe an occultation of Saturn by the Moon. Airy also records that:

> " The Earthquake of 1863, October 5, $15^{h}.23^{m}$. was seen with the Altazimuth Telescope by Mr Ellis, who happened to be observing the Collimator. The mark appeared to descend, to rise rather more, and to descend a little to its original position." [26]

The instrument was brought out of retirement very occasionally for the observation of lunar occultations in the period 1900−1910.

7. Conclusion

The Altazimuth is a very unusual example of a large and expensive instrument, requiring experienced observers to operate it and constructed to carry out a programme of necessarily restricted observations, but in doing so to meet a major astronomical need. That it fulfilled the hopes of its designer clearly gave him considerable satisfaction; after only three years' use he felt able to express to the Board of Visitors his opinion that:

> "… the erection of this instrument is the most important innovation that has been made in the Royal Observatory for many years." [27]

A decade later, discussing the improvement in lunar theory and consequent improvement of lunar ephemerides, he commented that:

> "… the introduction and vigorous use of the Altazimuth for observations of the Moon is the most important addition to the system of the Observatory that has been made for many years. The largest errors of Burckhardt's Tables were put in evidence almost always by the Altazimuth observations, in portions of the Moon's orbit which could not be touched by the meridional instruments; they amounted sometimes to nearly 40″ of arc, and they naturally became the crucial errors for distinction between Burckhardt's and Hansen's Tables" [28]

Hansen's Tables (published in 1857) were, with later amendments by Newcomb, to remain the basis of lunar ephemeris calculation until the publication of Brown's Tables (Brown 1919).

Airy's Altazimuth was clearly of seminal importance in positional astronomy. When Christie terminated its long observational life in 1897, it was to be succeeded by a new instrument, which he described as a universal transit circle, but which soon became known as an altazimuth. It was in effect a large, non-reversible transit circle, mounted on a turntable base so that it could be used in azimuths other than the meridian. Already erected in a new building in 1896, major problems, including significant flexure of the massive telescope tub, delayed its use; the first observation were not made until February 1899. It was used sporadically until 1929, but was never a success.

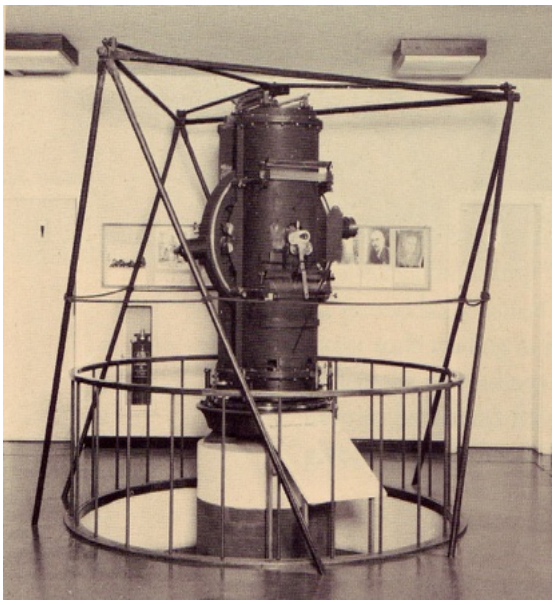


Figure 10

Airy's Altazimuth on display in the Pond Gallery at the Royal Observatory, Greenwich, *circa* 1967

Airy's Altazimuth was dismounted in 1910 and transferred to the Science Museum, London, in 1929, where it was exhibited until 1965. From 1967 it was displayed in the Pond Gallery in the meridian building of the Observatory, close to its original position (Figure 10). When removed from display in 1993, it was returned to the Science Museum, where it remains in store. It is to be hoped that this historic instrument will one day again be exhibited for the interest of future generations.

Acknowledgements

This paper is one of a series based upon research carried out over many years, and the writer wishes to acknowledge the help of many friends and colleagues, too numerous to be listed here. He would particularly like to acknowledge his debt to former colleagues at the Royal Observatory, especially the late Phil Laurie, to Gloria Clifton, Maria Blyzinsky, Emily Winterburn, Janet Small and the late Derek Howse at the National Maritime Museum, and to Peter Hingley, Librarian of the Royal Astronomical Society. I am grateful to Kevin Johnson, Tony Kinder, and especially Ray Hemming for much help with the illustrations.

Notes

Frequent reference is made in this paper to the annual *Reports of the Astronomer Royal to the Board of Visitors of the Royal Observatory*, a series begun by Airy on his taking office in 1835 and continued until the Board of Visitors ceased to exist in 1965. References to this valuable source are cited in the form (*ARR 18xx:*Page number).

1. Airy, G.B., *ARR 1836*:1.
2. Airy (1843:1).
3. Airy (1848b:v).
4. Airy, G.B., *ARR 1844*:13.
5. Airy, G.B., *ARR 1844*:14.
6. Airy (1848b:vii).
7. Simms, W. (1885).
8. Airy, G.B., *ARR 1845*:5.
9. Airy, G.B., *ARR 1846*:3-4.
10. Airy, G.B., *ARR 1847*:4.
11. Airy, G.B., *ARR 1856*:9.
12. Airy, G.B., *ARR 1873*:7-8.
13. Airy, G.B., *ARR 1875*:7-8.
14. Airy, G.B., *ARR 1876*:7.
15. Airy. G.B., *ARR 1877*:7.
16. Airy, G.B., *ARR 1880*:6.
17. Christie, W.H.M., *ARR 1895*:8.
18. Airy, G.B., *ARR 1850*:5.
19. Airy, G.B., *ARR 1880*:6-7.
20. Airy, G.B., *ARR 1848*:7.
21. It is conventional to refer to 'wires', but by the mid-nineteenth century it was the practice to use threads of spider's web; this was the case with the Altazimuth.
22. Airy, G.B., *ARR 1873*:3.
23. Christie, W.H.M., *ARR 1882*:17-18.
24. Christie, W.H.M., *ARR 1893*:9.
25. Airy, G.B., *ARR 1863*:8.
26. Airy, G.B., *ARR 1864*:11.
27. Airy, G.B., *ARR 1850*:8.
28. Airy, G.B., *ARR 1859*:18.

References

Airy, G.B., 1843. Address to the Board of Visitors of the Royal Observatory, Supplement. (Appendix, *Greenwich Observations, 1843*). Her Majesty's Stationery Office, London.

Airy, G.B., 1845. *Reduction of the Observations of Planets, made at the Royal Observatory, Greenwich, from 1750 to 1830.* John Murray, London.

Airy, G.B., 1848a. *Reduction of Observations of the Moon made at the Royal Observatory, Greenwich, from 1750 to 1830* (2 volumes). John Murray, London.

Airy, G.B., 1848b. *Description of the Altitude and Azimuth Instrument of the Royal Observatory, Greenwich*. (Appendix, *Greenwich Observations, 1847*). Her Majesty's Stationery Office, London.

Brown, E.W., 1919. *Tables of the Motion of the Moon*. Yale University Press, New York.

Howse, H.D., 1975. *Greenwich Observatory*, volume 3: *The Buildings and Instruments.* Taylor & Francis, London.

Satterthwaite, G.E., 2001a. Airy and positional astronomy. *Journal of Astronomical History and Heritage*, 4:101-113.

Satterthwaite, G.E., 2001b. Airy's transit circle. *Journal of Astronomical History and Heritage*, 4:115-141.

Satterthwaite, G.E., 2003. Airy's zenith telescopes and "the birth-star of modern astronomy". *Journal of Astronomical History and Heritage*, 6:13-26.

Simms, W., 1885. *Memoirs of Our Family.* cited in *At the Sign of the Orrery.* Cooke, Troughton & Simms, York, *circa* 1957.

The Work of John Isaac Plummer at Orwell Park Observatory in the years 1874 to 1890

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This paper builds on the unpublished collation by the Orwell Astronomical Society entitled *John Isaac Plummer*. It takes the form of a chronology and critique of papers published by John Isaac Plummer (1844-1925) in the *Monthly Notices of the Royal Astronomical Society* and *Astronomische Nachrichten* on work undertaken at the Orwell Park Observatory, Ipswich, in the years 1874 to 1890. This work, mainly, although not exclusively, in England, took the form of measuring the positions and deriving the orbits of as many comets as could be observed from Orwell Park. Plummer also published papers in other journals, such as *Nature* and *The Observatory*, but these are to be the subject of future research.

John Isaac Plummer (1844-1925) was employed by 'Colonel' George Tomline (1813-1889)[1] as a professional astronomer to operate and observe with the new 10-inch refracting telescope housed in the observatory that Tomline had completed in 1874 at his country house at Orwell Park, near Ipswich, England. Plummer's formative years, and earlier astronomical observing at Durham under the tutelage of the Reverend Doctor Temple Chevalier (1794-1873), are dealt with more fully elsewhere[2].

Figure 1

John Isaac Plummer (1844-1925)

Image by courtesy of Orwell Astronomical Society.

1874

Plummer joined "Colonel Tomline's Observatory" (the phrase he was to use to describe his employment in his annual report to the Royal Astronomical Society (R.A.S.)) in June 1874. In fact, in his first report[3], he proudly listed the equipment in the new observatory and set out his manifesto:

> " [to]… employ this fine instrument [the Tomline refractor] chiefly for the observation of comets, both periodical and occasional."

Figure 2 shows the 10-inch refractor mentioned.

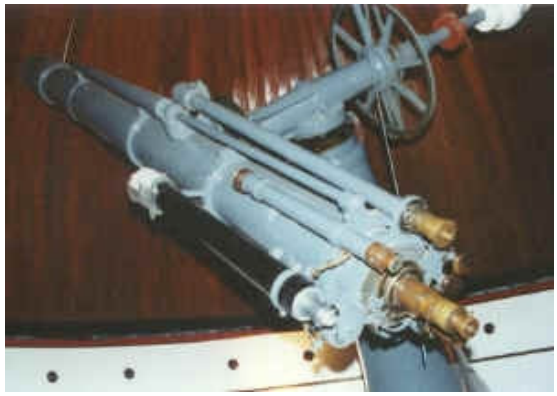

Figure 2

The 10-inch Tomline refractor

Image by courtesy of Orwell Astronomical Society.

For the remainder of his first year at Orwell Park, Plummer was setting up the observatory. This first entailed battling with the "opticians" (as he derisively called them) as they set up the 10-inch Merz lens[4]. The German-style mounting was manufactured by the Ipswich company, Ransomes, Sims & Head, which had made heavy castings for Airy's altazimuth instrument, 12¾-inch "great equatoreal" refractor and 8-inch transit circle.

Plummer next spent time trying to estimate the exact longitude of the observatory using "… a small transit instrument and an excellent clock by Dent." His initial estimates were 52º 0' 33" north, 4' 55.8" east[5]. This presumably entailed comparing timed measurements with another observatory (possibly the Royal Observatory, Greenwich), although this detail is not mentioned in his paper.

Figure 3

The 3-inch transit instrument installed in the Orwell Park Observatory

The location of the transit room is shown in Figure 4.
Image by courtesy of Orwell Astronomical Society.

Also in 1874 Plummer was introduced to the Ipswich Science Society - he hosted a visit by members to the observatory in July of that year. This was the start of a long association with this Society, to which he gave several lectures between 1874 and 1890. These were well reported in the local Suffolk press[6] - the *Suffolk Chronicle* and the *East Anglian Daily Times*.

In his first formal paper reporting observations from the Orwell Park Observatory, he noted the preponderance of the zodiacal light during the autumn of 1874, during the appearance of Coggia's comet. He suggested that there may be a periodic enhancement of the strength of the phenomenon over some eight years, based on his previous observations whilst in Durham[7].

1875

As already mentioned, Plummer's main work was the measurement and reduction of cometary orbits. His first published results, in *Astronomische Nachrichten*[8], concerned Coggia's Comet (V 1874). It should be emphasised that he concentrated only on the orbits of the comets he observed - he made no estimates of their magnitudes.

Not much else happened this year, for as Plummer noted, work suffered because of the "prevalence of unusually cloudy weather for so many months". This was not to be the last time he mentioned cloud cover preventing observations at Orwell Park[9], and the paucity of comets.

Other work started, included a blossoming interest in estimating the diameters of Venus and the Moon, and their respective brightnesses. This built on his earlier work at Durham, where he observed many lunar occultations, to investigate the properties of the supposed lunar atmosphere[10]. He also held a "strong suspicion" that the irradiation of Venus (i.e. its apparent brightness) varied with the transparency of the Earth's atmosphere. The lack of opportunity to gather evidence to support his hypothesis must have frustrated him.

1876

This year saw Plummer start his photometric experiments, measuring the brightness of Venus, comparing shadows cast by the planet and a standard whale-oil candle at known distances[11]. This was primarily because there were no comets available for him to observe[12]. The result was that he found the brightness of the "mean full Moon" to be 799.5 times that of Venus at greatest brilliancy. Unfortunately, at that time there was little similar work with which to compare his findings. Modern values put his estimate as being a factor of about 2.4 too low. He also found, by chance observation, that Sirius cast a shadow of one ninth the brightness of Venus, which is remarkably accurate. He stated that he was quite sure no one else had made this type of observation of Sirius before.

Plummer also commented disparagingly on the accuracy of the catalogue of stars published by the British Association[13], noting ever-increasing differences between contemporary observations of prominent stars and those historic observations of Bradley[14]. Others had formed the same opinion.

Also this year Plummer had the bright idea of proposing a new numbering system for the host of new minor planets (or planetoids as he called them) being discovered at this time[15]. Unfortu-

nately, he was not to know the huge number of solar system objects that would eventually need to be numbered. His peers must have had some idea, though, because his suggestions were rejected, as was his idea for renumbering stars within their constellations, grouped by magnitude in order of Right Ascension.

In this year, Plummer was elected a Fellow of the Royal Astronomical Society.

1877

During 1877, Plummer continued his apparent luminosity work by trying to measure the brightness of the totally eclipsed moon of 23 August. This was not altogether successful, and with the return of a number of comets, he concentrated on the "proper" work of the observatory[16]. However, he did publish a paper on an effect that he had noticed of regular annual fluctuations of the accuracy of the transit instrument when used to obtain local sidereal time. He ascribed this to the thermal influences from "the mass of brickwork" that composed the support of the "Equatoreal [sic] Telescope" (the Tomline refractor)[17]. However, there is no mention of any remedial work to verify or correct this supposed influence.

1878

The heavens were quiet again this year, so Plummer took the advantage of catching up on his mathematical reductions of previous cometary and stellar observations, publishing them in the *Astronomische Nachrichten*[18]. Also of note this year was Plummer's improved calculation of the observatory's longitude (4' 57.75" east). This determination is discussed in the Conclusions section below.

The observation of the transit of Mercury, which occurred on 6 May, was another high point in the year, eliciting the satisfied words:

> " [it] … was very fairly observed, and afforded gratifying proof of the excellence of definition of the object glass." [19]

However, in September of this year the telescope had to be dismounted to remove particles of rust from the declination axis bearing. A Mr Sims performed the work, after which Plummer noted that the instrument "has been quite satisfactory" [20]. This was most probably the Sims from Ransomes, Sims & Head, the Ipswich-based engineering firm that had built its mounting. In recent times a very similar problem has arisen again. The Orwell Astronomical Society is at present investigating options to rectify the problem.

1879

This was a good year for comets: Comets Brorsen, Swift, Hartwig and Palisa were visible. He lamented that observations on the latter two would have been better:

> "if intelligence of their discovery had reached the observatory at an earlier date." [21]

One can only wonder whether this was a general expression of despair, or was aimed at someone or some organisation in particular.

After five years Plummer also completed his determination of the observatory's exact geographic co-ordinates. This is discussed further later in this paper. Plummer's reports never mention any altitude measuring instrument, such as a meridian circle, so we must assume that he found the observatory's latitude using a sextant.

1880

This was another good year for comets – especially Schäberle, Hartwig and Pechüle. This obviously kept Plummer busy as he made a resolution to complete the "considerable arrears of cometary work which have not been fully reduced." He did, however, publish his results for comet Brorsen (1879) in *Astronomische Nachrichten*[22].

This year also saw a new departure in the work of the observatory. Plummer became interested once again in lunar occultations, in the hope of "detecting and elucidating the phenomena of projection on the limb" [23]. This is possibly a reference to the diffraction effects on an occulted star caused by the edge of the Moon.

1881

So much for lunar occultations! This year was exclusively taken up with comet observations and fulfilling his 'new-year resolution' to remove the backlog of orbit reductions. However, he did mention that his observational work was hampered by unfavourable weather conditions, and, more mysteriously, "other causes." [24]. Continuing his melancholic mood, he laments the fact that his cometary reductions depended upon out-of-date star catalogues for the positions of the reference stars, and the fact that the observatory lacked a meridian circle for determining the altitude of these stars.

Plummer also announced this year that he had obtained permission from Tomline to volunteer to assist Airy (the Astronomer Royal) during the forthcoming transit of Venus. Whether Airy had asked for Plummer, or whether he was a genuine volunteer, is unclear. However Airy must have

known Tomline, because Airy's country home was only a few miles away at Playford. Furthermore, Tomline had employed Airy's son, Wilfrid, as the designing engineer for his observatory.

1882-1883

This annual report[25] is very much a 'catch-up' account of the observatory activities, because Plummer had been sent by the Royal Observatory, Greenwich to Bermuda for four months to observe the 1882 transit of Venus. Unfortunately, there appears to be no surviving record of his observations in the West Indies, other than to note that he gave a lecture on the subject at Harwich upon his return.

Four new comets were observed (I 1882, III 1882, I 1883 and Pons 1812), and many orbit reductions from previous observations were completed. His main complaint was still the difficulty he had in measuring accurately the positions of the reference stars.

1884-1886

This was another 'catch-up' report, as Plummer had been ill during this period[26]. Work was completed and published in *Astronomische Nachrichten*[27] on the following comets: 1884 III Wolf, 1885 I Encke, 1885 II Barnard, 1886 I Fabry, 1886 II Barnard and 1886 V Brooks I. He reported that the observations of two further comets - Barnard-Hartwig and Finlay - were being reduced.

1887

Observations of five more comets were reported in the observatory report for 1887[28] - Brooks, Barnard I, II & III, and Olbers. However, there was a notable change this year; Plummer started to submit his results to the *Monthly Notices of the Royal Astronomical Society*[29], rather than in the *Astronomische Nachrichten*.

There is also an admission that comet tracking is what Plummer and the observatory did best, so that is what he is going to concentrate on in the future. There was a definite air of frustration in Plummer's tone, presumably as a response to the deficiencies of the equipment he had to hand.

1888

Bad weather and bad seeing conditions were the hallmark of this year's report[30]. Four comets were observed satisfactorily (Sawerthal I 1888, Brooks III 1888, Barnard e and f 1888) and results published[31]. Faye's comet was searched for but the conclusion was drawn that a 10-inch aperture was not sufficient to be able to observe this faint object properly. Preparations were made to observe the occultations of small stars during the total eclipse of the moon on 28 January, but "were rendered futile by cloudy weather."

1889

This was Plummer's final report from the observatory[32]. In it he reported:

> "… on August 25, after an illness of eight months, Colonel Tomline died at his residence in London."

He went on to say that the observatory was being closed up and that it was unclear whether funding (or "the means") would be available for him to complete the publication of the backlog of cometary data for the year.

Perhaps as an omen of Tomline's death, the declination axis of the telescope had become immovable several weeks before. The telescope was dismounted on 19 August, and the axis ground to the bearing, again by Mr Sims (again presumably of the manufacturer of the mounting, Ransomes & Sims). Plummer reported that after this attention the axis was "entirely satisfactory."

The outstanding orbital data that remained unpublished were for comets Barnard I and II 1889, Brooks 1889, Brooks 1890, Davidson 1889, Swift 1889, Barnard 1888 and Borelly 1890. Plummer completed his work at Orwell Park by publishing these results in 1890[33].

1890 onwards

It may only have been coincidence, but the report following that of Plummer in the *Monthly Notices of the Royal Astronomical Society* for his last two years at the Observatory, was from the Hong Kong Observatory. It was to there that Plummer's career took him next, to take up the post of First Assistant. It was at this point that Plummer's association with Tomline's Orwell Park observatory ended.

Conclusions

The 17 years during which Plummer worked at Orwell Park Observatory were fruitful. Obviously, his main contribution to Victorian astronomy was the observation and calculation cometary orbits, and highlighting the inaccuracies of contemporary star catalogues. In fact, it may have been this latter observation that led him to his post at Hong Kong Observatory, where he was instrumental, with William Doberck, in producing in 1905 a catalogue of right ascensions of 2120 southern stars[34]. More detail of Plummer's time at the Hong Kong Observatory has been published elsewhere[35, 36].

One enigma arising from Plummer's published work is the accuracy of his estimation of the position of the Orwell Park Observatory. Specifically, he needed to calculate the observatory's longitude to enable him to calculate the local sidereal time, and hence accurately to measure the position of stars and comets. As detailed above, to enable him to do this he had at his disposal a "small transit instrument". The first estimate he published in the *Monthly Notices of the Royal Astronomical* Society in 1875[37] was 0º 4' 55.8" east. Four years later he refined his estimate using the "Moon and culminators method", publishing the revised value in the *Monthly Notices of the Royal Astronomical Society*[38] as 0º 4' 57.75" east. He comments that this value was 2 seconds different from the Ordnance Survey value at that time.

This is an interesting result; the 2006 value derived from a global positioning system (G.P.S.) gives the longitude of the observatory as 1º 13' 50.0" east - more than 68 minutes difference! According to the Ordnance Survey map for Ipswich and Colchester (sheet 68) for 1838, Orwell Park Observatory is at longitude 1º 13' 58.8", only about 8" different from the G.P.S. value.

What is the origin of the remarkable discrepancy? Was Plummer inept in his observational techniques, or in his calculations? The latter is unlikely, because during his time at Hong Kong Observatory he was congratulated for his mathematical skills in reducing stellar positions. Was there an editorial or printing problem at the Royal Astronomical Society? Again, this is unlikely, as he published similar values on two occasions four years apart. The spotlight of suspicion must now fall upon the accuracy, or otherwise, of the Orwell Park Observatory transit instrument, although this does not explain the comment about the 2 second discrepancy with the Ordnance Survey map. However, as already mentioned, in several of his annual reports, Plummer did comment on the inaccuracies of the transit instrument. It is also possible that the sidereal clock contributed to these anomalies. This mystery is still unresolved. It is planned to repeat Plummer's observations using the original transit instrument, which is still in the Orwell Park Observatory (Figure 4).

Plummer's 'fringe' activities such as apparent brightness measurement and lunar occultation effects did not appear as regular threads in his annual reports. Was this because he was thwarted by bad weather, or lack of equipment, or did he just lose interest?

Figure 4

Orwell Park Observatory

The tower containing the observatory is located at the end of the east wing (the Royal apartments) of the main house. The observatory itself is only the upper-most storey of this tower. The floor of the equatorial room is approximately at the level of ledge running around the building above the arched windows of the circular, terraced belvedere. The top of the dome is 77 feet above ground level. The transit room containing the Troughton and Simms, 1872, 3-inch transit telescope, is the upper storey of the small, attached octagonal building.

Photograph, looking north-west, published by courtesy of Mr K.G.Goward, Orwell Astronomical Society.

However, Plummer's reputation for orbital reduction analysis was obviously made and recognised during his early career at the Orwell Park Observatory. This presumably helped him gain a high position at the Hong Kong Observatory,, where he was to remain until his retirement in 1911. A detailed account of the difficult and sometimes humiliating time he had there from 1891 to his retirement, under the less than benevolent direction of August Wilhelm (William) Doberck, has been published by Professor Kevin MacKeown[39].

John Isaac Plummer died in Oxshott, Surrey on 6 February 1925, at the age of 80 years[40]. He was married to Marion, and had a daughter, Beatrice Mary (born 1876) and a son, John Archibald (born 1878). In recent times Plummer's great grandson, Richard Bellamy-Brown, has been introduced to the place of his forebear's work.

Notes and References

1. The designation 'Colonel' was bestowed on Tomline by the Suffolk Militia, although he never undertook military training or service.
2. James Appleton. Web-published document entitled *John Isaac Plummer*. Ipswich: Orwell Astronomical Society. This document was compiled by James Appleton from articles by Roy Gooding, Ken Goward, Charles Radley and Paul Whiting in the Orwell Astronomical Society Journal. See www.oasi.org.uk .
3. Plummer, J. Colonel Tomline's observatory, Orwell Park, Ipswich. *Monthly Notices of the Royal Astronomical Society*. 1875, 35, 194-195.
4. Georg Merz (1793-1867) learned his trade as a lens crafter under Joseph Fraunhofer (1787-1826) in Munich, eventually taking over the latter's business after his death.
5. Reference 3. Page 195.
6. see Reference 2.
7. Plummer, J. Note on the Zodiacal Light. *Monthly Notices of the Royal Astronomical Society.* 1874, 35, 63-64.
8. Plummer, J. Observations of Comet V, 1874 (Coggia's) made at the Orwell Park Observatory. *Astronomische Nachrichten*. 1875, 85, 277-282.
9. Plummer, J. Colonel Tomline's Observatory, Orwell Park, Ipswich. *Monthly Notices of the Royal Astronomical Soci*ety. 1876, 36, 172-173.
10. Reference 2.
11. Plummer, J. Photometric Experiments upon the Light of Venus. *Monthly Notices of the Royal Astronomical Society*. 1876, 36, 351.
12. Plummer, J. Colonel Tomline's Observatory, Orwell Park, Ipswich. *Monthly Notices of the Royal Astronomical Society*. 1877, 37, 175-176.
13. Francis Baily. *Catalogue of stars of the British Association for the Advancement of Science; containing the mean Right Ascensions and North Polar Distances of 8377 fixed stars reduced to January 1, 1850*. London: British Association for the Advancement of Science. 1845.
14. Plummer, J. On the Proper Motion of Bradley's Stars. *Monthly Notices of the Royal Astronomical Society*. 1876, 36, 112-116.
15. Plummer, J. Astronomical Nomenclature. *Monthly Notices of the Royal Astronomical Society*. 1876, 36, 117. An example of his proposed nomenclature is 'pl. IV. 107', which would indicate a planetoid of the fourth class (a magnitude of between 9.0 and 9.5 when in opposition at unit distance) and 107th in order of discovery.
16. Plummer, J. Colonel Tomline's Observatory. *Monthly Notices of the royal Astronomical Society*. 1878, 38, 186.
17. Plummer, J. On the Supposed Influence of a Mass of Brickwork upon the Errors of a Transit Instrument in its Neighbourhood. *Monthly Notices of the Royal Astronomical Society*. 1878, 38**,** 367-369.
18. Plummer, J. Results of Observations of Comets Made at the Orwell Park Observatory 1877. *Astronomische Nachrichten*. 1879, 94, 65-70.
19. Plummer, J. Colonel Tomline's Observatory, Orwell Park. *Monthly Notices of the Royal Astronomical Society*. 1879, 39**,** 253.
20. As Reference 19.
21. Plummer, J. Colonel Tomline's Observatory, Orwell Park, near Ipswich. *Monthly Notices of the Royal Astronomical Society*. 1880, 40**,** 231-232.
22. Plummer, J. Observations of Brorsen's Periodical Comet made at Orwell Park Observatory near Ipswich 1879. *Astronomische Nachrichten*. 1880, 96, 329-334.
23. Plummer, J. Colonel Tomline's Observatory, Orwell Park. *Monthly Notices of the Royal Astronomical Society*. 1881, 41**,** 209-210.
24. Plummer, J. Colonel Tomline's Observatory, Orwell Park, Ipswich. *Monthly Notices of the Royal Astronomical Society*. 1882, 42**,** 168.
25. Plummer, J. Colonel Tomline's Observatory. *Monthly Notices of the Royal Astronomical Society*. 1884, 44, 174.
26. Plummer, J. Colonel Tomline's Observatory. *Monthly Notices of the Royal Astronomical Society*. 1887, 47, 161.
27. Plummer, J. Observations of Comets. *Astronomische Nachrichten*. 1886, 115, 289-292.
28. Plummer, J. Colonel Tomline's Observatory, Orwell Park, Ipswich. *Monthly Notices of the Royal Astronomical Society*. 1888, 48**,** 197.
29. Plummer, J. Observations of Comets at Orwell Park Observatory. *Monthly Notices of the Royal Astronomical Society*. 1888, 48, 55-61.
30. Plummer, J. Colonel Tomline's Observatory, Orwell Park. *Monthly Notices of the Royal Astronomical Society*. 1889, 49, 204-205.
31. Plummer, J. Observations of Comets at Orwell Park Observatory. *Monthly Notices of the Royal Astronomical Society*. 1889, 49, 73-78.
32. Plummer, J. Colonel Tomline's Observatory. *Monthly Notices of the Royal Astronomical Societ*y. 1890, 50, 211.
33. Plummer, J. Observations of Comets. *Monthly Notices of the Royal Astronomical Society*. 1891, 51, 51-56.
34. Doberck, A.W. *Catalogue of Right Ascensions of 2120 Southern Stars for the epoch 1900 from observations made at the Hong Kong Observatory during the years 1898-1904*. Hong Kong: Hong Kong Observatory. 1905.
35. Mckeown, K. William Doberck - A Stormy Career Founding the Hong Kong Observatory. *Journal of the Royal Asiatic Society, Hong Kong Branch*. 2004, 44., 5-39.
36. See Reference 2.
37. Reference 3. Page 195.
38. In Reference 19.
39. Reference 35.
40. Despite many searches, no formal obituary notice for Plummer has yet been located.

The Lockyer Ladies

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Astronomy and society have benefited from the contributions of three ladies who were directly linked to Norman Lockyer. His first wife, Winifred James, assisted him in his work and also made independent contributions by the translation of scientific texts from French into English. One of their daughters, Winifred, and his second wife, Mary, also assisted Lockyer in various ways and contributed to the administration of the Norman Lockyer Observatory at Sidmouth after his death.

This paper[1] is mainly concerned with three ladies who played major rôles in the life of Norman Lockyer. Two of them also made important contributions to the Norman Lockyer Observatory after Lockyer's death. None of them are to be found in the standard histories of astronomy since in their own right they made no important astronomical discoveries. Nevertheless, they did make useful contributions to astronomy and to other aspects of society.

The principal Lockyer biographies[2,3] give scant information about the lives of the ladies who supported him in his scientific life as well as in his family life. However, the archives of the Norman Lockyer Observatory in Sidmouth, Devon contain letters that supplement the other meagre published sources of information on their lives. The archives are held in the library of the University of Exeter.

An account of Lockyer's early life is given by Frost[4]; and a review of his scientific career is given by Wilkins[5]. Therefore, only the basic facts are given here. Joseph Norman Lockyer was born in Rugby in 1836. He was named after his father, Joseph Hooley Lockyer and his mother Ann, who was the daughter of Edward Norman. Unfortunately, she died in 1845, and so Norman was sent to live with his uncle. He went to school in Kenilworth, where he came to the attention Lord Leigh of Stoneleigh, Warwickshire. Norman's father was interested in chemistry, electricity and astronomy and Norman must have absorbed some of this interest. He was, however, mainly interested in languages, but did not go to university. After spending several months studying in Paris and teaching English in Geneva, he got a job as a temporary clerk in the British War Office in 1857 on the recommendation of Lord Leigh.

Mrs Winifred Lockyer

Lockyer obtained a permanent War Office post in 1858. He then married Winifred (Figure 1), the daughter of William James an engineer living in Leamington. We do not know when she was born, where she was educated or when she first met Lockyer. However, we do know that, like Lockyer, she was proficient in French and probably in Italian. They set up home in Wimbledon and very soon started a family. The first boy died when very young; there were six more sons and two daughters. Only one of the sons, William James Stewart, born in 1868, took an active interest in astronomy.

Figure 1
Mrs Winifred Lockyer
First wife of J. Norman Locker

This image is from Reference 3.

Lockyer became interested in astronomy through friends in a social club in Wimbledon. He soon obtained a good 6.2-inch refractor, which he used to study the Moon and then Mars, before turning to the use of a spectroscope to study the Sun. As a part-time source of income he became a science journalist, and also the science editor of a magazine called *The Reader*. Later he became the founder-editor of the prestigious journal *Nature.*

We must assume that Lockyer was able to afford help bringing up the family since Winifred was able to assist him in his observing – she confirmed his observation in October 1868 of the red C-line of hydrogen from a "red flame" at the edge of the Sun. This led to the award, jointly with Pierre Jules Cèsar Janssen (1824-1907), of a medal by the French Academy of Science. She also went on the solar eclipse expedition to Sicily in December 1870. Unfortunately, the ship hit a rock, but Winifred wrote a full account of the incident[6].

Her most important contributions to science and to astronomy in particular were, however, her translations of books from French into English. The first, *The Heavens: An Illustrated Handbook of Popular Astronomy* was published in 1866. It was written by Amedée Guillemin, and edited by Lockyer. It went through at least five editions.

Two years later she was responsible for the translation of the book, *Volcanoes and Earthquakes*. Then in 1870, came *The Marvels of the Heavens* by Camille Flammarion. These were followed by two more books by Guillemin: *The Forces of Nature* in 1872 and *The Applications of Physical Forces* in 1874. Again, Norman Lockyer acted as the scientific editor. Only his name is on the title page of at least one of these volumes!

We are told that she helped to arrange musical evenings when they entertained friends, and that they both enjoyed country walks, but otherwise the two Lockyer biographies tell us only that she died in 1879 after a short illness. The only published reference to her life and death that I have found is in an issue of *Nature*[7]. It reads:

> " We regret to have to announce the death of Mrs Norman Lockyer, an occasional contributor to this journal and translator of several works on popular science. Her husband's scientific work for the last eleven years owes whatever it may possess of merit to her constant interest, encouragement, and assistance. Her untimely death will be a shock to many men of science in many lands to whom she was personally known."

This was, presumably, written by Norman Lockyer himself. I did not find any further comment about her in the issues for the following few weeks. I have, as yet, not looked systematically for any of her contributions to *Nature,* but I hope to do so, although it is possible that she was not credited with them at the time.

Lockyer's daughters

Lockyer was left with two daughters and five sons to bring up, but neither of his biographers gives any indication of the domestic arrangements for looking after them.

The elder daughter, Rosaline Annie, was then 15 years old, but we know very little about her and so I can only repeat a few comments by one of Lockyer's biographers[8]:

> "... [she] seems to have inherited something of her father's stubbornness."
>
> "… when she was 23 [she] insisted on marrying a man of whom her father strongly disapproved. ... [he thought] the man was a waster …"
>
> "… in the nineties she had to go on the stage to make ends meet."

The younger daughter, Winfred Lucas (Figure 2), born in 1873, was the youngest child; she was only six years old when her mother died. We know very little about her early life. The 1928 biography of Lockyer does not even mention her birth! She went to a boarding school, and friends of Lockyer used to invite him to bring "Winnie" when he went to visit them. Meadows states that she acted as a companion to her father and that:

Figure 2

Winifred Lucas Lockyer

This image is from Reference 24, 2nd edition.

> "… she also seems on occasion to have acted as a moderating influence between her father and her brothers." [9]

In 1892 Winfred visited her brother, James, in Göttingen, Germany where he was studying for a Ph.D. in astronomy. He wrote to his father to say that she came with a crowd of girls, was well and enjoying herself. The girls went on to Dresden. Later we learn that Winnie "made a great hit" when she visited Ottawa for two months in 1901, before going on to Toronto; so clearly her father gave her the opportunity to travel. Winifred must have shared her father's interests in both languages and science, because in 1896 she translated, from German, for *Nature* a discourse by Professor Cornu on upper atmosphere phenomena[10].

Lockyer's career, 1873 to 1903

Prior to his wife's death Lockyer had started solar observations at South Kensington in 1873[11], and had transferred from the War Office to the Department of Science and Art in 1875[12]. In 1876 he organised an exhibition of scientific apparatus, which became the basis of the collection in the Science Museum. In 1881 he was appointed as a lecturer in the Normal School of Science, and became its first Professor of Astronomical Physics in 1887. He wrote several books, including *The Dawn of Astronomy*, in which he pioneered attempts to find an astronomical significance in ancient stone monuments, such as the pyramids and the temples of Egypt and Greece, and he dated Stonehenge. In 1897 Lockyer was knighted. In 1901 he retired his Professorship, but was formally appointed Director of the Solar Physics Observatory at South Kensington. At that time his son, James, was the Chief Assistant at the Observatory.

Lockyer corresponded with a large number of people of many different interests clearly he was a very sociable man. While cataloguing his letters that still remain, I tried to find out more about the people involved. I was intrigued by two letters from Lady Meux[13], who invited him lunch, offering him an undefined "amusing temptation", and two weeks later inviting him to join her in her box at Her Majesty's Theatre. I was amused to find that her husband was otherwise engaged in the siege of Ladysmith at the time!

In his biography we read that in 1903 "On May 23, Sir Norman married Thomasine Mary, the widow of Bernard E. Brodhurst, F.R.C.S., and the younger daughter of Mr. S. Woolcott Browne" [14]. No other information is given about Mary, as she was known, nor about the circumstances that led to the marriage, nor about the reason why they later retired to Sidmouth.

The Browne sisters

At this point we go back in time to pick up the story of two young girls, Annie and Mary Browne, who used to stay in Sidmouth with their grandparents, Captain and Mrs Carslake. Annie was a very delicate child, but her younger sister, Mary, born in 1852, was more robust and had a passion for riding and outdoor activities. In 1868, when they were still teenagers, they moved with their parents from Bridgwater to London, where they attended Queen's College in Harley Street. The elder girl, Annie, attended the College for six years until 1874, but there appears to be no record of her courses or results. On the other hand we know that Mary was awarded a scholarship that covered her attendance at classes in astronomy and natural philosophy. She became a mathematics tutor in 1875 and also attended courses at University College on physics and applied mathematics.

Whilst in Egypt in 1882 on a solar eclipse expedition, Lockyer wrote to Mary Browne[15], who was then employed at the Solar Physics Observatory. He told her about the eclipse and, after expressing the hope that she is very happy, he ended his letter "always very sincerely yours". Mary was 30 years old at the time; Lockyer was 16 years older. We can only guess about Mary's feelings, but we do know that she kept this letter.

At this time Annie and Mary were actively involved in establishing for women students in the University of London a residence hall, which later became known as College Hall[16]. They were also involved in the suffragette movement and in other social work in London. For example, they helped Canon Barnett to establish Toynbee Hall in Whitechapel. Lockyer was also involved with Toynbee Hall. Annie and Mary also kept up their love for Sidmouth. On visits to the town they used to attend the Unitarian Chapel. Annie donated the rent of adjacent May Cottage for five years, and in March 1885 it was opened as a cottage hospital. This developed into the present Sidmouth Hospital.

In the same year, 1885, Mary married one of the men on the committee for College Hall, a surgeon, Bernard Brodhurst, so she became the third Mrs Brodhurst[17], rather than Mrs Lockyer. She had six step-daughters, but I know nothing about her life whist she was married to Brodhurst, who died in 1900.

Lady Lockyer

We know nothing of the circumstances that brought Lockyer and the widowed Mary (Figure 3) together again, and I have not even been able to find out where they were married in 1903. We do, however, have a photograph of Lady Lockyer and Sir Norman in formal dress that might have been taken on their honeymoon. It is held in the Royal Greenwich Observatory Archives in the Cambridge University Library and, by chance, the archivist asked me if I could identify the man!

Figure 3
Lady Lockyer

This image is from Reference 24, 2nd edition.

In the same year as his second marriage, Sir Norman became President of the British Association for the Advancement of Science. Near the end of his term of office, he arranged a dinner for the Prince of Wales at the Athenaeum Club. The correspondence[17] for that event shows that the Club Committee agreed to Lockyer using some of his own silver and flowers, but would not agree to Lady Lockyer arranging the flowers!

In the following year, 1905, Lockyer started the British Science Guild, a pressure group formed to try to persuade the government to put a greater investment in science education and research. Lady Lockyer became the Honorary Assistant Treasurer; I think we can assume that she did the work, but that Lord Avebury, the Honorary Treasurer, took the credit. She also continued to campaign, with Sir Norman's support, for greater recognition of the rôle of women in society. She participated in the suffrage movement and lobbied members of both houses of Parliament.

Lady Lockyer must have retained her interest in astronomy because in 1905 she was a volunteer member of the solar eclipse expedition to Majorca. Her experience some 20 years before, when she had worked for a short time at the Solar Physics Observatory, must have stood her in good stead. Afterwards she contributed to the report on the expedition an account of the use of one of the instruments. Lady Lockyer was also a keen photographer. She accompanied Sir Norman on his visits to Stonehenge and other ancient stone monuments in Britain, and took photographs to illustrate his articles in *Nature*, for example.

As he entered his seventies, Sir Norman decided that it was time to think about retirement; he and Lady Lockyer planned to build a new home in Sidmouth on land that Mary had inherited. Later, after Lady Lockyer's death, the house was named Brownlands by the family that bought it, but in this case Brown was spelt without an 'e'.

Lockyer's daughter Winifred continued to live with her father and she was the co-author of his last book[20], which was about the scientific references in the poems of Alfred Lord Tennyson, who had been a friend of Lockyer for many years. It was published while the new house was being built at Sidmouth. A dome for Lockyer's personal telescope was erected near the house.

The Hill Observatory at Sidmouth

Although Lockyer had retired his Professorship in the Royal College of Science in 1901, he had continued to direct the Solar Physics Observatory, which became independent of the College. The poor observing site at South Kensington was needed for new buildings, and in 1907 the Solar Physics Committee recommended moving the Observatory to a new site on the North Downs near Caterham, Kent, where the observing conditions would be much better. In 1911, however, a committee of the Board of Education decided that the Observatory should be moved to Cambridge as part of the University[21]. Lockyer continued as Director until the end of March 1913.

In 1912 a family friend, Francis McClean[22], suggested to Sir Norman the idea of building an astrophysical observatory on the top of Salcombe Hill, above the new house. Such an observatory would provide a home for his father's telescope and other equipment, whilst also providing jobs for his friend, James Lockyer, and a small staff. The idea was taken up, and an appeal was launched for funds to establish the Hill Observatory. Work on building the observatory started in the same year.

Sir Norman and Lady Lockyer donated the site and other equipment. Lady Lockyer became the Honorary Secretary. Winifred became the Honorary Assistant Treasurer and Librarian. Lady Lockyer's sister, Annie Leigh Brown, became a member of one of the committees, and later she made various donations to the Observatory.

In addition to the telescope given by McClean, and one from South Kensington, it was intended that there should be a dome for Sir Norman's own 30-inch reflector. Unfortunately, construction and observing were halted by the start of World War I. A photograph of the ceremony of cutting the first sod for the dome on 21 April 1914 includes Lady Lockyer, Winifred and Princess Arthur of Connaught, who wielded the spade.

The Hill Observatory Corporation was formally established in 1916. Lady Lockyer became the Assistant Treasurer; Winifred the Assistant Secretary. I have not seen any record of Mary or Winifred using the telescopes, but Winifred certainly took an interest in observing since a letter from her was published in *Nature*[23]. In it she records seeing 22 meteors during the evening of 3 January 1918.

Sir Norman and Mary had a few more years together at Sidmouth, but Sir Norman died in August 1920 at the age of 84. Obituary notices and biographical articles may be found in many journals and encyclopaedias.

The Norman Lockyer Observatory

Sir Norman was succeeded as Director by his son, James, who had been his chief assistant at both the South Kensington and Sidmouth observatories. In 1921 the Hill Observatory was renamed the Norman Lockyer Observatory[24] (N.L.O.). James was a meteorologist and a photographer, as well as an astronomer. His cloud photographs are in the archives of the Meteorological Office and his 'Season's Greetings' cards show both local and astronomical photographs[25]. The observational work of the N.L.O. was mainly concerned with stellar spectroscopy. Detailed reports on the activities are given in the annual reports of the N.L.O. Corporation, and of the Director.

Both Lady Lockyer and Winifred continued with their administrative responsibilities. They also contributed financially and in other ways that have gone largely unrecognised. It appears, however, that they were given credit for one job that that they did not do! The 1928 biography of Sir Norman[26] was attributed to T. Mary Lockyer and Winifred L. Lockyer, with the assistance of Professor H. Dingle. But Sir Richard Gregory, who succeeded Lockyer as Editor of *Nature* and in other duties, states in a letter[27] that it he who designed the book and that he:

> "… got Prof Dingle to do the literary job… [so] … Lady Lockyer and Miss Lockyer did not write a word in the book."

This certainly explains why the book contains no details of the life of the family.

Lady Lockyer was elected a Fellow of the Royal Astronomical Society in 1923, a few years after the Society first admitted women to Fellowship. She maintained her association with College Hall in London, and in 1931 laid the foundation stone for the new building in Malet Street. She, her sister Annie Leigh Browne, and Winifred involved themselves strongly in Sidmouth affairs, but this is not the place to describe these activities.

Winifred died in 1934 aged 60 years. The 1935 edition of the N.L.O. Handbook was dedicated to her memory. Her brother, James, died suddenly in 1936. Lady Lockyer maintained her active interest in the Observatory and it is said that each week she invited the astronomers and local scientists to tea. In her later years, during World War II, she was advised not to travel to London, but she continued to correspond regularly with McClean and Gregory about Observatory affairs .

Dr H. S. Jones (later Sir Harold Spencer Jones), the Astronomer Royal, was a member of the N.L.O. research committee, and he and his wife became good friends of Lady Lockyer. For example, they spent Christmas with her in Sidmouth in 1939 and Whitsuntide in 1940. She also agreed to store chronometers for the Royal Navy in the basement of Lockyer House, as Sir Harold was concerned that they might be destroyed by an air raid on Exeter, where they were then kept.

Lady Lockyer died[28] in 1943 aged 91 years[29,30]. She bequeathed Lockyer House and land, and the residue of her estate, to the N.L.O.. Although there is a small memorial plaque to Winifred at the Observatory, surprisingly, there is nothing to mark Lady Lockyer's contributions.

Kate Lockyer

One other Lockyer lady should be mentioned to complete the picture. James Lockyer married a widow, Kate Irene Wright, in 1921, when he was 53 years old and she was 32. They had met during the Great War, but once again it appears that Sir Norman did not approve, and so they did not

marry until after his death. She appears to have played no significant rôle in the affairs of the N.L.O., but she was paid £100 per year for four years after her husband's death. During an interview in 1971[31] she said that Lady Lockyer was very kind to her, especially after James's sudden death, but that she did not get on well with the rest of the family. The *Sidmouth Herald* stated in the report on James's funeral that they had adopted a son. She died early in 1972.

Epilogue

After the World War II the University College of the South West of England (which became the University of Exeter) provided financial support for the N.L.O. and effectively took control of the N.L.O. Corporation. Observational work ceased in about 1980 and later the site and the principal telescopes were sold to the East Devon District Council. The auxiliary equipment and furniture was sold by auction or scrapped. The proceeds were used to set up the Sir Norman Lockyer Memorial Trust, which is administered by the Royal Astronomical Society. The Observatory is now operated on behalf of the Council by the N.L.O. Society, which is a registered educational charity. Its activities include amateur radio and meteorology as well as astronomy. In recent years extra facilities, including a planetarium, a modern telescope and dome, and a lecture theatre, have been added (see www.ex.ac.uk/nlo). The archives, as well as much of the original extensive library of the Observatory, are held by the University of Exeter[32].

There are still many loose ends to tie up before a full account of the Lockyer ladies can be written; but I hope that this partial story conveys some of the interest that the Lockyer family has given me. I would welcome further information or leads that would help me to fill in more of the detail and, if possible, to find more photographs of these ladies who played such important roles in the life of Sir Norman and the people of Sidmouth.

Notes and References

1. This paper is based on a presentation given by the author at the 2006 Spring Conference of the Society for the History of Astronomy, which had the theme *Women in Astronomy*.
2. T. Mary Lockyer and Winfred L. Lockyer. *Life and Work of Sir Norman Lockyer.* London: Macmillan & Co. Ltd. 1928. But see text for comment about authorship. Referred to hereafter as: Lockyer and Lockyer. *Life and Work.*
3. A. J. Meadows. *Science and Controversy.* London: Macmillan & Co. Ltd. 1972. Referred to hereafter as: Meadows. *Science and Controversy.*
4. Mike Frost. J. Norman Lockyer: The Early Years. *The Antiquarian Astronomer: Journal of the Society for the History of Astronomy*. Issue 2, 2005, 21-26.
5. G. A. Wilkins. Sir Norman Lockyer's contributions to science. *Quarterly Journal of the Royal Astronomical Society*. 1994, 35, 51-57.
6. Lockyer and Lockyer. *Life and Work.* Reference 2. Page 28.
7. Anonymous. *Nature.* 25 September 1879, 20, 513.
8. Meadows. *Science and Controversy*. Reference 3. Page 209.
9. As Reference 8.
10. A. Cornu. Physical phenomena in the high regions of the atmosphere. *Nature*. 23 April 1896, 53, 588-592.
11. Lockyer and Lockyer. Life and Work. Reference 2. Page 72.
12. Lockyer and Lockyer. Life and Work. Reference 2. Pages 88-89.
13. University of Exeter Library (Special Collections). MS 110, Meux. Hereafter this source is referred to as EUL
14. Lockyer and Lockyer. Life and Work. Reference 2. Page 185.
15. EUL MS 110, Browne.
16. Alice M. Copping. The Story of College Hall 1882-1972. London: Newman Books. 1974.
17. There is a photograph of Mary in her wedding dress in the Sidmouth Museum.
18. EUL MS 110, Tedder.
19. EUL MS 110 ZN. This is a report and a cartoon from The Daily Graphic, dated 31 October 1905, on the first meeting of the British Science Guild.
20. J. N. Lockyer and W. L. Lockyer. Tennyson as a student and poet of Nature. London: Macmillan & Co. 1910.
21. Meadows. Science and Controversy. Reference 3. Pages 290-297.
22. EUL MS 72 add. 1. Unpublished note by F. K. McClean; probably written after 1948.
23. W.L. Lockyer. The January meteors of 1918. *Nature*. 10 January 1918. 100, 365.
24. W. J. S. Lockyer. Handbook to the Norman Lockyer Observatory. London: Norman Lockyer Observatory Corporation. 1st Edition 1921; 2nd Edition 1935.
25. EUL MS 72/3/17.
26. Lockyer and Lockyer. Life and Work. Reference 2.
27. EUL MS 110, Gregory to Armstrong, dated 05 November 1945.
28. Notices of death and funeral, *etc*., of Lady Lockyer appear in the Sidmouth Herald and Directory, dated 11 September 1943. Page 3, column 1; and 18 September 1943. Page 6, columns 1-4, and Page 7 column 1.
29. R. A. Gregory. Lady Lockyer. *Nature*, 9 October 1943. 152, 405-406.
30. H. Spencer Jones. Obituary Notice of Lady Lockyer. *Monthly Notices of the Royal Astronomical Society*. 1944, 104, 91-92. Notice that in this obituary, her name (Thomasine Mary) and the date of the renaming of the Hill Observatory (1921) are given wrongly.
31. EUL MS 72 ZX. This item is the transcript of an interview with Kate Lockyer on 23 August 1971 by R. E. Evans on behalf of A.J. Meadows.
32. G. A. Wilkins. The archives of the Norman Lockyer Observatory. *Journal of Astronomical Data*. 2005, 10 (7), 153-162. Also in: Christiaan Sterken and Hilmar W. Duerbeck (Editors). *Astronomical Heritages: Astronomical Archives and Historic Transits of Venus*. Published by C. Sterken at Vrije Universiteit Brussel.

The Antiquarian Astronomer

Journal of the Society for the History of Astronomy

Scope

The Society for the History of Astronomy was formed in June 2002 with three main objectives:

- To provide a forum for those with an interest in the history of astronomy and related subjects;
- To promote interest in the history of astronomy by academics, educators and amateur astronomers and local historians;
- To encourage research into the history of astronomy, especially research by amateurs, and to facilitate its collation, interpretation, preservation, publication and dissemination.

To implement these aims, the Society organises regular meetings and publishes its quarterly Newsletter and its annual Journal, *The Antiquarian Astronomer*.

Council established *The Antiquarian Astronomer* to provide a medium to publish research by members and others into any aspect of the history of astronomy and related subjects. Council recognised that because most members were amateur astronomers and amateur historians, most of their research would be about local history, which though of lasting value, was unlikely to fall within the scope of professionally-published journals. *The Antiquarian Astronomer* therefore provides a means by which the results of research can be shared with other individuals and organisations having interests similar to those of the Society, and be made available to posterity. Papers need not be restricted to local history, but should contain original research, new interpretation or insight of material already in the public domain, or description that brings to a wider audience material of limited availability, or that is available only in disparate locations. They should not have been previously published.

An important principle established by Council is that papers published in *The Antiquarian Astronomer*, though mainly by amateurs, are to be of a standard that will be recognised as giving the research and the Society lasting credibility. To fulfil this principle, each paper is peer-reviewed by one or more Reviewers, in addition to the usual scrutiny by the Editorial Team. Reviewers are selected for their knowledge of the subject of the paper, able to provide helpful feedback to the author and to the Editor, and be supportive of the aims of the Society.

The Antiquarian Astronomer also publishes Essay Reviews of books of significance in the history of astronomy. Short reviews of single books appear in the S.H.A. Newsletter.

Papers should be prepared using the Guidelines to Authors (see Pages 58 and 59 of this Issue and the Society's website, www.shastro.org.uk), and should be sent, preferably in electronic form, to the Editor of *The Antiquarian Astronomer*, whose contact details are given on Page 60 of this Issue, and in the S.H.A. Newsletter.

The Antiquarian Astronomer

Journal of the Society for the History of Astronomy

Guidelines for Authors

Our aim is to publish as much as possible of the material submitted to *The Antiquarian Astronomer*. To help us in this aim, papers submitted should adhere as far as practicable to the following guidelines. Doing so will minimise the effort and time taken by the author in preparing the draft, and by us in handling, reviewing, revising and formatting it.

Send papers, in electronic form, simultaneously to both the Editor (theaa@shastro.org.uk) and the Assistant Editor (kevin.johnson@ScienceMuseum.org.uk). We aim to acknowledge receipt within 48 hours. If you get no response within 5 days, e-mail to ask us to confirm that we received your submission.

Length of papers

Papers can be up to 5,000 (longer if essential). Very short papers, up to 1,500, words are also welcomed. As a guide, each full page of body text in this Issue contains about 900 words. A 5,000-word paper with figures, etc. will be about 8 pages long; more if some of the Figures need to be in 2-column format.

Basic principles underlying writing up a paper

The following principles should guide you when preparing a paper:

- Statements must be evidenced by reference to suitable sources.
- Sources must be described by Notes and References in sufficient detail to allow a reader to locate the same information.
- Citations should be to primary, not secondary, sources whenever practicable (i.e. cite the original item, not a paper, book, etc. that cites it).
- Interpretations of, or conclusions drawn from, your data should give all the steps in your reasoning.

Paper structure

To keep reformatting work to a minimum, please ensure that papers have the following basic structure (use this Issue as a guide):

- First (exceptionally, a second) line - **title**.
- Next line - author's **name** in the form preferred.
- Next line - an astronomical or other **affiliation**.
- **Summary** of the paper 100-130 words (it will be edited to occupy the space allocated).
- **Main body** of the paper (using sub-headings if the paper is sufficiently long to need them); As either a separate section, or as a paragraph at or near the end of the paper, identify further research needed.
- **Acknowledgements**.
- **Notes and References**, should be cited in numerical sequence in this form (1), and included as endnotes starting on a separate page. (**Avoid** using automatic footnotes available in word-processing software, because these cause an enormous amount of work when transferring the final text from word-processed document to page lay-out software).

- Printouts of **Figures, Line diagrams, Tables**, etc.; a separate page for each. Every Figure, etc. must have a caption (with additional notes if necessary) **on the same page as the Figure** (not on a separate page). Number Figures, etc. sequentially. (See the guidance below on the requirements for submitting photographs, line diagrams, etc.).
- On a separate page a 100- to 150-word **biography** of the author in the style of those in Issue 2. The biography should include an indication of what stimulated the research described in the paper. The author's name should include full initials, and post-nomial letters of all relevant honours, awards and academic qualifications.

Style, grammar and spelling

Guidance on these aspects of preparing a paper are being developed. Do not delay submitting a paper until the style guidelines appear; the Editorial Team will advise authors on any changes needed. The guidance will be based on various 'standard' texts on English usage and on Oxford University Press style books; spelling will be that of the Oxford English Dictionaries.

Preparing the typescript

- Use Microsoft Word if possible.
- Use A4 paper printed on one side only.
- Set left and right margins to 3 cm (this makes the text 15 cm wide).
- Set the language to English (U.K.) **not** English (U.S.).
- Set Times New Roman, 10 point font.
- Set line spacing to 1.5 lines.
- Keep **formatting** to the **minimum** necessary to ensure that the draft is intelligible.
- **Do not** use tabs or spaces to indent material such as quotations (they all have to be removed by hand); use the Format/Paragraph/Indentation facility (in Word).

Reference styles

References should have the following form (note the punctuation and use of italics):

- Paper in a Journal
- Author surname, initials (or name(s) in full if that is used in the paper being cited). Title of paper. *Journal name* (not abbreviated). Year, Volume number (part number), Start and end pages of the paper, and if necessary (specific Page(s) cited.
- Here is an example:
- Hingley, P.D. Urania's Mirror - a 170-year old mystery solved? *Journal of the British Astronomical Association*. 1994, 104(5), 238-240.
- Book
- Author surname, initials (or name(s) in full if used in the book). Title. Place of publication: Publisher (full name as it appears in the book), Edition (if necessary) Year of publication. Page(s) referred to.
- Here is an example:
- Clerke, Agnes. *A Popular History of Astronomy During the Nineteenth Century*. London: A. & C. Black, 4th edition 1902. 152-154.
- Newspaper
- Author surname, initials (or name(s) in full if that is used in the article being cited). (Title (in full). Number of issue (if it has one). Date. Page number(s). (Column. Location in column. If necessary.)
- Archive or other unpublished material
- Author surname, initials (or name(s) in full if that is used in the item being cited). Title or name of item. Page (folio) number. Obverse or reverse (if appropriate). Column location, and/or place on the page (if required to locate points of detail). Name of archive (in full). Location of Archive - Street, Town, Country, Post code.

Reference number of accession, or location place. Any other information needed for another to locate the item being cited.

- Map
- Map originator. Series. Sheet number. Date of sheet. Scale, of original and of reproduction. Grid reference or other unambiguous method of locating the place under discussion. Include in the Figure showing the map credit to the copyright holder. For Ordnance Survey maps this is currently:
- Ordnance Survey mapping. © Crown Copyright.

•Internet sites

Internet sites should be treated as ephemeral, and not be cited as primary sources.

Requirements for photographs and line diagrams

- Submit as jpg files scanned at 300 dpi, and attached to your electronic submission, or on a CD/DVD. Do not crop images closely (we need flexibility to ensure that an image fits into the layout in an appropriate way.) Images can be colour or black and white; but they will be printed only in black and white.
- Photographs should include a note of by whom and when the photograph was taken; and a compass direction of the view (eight compass points should suffice in most cases).
- A credit should accompany all images stating its origin and by whose permission it appears.

Review Process and Timescale

Process

We are still learning from experience the best way to move papers from draft submissions to printed pages. Please have patience and understanding whilst we find what is optimum for authors, reviewers and the Editorial Team. The basic process we follow is:

- Draft received;
- Initial comments sent to author by editorial team;
- Revised draft received;
- Revised draft sent for scrutiny by an Independent Reviewer;
- Reviewer's comments sent to author;
- Second revised draft received;
- Pages edited to layout and style.
- Interaction with authors to finalise details;
- Page proofs sent to author for scrutiny;
- Page proofs agreed.

This is the basic process. Frequently, there are many iterations of the reviewing and editing stages. Our experience is that the page layout and editing stage is the most onerous and lengthy. We may, therefore, try to shorten it by making up the pages earlier. This will identify details or omissions that will be needed for the final draft. However, it has the disadvantage that if extensive revision of a paper is needed after the independent review stage, the earlier layout work is largely wasted. Our goal is to find the balance between these various conflicting requirements.

We plan to use the following schedule for Issue 4:

- 30 June 2007: Deadline for receipt of new drafts.
- 30 September 2007: Deadline for receipt of final draft.
- 03 December 2007: Copy sent to printer.

Each paper is treated individually, and by negotiation between author and the Editorial Team, different schedules may apply to each one. The first deadline is **not** an invitation to defer submitting a paper until that date; please submit as early as you can.

The Antiquarian Astronomer
Journal of the Society for the History of Astronomy

Miscellany

Charles Dickens and Astronomy

Mary Brück

Allan Chapman's *fascinating* paper (Observers Observed: Charles Dickens at the Royal Observatory, Greenwich 1850) in Issue 2 (December 2005) of *The Antiquarian Astronomer* draws attention to a set of three major articles on the Royal Observatory published in *Household Words*, the popular magazine founded and edited by Dickens himself. Dr Chapman regards these articles, full of details of the observatory's activities and giving the public perception of the observatory's function, as invaluable primary sources in the history of astronomy.

The contributors to the magazine were anonymous but, as Dr Chapman points out, the style and content of the articles may be taken as Dickens' own, he being the "hands-on" chief editor and "conductor" of his famous publication. It is interesting, nevertheless, to identify the actual writer. Dickens had a team of experienced colleagues helping to run *Household Words*. His sub-editor was William Henry Wills (1810-1880)[1] who among other duties kept the business accounts. Wills' papers are preserved in an American archive, and include records of payments to authors. Research on these and other documents reveals that there were hundreds of contributors to the magazine during the 1850s: in all, over three hundred names have come to light, the majority with their identities confirmed[2]. The author of the Greenwich articles was one of the regular contributors, Frederick Knight Hunt (1814-1854), a close associate of Dickens who was also qualified in medicine and continued to practise while pursuing his writing career in literary and medical periodicals. He wrote for *Household Words* from 1850-52 before becoming editor of the newspaper *Daily News*. Dickens thought very highly of Hunt's work: he gave, he wrote, "very good service indeed" and singled out "Swinging the Ship" (on the Greenwich magnetic department) as "a very good article". Dickens was known on occasion to "make excursions in company with a staff member to gather material for articles": was this, perhaps, one of them? [3]

In May 1850, the same month in which the first of the Greenwich articles appeared, Dickens made a very important scientific contact. He wrote to the renowned Michael Faraday, Director of the Royal Institution, requesting material from his popular lectures which he might publish in *Household Words*. Faraday sent him the notes of his famous series of lectures, *On the Chemical History of a Candle*, (the most celebrated of his Christmas Lectures for children, delivered in 1848-49). Dickens thanked him profusely, and asked as a favour that he or his sub-editor be allowed to attend his next lecture, declaring himself " one who has long respected you and strongly felt the obligation society owes to you"[4]. There is no record that Dickens personally attended the lecture[5]. Percival Leigh, one of Dickens' contributors, worked Faraday's notes into a story about a boy, an enthusiastic attendant of the Royal Institution lectures, who explains the chemistry of the candle and other wonders of science to an untutored uncle and is rewarded. Leigh (1813-1889) was a writer best known for his contributions to Punch. His version of Faraday's lecture was published on August 3 of the same year.

The fact that Dickens communicated personally with Faraday, the great public scientific figure of the day, on behalf of his magazine, would seem to make it not at all unlikely that he would have approached the Astronomer Royal in the same way. Dr Chapman has found no record of such a communication - but we must hope that some clue may yet be found, and that we may look forward to further reflections in our journal on Charles Dickens' associations with the world of science.

Notes and References

1. Biographies of Wills and of Hunt and Leigh, mentioned later, may be found in the Oxford Dictionary of National Biography 2003.
2. Lohri, Anne. Household Words: list of contributors and their contributions. Toronto: University of Toronto Press. 1973.
3. It may also be relevant that Hunt lived for a time in Greenwich.
4. James, Frank A.J.L. The Correspondence of Michael Faraday. London: Institution of Electrical Engineers. 1991. Letters from Dickens, 28 and 31 May 1850.
5. Hamilton, James. Faraday, a Life. London: HarperCollins. 2002. 345.

Errata

The Antiquarian Astronomer Issue 2, December 2005

The Editor is very grateful for being notified of two factual errors; he apologies for both.

Page 47, Column 1, Paragraph 1.

" You describe Norwood as being in west London; actually it is in south-east London. It must have been a haven for astronomers, as by the 1920-30s other well-known amateur astronomers lived thereabouts - B.A.A. stalwart Dr W. H. Steavenson and Will Hay!"
K. G. Goward
By e-mail December 26, 2005 2:35 PM

Page 56

"… you refer to me as the 'Former Superintendent, National Almanac Office' when the correct name is 'H.M. Nautical Almanac Office'."
G. A. Wilkins
By e-mail Mon 09/01/2006 11:34

The Editor invites items for this section of *The Antiquarian Astronomer*

Miscellany is a forum for correspondence from members and others on topics related to the history of astronomy and related sciences. Short correspondence will continue to appear in the S.H.A. Newsletter. Items in this section will relate to matters such as: comment or additional information relating to papers published in this or previous Issues; requests for information for long-term projects; reports of very short research projects that result in the need to place on record findings of lasting value; reports of finds of interesting artefacts (letters, photographs, instruments, etc.). Of particular importance are items pointing out errors of fact. *The Antiquarian Astronomer* is one the Society's main publications of record. It is therefore important to correct errors in published papers. Material submitted will not usually be independently reviewed, but will be subjected to editorial scrutiny in consultation with the authors. Send items to the Editor using these contact details:

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The Antiquarian Astronomer

Journal of the Society for the History of Astronomy

Issue 1, 2004

Issue 2, December 2005

The Antiquarian Astronomer

Journal of the Society for the History of Astronomy

Contents of Issue 3, December 2006

ISSN 1740-3677