# The Antiquarian Astronomer

Journal of the Society for the History of Astronomy

*Maria Mitchell (1818–89), America's first female professional astronomer*

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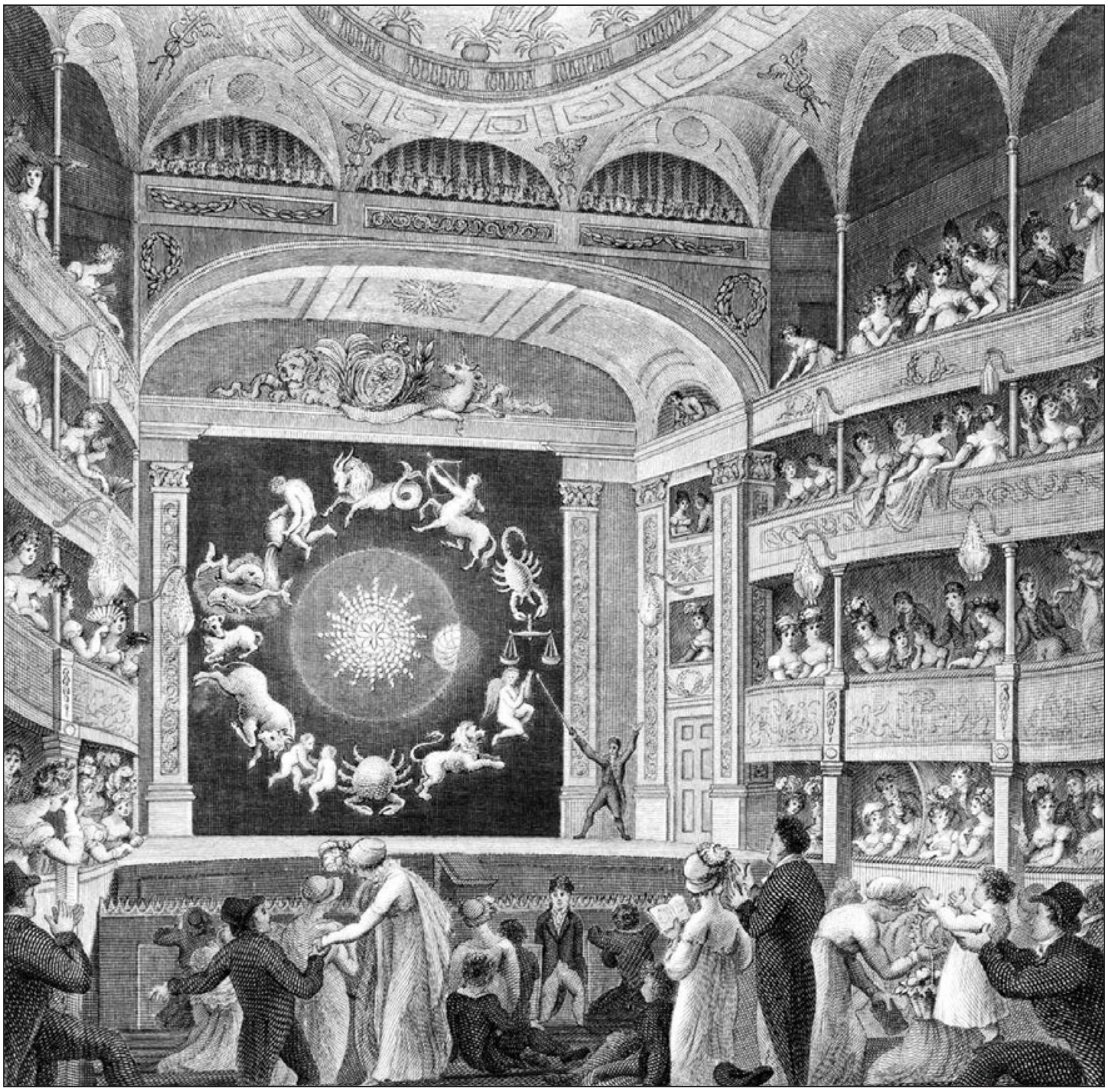
# Lecturing on a grand scale



*From the 1780s into early Victorian times audiences at theatres around Britain were entertained by astronomy lecturers who wove their talks around back-projected illustrations, the 'transparent orrery'. The leading proponent was the lecturer Adam Walker (1731–1821), who named his device the Eidouranion. His screen could produce images up to 20 ft in diameter. After his retirement the shows were continued by his sons William (1766–1816) and Deane (1778–1865). Here, Deane Walker demonstrates the orbit of the Earth around the Sun at the English Opera House in the Strand on the evening of 1817 March 21, in an engraving by James Stow. For more on popular astronomy in late Georgian and early Victorian England see page 15 of this issue. (Victoria and Albert Museum, London. Item S.176-1997)*

*COVER: Maria Mitchell (1818–89), photographed c.1880. (Schlesinger Library, Radcliffe Institute)*

# From the Editor

The Royal Park at Richmond in south-west London is a popular recreation area for cyclists, runners, and walkers. During World War II the park was taken over by the military and closed to the public. As visitors returned in 1945, among the detritus of wartime they would have seen a cabin on wheels topped with aerials resembling an elaborate clothes-dryer. This, alongside other army surplus radar sets, was Britain's first radio telescope, operated by Stanley Hey and his team of John Parsons, James Phillips, and Gordon Stewart, who had become Britain's first radio astronomers after accidentally discovering radio signals from a range of astronomical objects. Today there is no sign of the location of that historic observatory, but thanks to research by Timothy Baker we can reveal in this issue of *The Antiquarian Astronomer* its precise position, overlooked by a clump of oak trees that still stand today, bearing silent witness to where British radio astronomy began. Perhaps the site of Hey's antenna, which is now part of a sports field, deserves to be marked with a permanent memorial. Will local historians take up the challenge?

Long before Powerpoint (very long before, in fact) there was the Eidouranion, a vertical orrery devised by Adam Walker (1731–1821) capable of projecting images 20 feet wide that gave a cinematic quality to the visuals accompanying astronomical lectures in the late 18th and early 19th centuries. 'Every Planet and Satellite seems suspended in space, without any support; performing its annual and diurnal revolutions without any apparent cause,' enthused one contemporary account. 'It is certainly the nearest approach to the magnificent simplicity of nature, and to its just proportions, as to magnitude and motion, of any Orrery yet made.' Inevitably there were imitators, notably Robert Lloyd's Dioastrodoxon which also enthralled audiences at theatres around the country. On pages 15 to 27 of this issue David Bryden writes about some prominent exponents of astronomical popularization during the 18th and 19th centuries, including the owners of public observatories in the Birmingham area. On a similar theme, Kevin Johnson uncovers some forgotten English astronomers and their observatories from late Georgian times, inspired by a mystery list found in a 19th-century reference book.

Finally, our regular contributor Paul Haley rounds out this issue with a survey of the groundbreaking career of Maria Mitchell, America's first female professional astronomer and the first American to discover a comet, who rose from humble beginnings on the island of Nantucket to become the first professor of astronomy at Vassar College and director of its observatory.

**Ian Ridpath**

# About the Society for the History of Astronomy

The Society for the History of Astronomy (SHA) was formed in June 2002 with three main aims:

- To provide a forum for those with an interest in the history of astronomy and related subjects;
- To promote the history of astronomy by academics, educators, amateur astronomers, and local historians;
- To encourage research into the history of astronomy, especially by amateurs, and to facilitate its collation, interpretation, preservation, publication, and dissemination.

To implement these aims, the Society organizes regular meetings and publishes its twice-yearly *SHA Bulletin* and an annual Journal, *The Antiquarian Astronomer*. These provide opportunities to publish research by members and others into all aspects of the history of astronomy and related subjects. Because most members are amateur astronomers and amateur historians, much of their research is likely to be outside the scope of professional journals.

Papers for *The Antiquarian Astronomer* should contain original research, new interpretation, insights of material in the public domain, or bring to a wider audience material of limited availability or that is available only in dispersed locations. Papers offered to *The Antiquarian Astronomer* should not have been previously published and are subject to external peer review. Back issues of *The Antiquarian Astronomer* appear on the SAO/NASA Astrophysics Data System (ADS) two years after publication; to access them, go to http://adsabs.harvard.edu/bib_abs.html and type our official abbreviation, antas, into the box marked Journal Name/Code.

The Society also publishes a Bulletin which usually appears twice per year. The scope of the Bulletin includes, but is not necessarily limited to: news and developments in the history of astronomy, meeting reports, articles, obituaries, book reviews, and members' letters. Articles for the Bulletin can be on any aspect of the history of astronomy and are usually up to 2000 words in length. They normally do not contain significant new research (such research should be published in *The Antiquarian Astronomer*) and are not peer reviewed. Contributions for the Observatory Scrapbook series are particularly welcome; these items consist of a brief description (typically 500 words or fewer) and an illustration of some historical observatory. It is prudent to discuss contributions for the Bulletin, particularly book reviews, with the Editor(s) in advance to avoid duplication. Addresses can be found on the inside back cover of this Journal.

Timely information, particularly about forthcoming events, both SHA and other, is communicated to members via the quarterly e-News, which most members will receive by email.

# British radio astronomy's birthplace: Stanley Hey's radio observatory in Richmond Park

Timothy M. M. Baker

Stanley Hey and his group, principally John Parsons, James Phillips, and Gordon Stewart, were the pioneers of radio astronomy in Britain. In the 1940s they discovered radio emission from the Sun, detected radar echoes from meteors, and found the first discrete cosmic radio source, Cygnus A. Although their work is well documented, its importance is not as widely recognized as that of other giants of early radio astronomy such as Bernard Lovell, Martin Ryle, and Antony Hewish, even though the observatories at Jodrell Bank and Cambridge were the scientific offspring of Hey's observatory in Richmond Park, south-west London. The precise location of this observatory appears not to have been identified by historians or biographers. It seems odd, and was perhaps a consequence of the group's ambiguous military–scientific status, that the site of such a historically significant observatory should have remained obscure. This paper draws on published and unpublished sources to identify the location of Hey's observatory near Sheen Cross in the north-east corner of Richmond Park, and highlights the significance of what Hey and his team achieved there.

## 1. Stanley Hey, his group, and their unlikely career

James Stanley Hey (1909–2000) (Figure 1) was born in Nelson, Lancashire, the son of a cotton manufacturer. He graduated in physics from the University of Manchester in 1930, and obtained a master's degree in X-ray crystallography as a student of Lawrence Bragg (1890–1971). Unable to continue his research for a doctorate because of the economic depression, Hey became a schoolmaster first in Colwyn Bay in north Wales and then from 1934 at Burnley Grammar School in Lancashire.[1]

In 1940 Hey was called up for wartime service. After receiving his first training in radio science at the radar school run by the Cambridge physicist John ('Jack') Ashworth Ratcliffe (1902–87) at Elm Lodge, Richmond Road, Petersham, Surrey, Hey became a radar specialist with the Air Defence Research and Development Establishment's Operational Research Group ADRDE (ORG), headquartered at the Old Vicarage, Sudbrook Lane, Petersham, on the west side of Richmond Park in Surrey.

In January 1943 the Operational Research Group separated from ADRDE, and became the Army Operational Research Group (AORG), its headquarters moving to Ibstock Place, Clarence Lane, Roehampton, on the opposite side of Richmond Park (Figure 2), and after the War to Broadoaks, West Byfleet, Surrey.[2] But throughout the Petersham and Roehampton periods it kept a research site in Richmond Park, which became the Hey group's observatory from 1945 until the group's disbandment in 1947–48.[3]

In 1949, after the closure of the observatory, Hey was appointed head of AORG. From 1952 he was chief scientist of ADRDE at Great Malvern, Worcestershire, which soon after merged with the Telecommunications Research Establishment to become the Royal Radar Establishment (RRE). There, and at nearby Defford, he resumed his radio astronomy research, focusing on 10-cm observations and 'radio stars' (now known as radio galaxies). Hey finally obtained a DSc from Manchester University in 1950 on the strength of his 1940s work in Richmond Park, and won the Royal Astronomical Society's Eddington Medal in 1959.

He retired in 1969 to Eastbourne, Sussex, to look after his wife Edna (née Heywood), where he wrote a textbook and history of radio astronomy. He was eventually elected a Fellow of the Royal Society in 1978.

*Fig. 1: Stanley Hey (1909–2000), the first British radio astronomer. (National Radio Astronomy Observatory/Associated Universities, Inc. Archives, Papers of Woodruff T. Sullivan III, Hey file)*

1.1. *Hey's research team*

Hey's discoveries at Richmond Park were not a solo effort. He was the physicist in a group which included the following:

Sydney John Parsons (1918–92), an electrical engineer and graduate of the University of Birmingham in 1939, also the group's mechanical engineer, who joined ADRDE(ORG) in 1941; from 1948 he became a manufacturer of cathode-ray tubes with the Mullard electronics company.[4] The author was unable to trace an image of him.

Gordon Scott Stewart (1919–2003) (Figure 3), another electrical engineer and a graduate of the University of Liverpool in 1940, who joined AORG in 1941. After his time there he worked at the Royal Aircraft Establishment at Farnborough.[5]

James William Phillips (1914–2003) (Figure 4), a mathematician and graduate of East London College (now Queen Mary), University of London, and like Hey a schoolmaster before the war, at Fakenham, Norfolk, who joined the group in 1944. After his time at AORG he returned to teaching at Charterhouse and Cheltenham, then had a career in fuel research at the National Coal Board and with CSIRO in Australia.[6]

In addition there were other technicians and expert women 'computers' who calculated results, making a total of about twenty people in all.

Hey was the formal leader, but his style was collegiate. He, Parsons, Phillips, and Stewart were very much a 'band of brothers', pursuing research individually, but discussing results together and publishing them under Hey's overall supervision. For example, Phillips

*Fig. 2: Ibstock Place in Roehampton, south-west London, was the headquarters of the Army Operational Research Group, and the Hey group's office, from 1943 to 1947. It is now the home of Ibstock Place School.*
*This photograph was taken by the author in the winter of 2020/21.*

stated that he played the main role in the group's post-war survey of cosmic radio noise and the discovery of Cygnus A.[7]

The team effort is reflected in the joint authorship of papers.[8] The group was an early example of the type of multi-disciplinary research which is now common. That was perhaps its strength, but also the source of the uneasy relationship with the professional scientific community which led to its relative obscurity.

Hey's biographers noted his reticence and modesty, with 'the air of a kindly schoolmaster';[9] 'a quiet man, with an exceptional talent for innovative ideas ... an impish sense of humour ... a twinkle in his eye ... a boyish enthusiasm for all his projects'.[10] Hey even entitled his autobiography *The Secret Man*. The entry on Hey in the *Oxford Dictionary of National Biography* did not appear until 2020, twenty years after his death.[11]

There can have been few more modest scientific giants than Hey and his colleagues, but few with less to be modest about. Seventy-five years on, it is time that Hey, Parsons, Phillips, Stewart, and the site of their historic observatory, emerged from the shadows and took their rightful place in radio astronomical history.

**2. Radio astronomy before Hey**

In 1894 at the University of Liverpool, the British physicist Oliver Lodge (1851–1940) had searched for radio signals from the sky, but did so at wavelengths longer than 20 metres which are prevented from reaching the Earth by the ionosphere.[12] In this he was not alone. Similar unsuccessful attempts were made by the German astronomers Johannes Wilsing (1856–1943) and Julius Scheiner (1858–1913) at Potsdam in 1896, and by the Frenchman Charles Nordmann (1881–1940) observing at Mont Blanc in 1901.[13]

In 1931 at Bell Labs, New Jersey, while investigating static interference with radio signals at about 15 metres wavelength, the American radio engineer Karl Guthe Jansky (1905–50) discovered that part of the static was caused by a cosmic source of radio waves concentrated

*Fig. 3: Gordon Stewart (1919–2003): graduation photograph from the University of Liverpool, 1940. (University of Liverpool Library, reference D1082/1/23)*

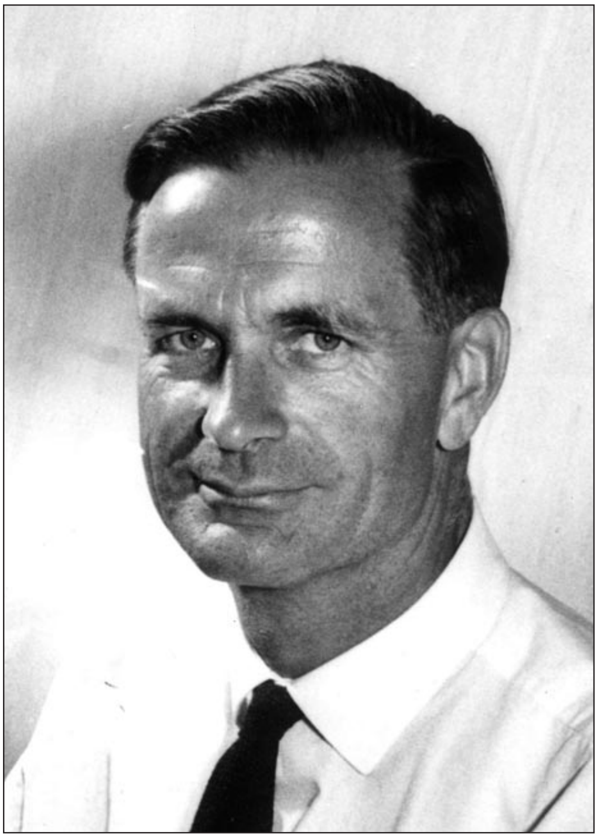


*Fig. 4: James Phillips (1914–2003). (National Radio Astronomy Observatory/Associated Universities, Inc. Archives, Papers of Woodruff T. Sullivan III, Phillips file)*

in the region of the constellation Sagittarius. Jansky speculated that the cause was charged particles of interstellar matter. Much later it was shown that Jansky's signal included the discrete source Sagittarius A, now known to be the black hole at the centre of our Galaxy. Hey thought that at these wavelengths Jansky would have discovered the radio Sun had it been active at the time.[14]

In 1937 at Wheaton, Illinois, the American electrical engineer Grote Reber (1911–2002) built the first parabolic dish, and the first observatory designed for radio astronomy, in his back yard. From 1939 he found what he termed 'cosmic static', concentrated in the plane of the Milky Way, and by 1941 mapped it, finding concentrations in Sagittarius, Cygnus, and Cassiopeia. Reber speculated that the cause was interstellar electrons.[15]

In 1935–39 at Clacton-on-Sea, Essex, the British radio enthusiast Denis William Heightman (1911–84) discovered daytime radio interference which coincided with fade-out in the ionosphere. He suspected it was caused by radiation from the Sun, but did not have the directional equipment to verify it.[16] In 1938 in Tokyo radio engineers Minoru Nakagami and Kenichi Miya (1915–2004) similarly noted interference coinciding with fade-out, which Miya suggested was caused by the Sun.[17]

## 3. The Hey group's wartime discoveries at Richmond Park

The Hey group's achievements were classic examples of scientists equipped with new instruments accidentally finding the unexpected, and having minds capable of recognizing what they were seeing.

The group mainly used the GL2 (Gun-laying Type 2) radar, originally designed to guide anti-aircraft artillery, with a wavelength of 5 metres, modifying it in various ways to meet operational and later astronomical needs. Other radar that AORG used included the powerful and accurate 10-cm GL3 radar; the American 10-cm SCR 584 radar;[18] and searchlight radar.

### 3.1. *The radio Sun, 1942*

The event that precipitated the advent of radio astronomy in Richmond Park was the Channel Dash on 1942 February 11–13. In a major tactical reverse, which *The Times* called 'the most mortifying episode in our naval history since the Dutch got inside the Thames in the seventeenth century',[19] the Germans jammed British radar to enable their heavy ships *Scharnhorst*, *Gneisenau*, and *Prinz Eugen* to escape blockade in Brest and run for Hamburg, up the English Channel and through the Strait of Dover, suffering only light damage *en route*. As part of the investigation into what went wrong, Hey was detailed to run Army J-watch (J standing for 'Jerry', the servicemen's shorthand for Germans) monitoring and researching the enemy's radar jamming. Hey regarded this job as a chore, and had no idea what it would lead to.[20]

Just two weeks later, on 1942 February 27 and 28, Hey received reports from Bristol, Derby, Dover, Great Yarmouth, Hull, London, Nevin, North Foreland, and Southampton of heavy daytime jamming at wavelengths between 4 and 8 metres. He noticed that it started at dawn, its source moved over the course of the day, following the Sun, and it stopped at sunset.[21]

A call to the Royal Observatory revealed that the interference coincided with a large sunspot which the Sun's rotation had moved into the middle of the solar disc, as seen from the Earth. Hey realized that the coincidence of the jamming source with the position of the Sun meant that the interference must be travelling at the speed of light, and thus be caused by radio waves emitted by the Sun.[22]

Hey's explanation initially encountered widespread scepticism, among others from his superior Maurice Vincent Wilkes (1913–2010), later a pioneer of computer science, and from Cambridge expert on the ionosphere, Edward Victor Appleton (1892–1965). However, AORG's well-read superintendent, Basil Ferdinand Jamieson Schonland (1896–1972), accepted it, and drew Hey's attention to Jansky's 1932 paper about cosmic radio noise.[23] Whereas Jansky and Reber had mapped regions of the sky that were active in the radio spectrum, Hey's discovery that the Sun is a radio source marked a new beginning in radio astronomy. Coming as it did from the collation of reports from across the country, it was not a discovery specific to Richmond Park, and Hey probably made it at his office in the attic of AORG headquarters at Petersham Old Vicarage.[24]

The finding was kept secret at the time, for fear that the enemy would schedule attacks to coincide with solar activity. In America, George Clark Southworth (1890–1972) discovered radio emission from the Sun, at higher frequencies, later that same year, 1942, as did Reber in 1944.[25, 26] Frances Elizabeth Somerville Alexander (1908–58) identified solar radio emissions in New Zealand in 1945, followed by Owen Bruce Slee (1924–2016) in Australia in 1945–6.[27]

3.2. *Short scatter and cosmic radio noise, 1944*

Further pioneering discoveries came in 1944, again by accident. The threat to London by this time came from V1 'doodlebug' flying bombs, and then from V2 rocket bombs. Hey sought to give warning of approaching V1s and V2s, to help direct aircraft and guns to intercept the former, and to allow alerts for the predicted impact point of the latter since they were too fast to intercept.[28]

To be able to distinguish the reflections of low-flying V1s on 10-cm GL3 gun-laying radar from 'ground clutter' reflection by buildings, Hey's group experimented by putting up screens at Richmond Park with which they were able to block the ground clutter from the Kew gasometer and Wall's sausage factory in Acton. Stewart recalled how a Richmond Park deer once got caught in the carpet of chicken wire beneath the radar which they used to screen the ground reflection, and that the Park Ranger refused to allow them to supplement their ration with it.[29]

Hey's group aimed to be able to estimate the V2s' impact point from radar analysis of their trajectories a minute before they hit, although no warning system was ever put in place. To estimate the trajectory of V2s from their launch sites in Holland, they used modified GL2 gun-laying radars along the east coast to track the missiles as they passed overhead. Pointed at an elevation of about 55°, the radars encountered 'short scatter' interference at a height of between 90 and 100km (about 60 miles), which Hey speculated, as had others in the 1930s, came from the ionized air in meteor trails.

They tried to increase the sensitivity of the GL2s' 5-m receivers with Yagi (rod) aerials to detect V2s at a greater distance from their target, but found it was impossible to do so because of the same cosmic radio interference that Jansky had discovered and Reber had mapped.

## 4. Radio astronomy in Richmond Park after the War

After Victory in Europe Hey and his group turned 'swords into plowshares' and used AORG's radars to follow up on the 1942 and 1944 discoveries.[30] Hey was finally able to publish his wartime results in 1946.[31] At this stage he was collaborating uneasily with Edward Appleton, who shortly afterwards won the Nobel Prize for Physics for his research on how radio waves propagate in the ionosphere, although he had not been active in this field since Jack Ratcliffe had taken over the Cambridge research group in 1939.

Hey was not a professional scientist or a showman, and Appleton took the limelight, so the importance of Hey's wartime discoveries was overshadowed, a process that continued as the observatories at Jodrell Bank and Cambridge developed during the late 1950s and 1960s.[32]

4.1. *The radio Sun*

In 1946 February to July, when the Sun became active again, Hey's group continued research on its radio emissions, confirming that they coincided either with sunspots or with substantial solar flares, and that they were circularly polarized. The Press visited Richmond Park on 1946 February 5 to observe and report on this work.[33]

4.2. *Meteors*

In 1945 June and July Hey's group used AORG's receivers at Richmond Park, Walmer in Kent, and Aldeburgh in Suffolk to monitor 'short scatter' simultaneously from the three locations in a patch of sky some 100 km above Maldon, Essex. The maximum signal occurred at right angles to the meteor track. The absence of correlation between the maximum signals at each of the three receivers proved their sensitivity to the direction from which they were viewed. Vertical


*Fig. 5: A composite aerial photograph of the gun site and AORG experimental site in Richmond Park, c. 1945, part of a photographic map of London prepared by the Ordnance Survey from photographs taken by the RAF, 1945–49. North is at the top. The continued presence of the gun site and the amount of wartime clutter on the Polo Field suggests a date soon after the end of the war. The inset shows the centre of the photograph in detail. The GL2 radar illustrated in Figure 6 can be seen at the end of the spur road south-east of Sheen Cross, and the oak trees beyond it to the east. (Licensed by Layers of London (2020) supported by The National Lottery Heritage Fund, under Creative Commons licence CC BY 4.0. Graphics by Brendan Blake)*

radar at Aldeburgh measured the height of the echoes at 97 km. With staff reductions as the war ended, observation continued from 1945 August at Richmond Park alone.[34]

The timing of maximum incidence of echoes at the three stations as the Earth turned, and correlation with known meteor showers – the 1945 August Perseids, the 1946 January Quadrantids, and the 1946 April Lyrids, the last confirmed by coincidence of visual observations – showed that the cause was indeed ionization of meteor paths. By comparing the maximum frequency of reflections received at Aldeburgh, Walmer, and Richmond Park, Hey and Stewart mapped the radiants of meteor showers to an accuracy of 10°. A radiant measured by radar between 1945 July 26 and 1945 August 1 at about right ascension 330° and declination −12° corresponded with the radiant of the Delta Aquariid meteor shower. Although Lovell at Jodrell Bank became a daytime meteor specialist, it was Hey and Stewart who discovered the first such daytime shower, probably the Lambda Taurids, on 1945 June 6–13, with its radiant at about right ascension 58°, declination +5°.[35] Stewart recalled that they might have missed the Eta Aquariids because of a lunch break.[36]

Like Lovell, they observed the heavy Giacobinid (now called Draconid) meteor shower of 1946 October 9. The Press was invited to visit Richmond Park on the eve of the shower, which duly delivered. Hey's group were able to measure the meteors' speed at 23 km/s.[37]

4.3. *Cosmic radio noise, Cygnus A, and a near miss*

At Richmond Park in 1945 June and July, then again with a narrower beam between 1946 February and November, Hey, Parsons, and Phillips mapped the sky at 64 MHz (about 5 metres), identifying similar variations to those Jansky and Reber had found, including the strong signal emitted from the galactic centre in Sagittarius. They used the GL2 radar, at first with two Yagi aerials, later with four, to scan the sky with a 12° elevation and 30° azimuth beam, rotating at 10° intervals over 48 great circles every 24 hours. Phillips developed mathematical techniques to improve the resolution of the scan to 2°.

One strong source caught their attention in 1946 February in the constellation Cygnus. Its intensity fluctuated quickly, within a minute, by up to 20%, which they realized must mean that it was compact.[38] They speculated the scintillation was caused by variation in the source itself, but recognized that it might be due to the medium through which the radio waves passed.

Although the variations were later shown to be caused by distortion of the signal through the Earth's atmosphere, they were right about the source's small angular size. It was later called Cygnus A, at first thought to be an intensely bright 'radio star', but later shown to be the first radio galaxy, 6,000 times as far as Sagittarius A at the centre of the Milky Way. Phillips did much of the observation, and the reduction of data, and stated that the discovery of the Cygnus source was principally his.[39]

Hey's team would no doubt have discovered the brightest extrasolar radio source, the supernova remnant Cassiopeia A, but their antenna did not allow the northernmost declinations to be observed because they were never near enough to the horizon.[40] They were planning a search of the missing region when the radio astronomical work at Richmond Park wound down.[41] Instead, the discovery went to Martin Ryle (1918–94) and Francis Graham-Smith (b. 1923) at Cambridge in 1948.

4.4. *Passing the baton: the closure and legacy of the Richmond Park observatory*

Hey's observatory continued in Richmond Park until late 1947 or 1948, when AORG moved to West Byfleet, Surrey. Electrical interference from surrounding London was already impeding observations. Phillips recalled the morning of 1946 June 24 when their observation of cosmic noise, which was aided by a balloon-borne oscillator, was jammed by the BBC's relay of the Wimbledon lawn tennis championships for the first time on television.[42] The BBC was similarly being 'wrecked' by the oscillator: the Army had been instructed to keep off the air, but no one had thought to tell the boffins in the Park.

By the time AORG was installed at its new headquarters in West Byfleet, the emerging Cold War had caused its transfer from the Ministry of Supply to the War Office, which closed down its radio astronomy before it had time to start up again.[43, 44] Richmond Park was thus active as an observatory for perhaps only two years.[45]

In 1945 Bernard Lovell, a radar veteran of the Telecommunications Research Establishment at Great Malvern, intended to use radar to look for cosmic rays. Hey predicted he would not find them, pointing Lovell towards meteors instead. Hey, Parsons, and Phillips helped him to install apparatus similar to their own at the University of Manchester, based on GL2 gun-laying radar. Hey warned that electrical interference from the trams that ran past the University would prevent any useful results.[46] This was indeed the case, and Lovell moved his observatory to Manchester's botanical research station at Jodrell Bank in rural Cheshire, where he developed the Hey group's work to map the radiants of daytime meteor showers.

Hey, and his modified GL2 radar, make a brief cameo appearance in the Central Office of Information's 1957 film *The Inquisitive Giant* about the construction of Jodrell Bank's Lovell Telescope.[47] Another visitor to Hey at Richmond Park was his old Petersham radar teacher Jack Ratcliffe, by then back at Cambridge, under whom Martin Ryle and Antony Hewish (b. 1924) established their own pioneering radio observatory.[48]

The work on southern-hemisphere meteors by the New Zealand radio astronomer Clifton Darfield Ellyett (1915–2006) at Christchurch, and by the Australian radio astronomers Leonard George Holden Huxley (1902–88) and William Graham Elford (1926–2017) at Adelaide, was suggested by Lovell. At Sydney, Joseph Lade Pawsey (1908–62) began radio astronomy studies with observation of the Sun, building in particular on Elizabeth Alexander's 1945 observations in New Zealand as well as those of Hey, and of discrete cosmic sources. At Sydney and in New Zealand John Gatenby Bolton (1922–93), Gordon James Stanley (1921–2001), and Bruce Slee followed up the Hey group's discovery of Cygnus A, proving it to be a discrete source, and using sea interferometry to discover other 'radio stars'. Thus the work of Hey's group was a forerunner of the early development of radio astronomy in Australia too.[49]

Parsons, Phillips, and Stewart left the Army and went to civilian jobs. Hey alone continued in a scientific career. From 1952 he re-established his observatory at Great Malvern, Worcestershire, and at nearby Defford, in what became the Royal Radar Establishment. There he made observations at 10-cm wavelength; built a two-element variable-spacing radio interferometer with a 1-km baseline, which briefly parallelled Martin Ryle's similar work at Cambridge[50] and became part of Jodrell Bank's country-wide Multi-Element Radio-Linked Interferometer Network (MERLIN); and continued research on 'radio stars'. But none of Hey's later work quite matched his and his group's spectacular discoveries of the 1940s at Richmond Park.[51]

## 5. The location of Hey's radio observatory

Having made the first discoveries of specific astronomical radio sources – the Sun, meteors, and Cygnus A – AORG's Richmond Park radar, with the outstations at Aldeburgh and Walmer, thus fortuitously became the first British radio observatory. But where exactly was it?

Richmond Park is a big place, covering some 2,400 acres, and was stuffed with military installations during World War II, during which it was closed to the public.[52] In a paper published in *Proceedings of the Royal Society* in 1948, Hey, Parsons, and Phillips reported the observatory's latitude and longitude, but apparently to an accuracy of only 5 minutes of arc, describing it as 'near London' at 51° 25′ N, 0° 15′ W.[53] This precise location is well outside Richmond Park, near the junction of Coombe Lane and the Kingston bypass. The area within a 2 minutes 30 seconds margin of error north and west from there covers almost the whole of Richmond Park, north as far as the Sheen Gate, and west as far Petersham Park. Three sites in Richmond Park were associated with ADRDE(ORG) and AORG, as follows.

### 5.1. *Petersham Park*

The Radar School at Petersham had radar sets in the grounds of the Old Vicarage, on the golf course at Sudbrook Park, and also in adjacent Petersham Park (which is part of Richmond Park), at the bottom of the scarp slope of Richmond Hill.[54] While adequate for training, this west-facing site, screened by the hill to the east, would have been poorly positioned for operational and research radar.

### 5.2. *The Anti-Aircraft gun site at Sheen Gate*

The location of operational radar was near the ZS20 (Zone Southern 20) Heavy Anti-Aircraft battery, which occupied an 18-acre site just inside the Sheen Gate on the northern boundary of the Park. The battery operated 3.7-inch guns, manned until mid-1941 by 333rd HAA Battery, Royal Artillery, and thereafter by 490 AA Battery, Royal Artillery, famous for being the first mixed battery, with ATS women operating the range-finders and predictors. Winston Churchill had visited it on 1940 October 10: 'This exhilarates me – the sound of these cannon gives me a tremendous feeling', he characteristically observed.[55]

The battery is visible at the top of a 1944 aerial photograph of Richmond Park in the National Monuments Record.[56] It appears on the edge of the photograph as a pair of circular entrenchments on the hilltop to the west of the road from Sheen Gate to Sheen Cross. It also appears on the 1945–49 RAF aerial photograph on Historic England's Institute of Historical Research's 'Layers of London' website (Figure 5).[57] It is a fine, open site, with a good view to the east and south. Its GL2 gun-laying radar would have been nearby, communicating with the guns and with a similarly open view of the approaching enemy.

David Catford, a local historian of Mortlake, near Richmond, referred in an unpublished radar history of the area to AORG having a radar site 'opposite the gun-site near Sheen Gate'.[58] The 1944 aerial photograph shows several works in the vicinity of the guns which might be radar installations, although it does not have enough resolution to identify them as such.[59]

### 5.3. *The Polo Field at Sheen Cross*

Catford states that AORG also had a site referred to as the Gun-Site Operations Section on the Polo Field, in the valley bottom south-east of Sheen Cross, a few hundred yards from the gun site. It was used before the war by the Ham Polo Club and for rugby football, and rugby pitches still cover it today.[60]

As at the gun site, the 1944 aerial photograph shows what might be radar installations on the Polo Field.[61] The 1945–49 RAF aerial photograph shows more detail, including shadows: the field is peppered with vehicles, some of which may be mobile radar sets.[62] A photograph in a 1945 AORG report on the ground clutter screening experiments includes a photograph of one of the experimental screens looking southwards across the Polo Field.[63]

### 5.4. *Hey's description of the radar*

In his autobiography, Hey made clear the association between the gun site and his experimental work:

> In the park we had radar equipment and there was also an operational A.A. gun site, the park itself being closed to public access. … The GL2 radar was by now installed on A.A. gun sites to detect and track enemy aircraft. The data on distance and direction were then fed into a predictor to determine the likely future position of the aircraft so that A.A. shells would be fired to intercept the aircraft's flight … I recall one morning when … I went into Richmond Park for some experiment on our G.L. equipment. Suddenly a dispatch rider appeared – I was wanted urgently at the War Office.[64]

Hey also described his experiments using the high-definition GL3 10-cm gun-laying radar to detect low-flying (1,000 ft) V1 bombs by distinguishing them from the 'ground clutter' reflections from features on the ground. This is the work in which he was able to use wire mesh to screen the reflection from the gasometer and the sausage factory.[65]

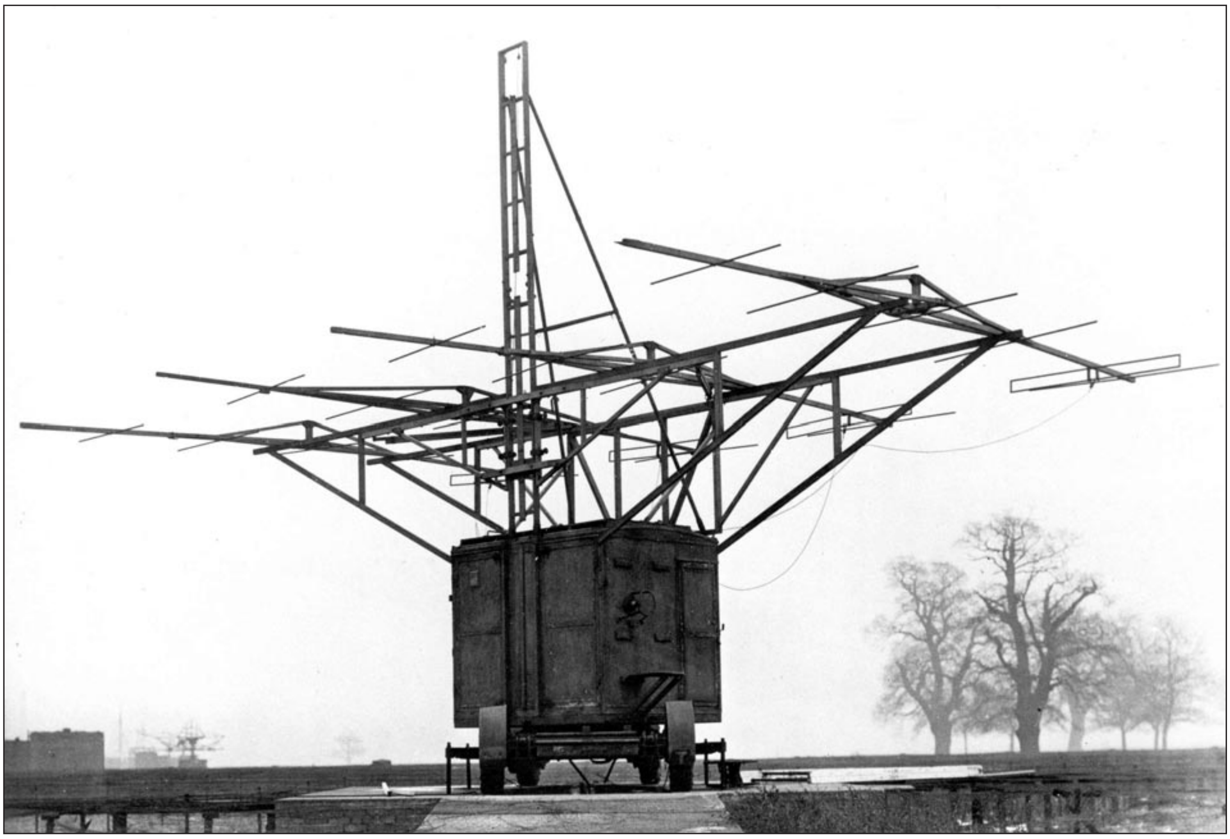


*Fig. 6: The first British radio observatory: the Hey group's modified GL2 radar, which they used to survey the sky for cosmic radio noise, and to discover Cygnus A, on the Polo Field in Richmond Park, looking east, probably in the winter of 1945–46 or 1946–47. Most of the trees in the background to the right are still there, including the two large oaks on the left of the clump (see Figure 7, opposite). The third large tree, the rightmost of the three, has since disappeared. (National Radio Astronomy Observatory/Associated Universities, Inc. Archives, Papers of Woodruff T. Sullivan III, Cosmic Noise)*

5.5. *Hey's photograph of the antenna*

GL2 and GL3 sets were mobile, like much radar equipment, including the Army surplus equipment that Hey and Parsons drove to Manchester, and which Bernard Lovell then moved to Jodrell Bank. Hey's group may well have used different radar sets at different locations for different observations, and it is possible that they did operational research work at both the Sheen Gate and the Polo Field sites. However, other photographic evidence locates the radar with which they made their 1945–46 cosmic noise survey specifically on the Polo Field. Phillips stated that the same site was used for other work as well, including for training as early as 1941, and possibly for all of the 1945–47 radio astronomical observations. Phillips said that the meteor work was done with a directional array mounted on a searchlight chassis on the same site.[66]

In their 1948 paper in *Proceedings of the Royal Society*, Hey, Parsons, and Phillips published a photograph of the antenna with which they surveyed the cosmic radio signals and discovered Cygnus A (Figure 6).[67] It is a modified GL2 radar, a van-sized rotatable wheeled cabin supporting a splendid array of four Yagi aerials spanning some 10 metres (33 ft). Hey republished the photograph in his book *The Evolution of Radio Astronomy*.[68] It also appeared on the cover of Woodruff Sullivan's *Cosmic Noise: A History of Early Radio Astronomy*.[69]

Out of the mist in the background of this wintry photograph, amidst a clump of smaller trees, loom two leafless ancient Richmond Park oaks. These trees are still there today, the detail of their branches changed by 75 years of growth, but their overall profile still recognizable (Figure 7).[70] The site and configuration corresponds exactly to an approach road, with what must be the GL2 radar indistinctly at its end, shown in the 1944 and 1945 aerial photographs.

The RAF aerial photograph on Historic England's Layers of London website shows what must be the radar, and its shadow, on this site.[71] As noted above, the 1945 RAF aerial photograph shows quite a number of vehicles scattered across the Polo Field, several of which presumably represent other radar sets which AORG used, some of which may also have been used for radio astronomy. Hey's own photograph shows a second radar set dimly visible in the distance. John Fielding, a radio historian, stated that Hey had several GL radars in various states of modification at his disposal, and that the Richmond Park site had more than one in use.[72]

But the GL2 radar is the one that Hey's photograph

*Fig. 7: The site of the first British radio observatory 75 years on, photographed by the author in the winter of 2020/21: the Polo Field in Richmond Park, looking east, viewed from the same spot as Figure 6. The two large oak trees in the distance at the right of Figure 6 have grown and lost some branches since the 1940s, but are recognizably the same.*

attests. Mute witnesses to radio astronomical history, the two oaks in the photograph stand just to the south of the Polo Field, behind the second and third rugby grounds to the east of the road from Sheen Cross up to White Lodge.[73]

This photographic evidence places Hey's observatory at about the southern 22-metre line of the first rugby ground, in front of the goal, at Ordnance Survey grid reference TQ206738. GPS puts the coordinates at 51° 27′ 3″ N, 0° 15′ 59″ W, well within Hey's margin of error. Phillips's statement that the observatory was at Roehampton is also consistent, since the site is close to Richmond Park's Roehampton Gate and Ibstock Place just outside it.[74]

After the war, and the closure of the observatory in 1948, the entrenchments of the gun battery and the hard standing there and on the Polo Field were levelled with the grass. Nothing beside remains – except the oaks and, of course, the sky – to tell that here radio astronomy began.

## 6. Conclusion

Stanley Hey's Radio Observatory is here identified as on the Polo Field south-east of Sheen Cross at Ordnance Survey grid reference TQ206738, and perhaps during the war also by the gun site up the hill towards Sheen Gate near TQ204742. It was a site of great importance in the history of radio astronomy, supported by AORG's headquarters at, successively, Petersham Old Vicarage; Ibstock Place, Roehampton; and Broadoaks, West Byfleet, Surrey; plus other AORG sites on the east coast.

1. Its astronomical work began quite unexpectedly, but it became the first radio observatory in Britain.
2. It was only the third radio observatory in the world, after those of Jansky and Reber.
3. Hey accidentally discovered the Sun as a radio source by collating jamming reports, probably at Petersham Old Vicarage, and correlating them with a sunspot. This was the first identification of a radio-astronomical object. Hey's group later identified at Richmond Park the coincidence of solar radio noise with solar flares as well as sunspots.
4. Hey's group accidentally discovered 'short scatter' by collating radar reports, probably at Ibstock Place Roehampton, which they speculated and later showed, at Richmond Park, Aldeburgh, and Walmer, were the radio trace of meteors. Hey's group used observations from Richmond Park to map the first daytime meteor shower radiant, and to record meteor speeds. This was

the second identification of radio-astronomical objects.

5. Hey's group rediscovered, at Richmond Park and elsewhere, the cosmic radio noise that Jansky had found and Reber had mapped. Hey's group remapped it at 5-m wavelength at the Polo Field in Richmond Park.

6. Hey and Phillips identified from the scintillation of a bright radio source in Cygnus that it must be a compact and distant object. Apart from Jansky's recording of the signal from Sagittarius A, this was the first identification of a discrete radio source beyond the Solar System. It proved to be the first discovery of a specific extra-galactic radio source, and the first discovery of a radio galaxy (before it was even known what they were). The group was probably close to discovering the Cassiopeia A supernova remnant as well when the AORG observatory was closed down.

7. The Hey group's work preceded, and influenced the activities of, two other great British radio observatories, at Jodrell Bank (since 2019 Britain's newest UNESCO World Heritage Site) and at Cambridge. It also influenced the development of radio astronomy in its other early great centre in Australia.

8. Although Hey and his group were not the first radio astronomers, cumulatively their achievements, particularly the way in which they related astronomical radio noise with optically identified objects, and their influence on the development of other more enduring observatories, arguably marked the beginning of radio astronomy as a separate discipline.

This is a remarkable tally of achievements for a group of schoolmasters and electrical engineers without doctorates or astronomical training, some of whom never intended to get into radio, who did not (except Hey himself) really regard themselves as scientists, and made many of their great discoveries fortuitously and in the middle of a desperate war. Nor was it bad for an observatory which existed for at most seven years, and was actually looking for astronomical objects for only two of those years.

These achievements are a demonstration not only of the often serendipitous nature of scientific discovery, but also of how the technological demands of war and the new instruments it generates accelerate it. Let the last word go to the American astronomer and historian Woodruff Sullivan: 'If one were to name a single person who most influenced the course of early postwar radio astronomy, it would be … Stanley Hey'.[75]

**Acknowledgements**

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3. This paper refers to Hey's equipment in Richmond Park as an 'observatory'. In the 1940s the word 'observatory' was restricted to places where traditional optical astronomy was done. The term 'radio observatory' was not used until 1950, and only rarely before the mid-1950s. This paper takes the view that the importance of Hey's apparatus to the origin or radio astronomy is such that describing it as an observatory is appropriate, despite the anachronism. See Sullivan, W. T., *Cosmic Noise: A History of Early Radio Astronomy* (CUP, 2009), p. 425, for a detailed account of the use of the term. AORG moved out of Ibstock Place in July 1947 (personal communication from Angela Platt, archivist of Ibstock Place School, 2021).
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Hey, J. S., Parsons, S. J., and Phillips, J. W., 'Fluctuations in cosmic radiation at radio frequencies', *Nature*, 158 (1946), p. 234;

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73. A third large tree, visible beyond and just to the right of the pair in Hey's photograph, and also shown in the RAF aerial photograph, has since disappeared.
74. NRAO/AUI Archives, Sullivan Papers, Sullivan interview of Phillips, 1978 August 31.
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**The author**

Timothy Baker graduated in English language and literature from Corpus Christi College, Oxford, in 1982. He spent most of his professional career in financial services policy and regulation in the City of London and now works in London and Oxford as a researcher and writer on local history and the history of science. He came across the mystery of Stanley Hey's 'lost' radio observatory in Richmond Park while conducting wider-ranging research on the scientific history of London.

# Popular practical astronomy in late Georgian and early Victorian Birmingham

David J. Bryden

For over a year from 1835 October John Gill, dealer in coals, opened his Birmingham premises at Snowhill Wharf to give public access to his telescopes to view Halley's Comet and other astronomical phenomena on a pay-as-you-view basis. Similar paid observation of the heavens was later provided at the Handsworth Observatory, Heathfield Road, established by Joseph Bembridge in 1838. It moved closer to the centre of Birmingham in the early 1840s and operated in total for nearly a decade. In this paper these two attempts to provide Birmingham residents with an opportunity to view, at a price, the wonders of the heavens are outlined in the context of an interplay between popular science, public entertainment, and income generation.

## 1. Popular astronomy in Birmingham

From the later decades of the 17th century, popular expositions of science through lecture demonstrations were a regular feature of London life, and spread into the rest of the country during the 18th century.[1] Birmingham, in particular, was on the route of many itinerant scientific lecturers.

Among the more flamboyant was the inventor and science popularizer Adam Walker (1731–1821), who in 1781 illustrated an astronomy lecture in the Birmingham New Theatre with a giant transparent orrery of his own devising called the Eidouranion, an impressive-sounding name derived from the Greek words meaning a view or image of the heavens.[2] (Figure 1). During the early part of the 19th century his youngest son Deane Franklin Walker (1778–1865) and a noted competitor, Robert Evans Lloyd (c.1755–1838), routinely visited Birmingham, offering a short series of astronomy lectures which they illustrated with such large transparent orreries.[3]

The introduction to Lloyd's printed syllabus indicates that his standard three-lecture course would not deal with 'scientific' astronomy, for which knowledge of mathematics was required, but would instead communicate to the public 'the results of astronomical observations and calculations in a plain, familiar and popular language'. To that end he had a massive visual aid he called the Dioastrodoxon, a 'grand transparent orrery, the largest and most magnificent in the British Empire', built to his specification and costing 'upwards of 500 guineas'. At 21 feet (6.4 m) in diameter, this quasi-mechanical model of the Solar System with a series of back-illuminated drops assisted in providing 'an explanation of the various objects which it will present to the eye, to aid the imagination in forming clear conceptions of astonishing phenomena existing in nature'.[4]

Advertising his 1833 April Birmingham lecture series to be given in the Theatre Royal, Lloyd indicated:

> The Course will introduce all the splendid Scenery usually displayed in London.
>
> By this CELESTIAL MENTOR the Tyro is pleasingly and familiarly instructed: the Gentlemen and the Scholars are presented with a grateful medium of refreshing their memories by a sublime and interesting volume of the most elegant and refined amusement; and the Man of Business relieved from the tedium of abstruse study, traverses with ease and pleasure the Solar Walk, and as he contemplates with astonishment and admiration the countless millions of stars (suns) that illumine the Milky Way, he sees Omni science in every star, *feels a Godhead reigns*! [5]

### 1.1. *Press coverage of Halley's Comet 1835*

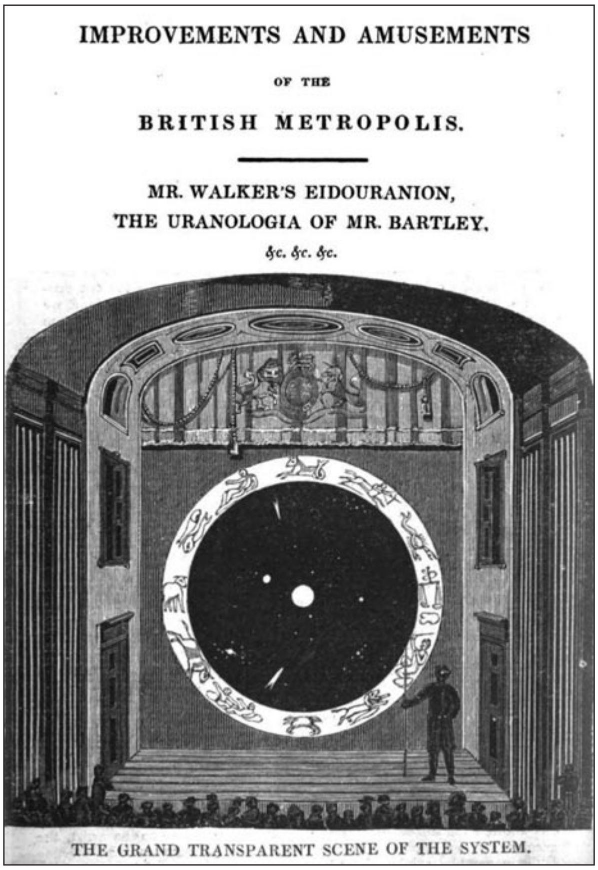
For centuries, annual almanacs had kept the general public informed of forthcoming astronomical phenomena.[6] Astrology still had sufficient adherents for newspaper and magazines to print prognostications, but rationality was pushing such mumbo-jumbo aside. By the 19th century predictions of future astronomical events free of astrological interpretations were widely accessible in annual publications such as *Time's Telescope* (an almanac for astronomers and naturalists)[7] and *Temporis Calendarium*.[8]

Throughout the 1820s and 1830s and beyond, the Birmingham press included short notices informing readers about forthcoming astronomical happenings, with subsequent reports of what had been seen.[9] The passage of comets was considered of particular public interest.

The 1832 edition of *Time's Telescope* gave extensive coverage to comets, drawing particular attention to the return of Halley's Comet in late 1835.[10] The London press summarized the pamphlet on Halley's Comet written by the Austrian astronomer Karl Ludwig von Littrow (1811–77), and provincial papers picked up and repeated the translation.[11]

A long article on comets in the *Edinburgh Review* in 1835 by the Irish popularizer of science Dionysius Lardner (1793–1859) was mined by some provincial journalists.[12] In addition there were other accounts, both specialist and aimed at the general reader.[13] The popular eight-page exposition *Gilbert's Guide to and History of Halley's Comet* cost 1½d and ran to at least four editions, while Archer's coloured *Map of the Heavens shewing the path of Halley's Comet* sold for sixpence. Both were stocked by at least one Birmingham outlet, and advertised widely across the region.[14]

*Fig. 1: The Eidouranion, a vertical transparent orrery large enough to display on a theatre stage, was invented by Adam Walker c.1781 and was used by him and others to illustrate lectures on astronomy. Here the actor George Bartley (c.1782–1858) delivers a lecture called Ouranologia by the playwright Samuel James Arnold (1774–1852) against a backdrop of the Solar System projected by the Eidouranion. From the guidebook London Lions for Country Cousins and Friends About Town (1826).*




Midland newspapers provided details of the comet, reprinting parts of a letter from William Rogerson (1797–1853) of the Royal Observatory Greenwich to the itinerant Wesleyan minister Hugh Beech (1787–1856), then at Birstall, Leicestershire. This was in 1835 June even before any telescopic sightings had been made.[15] The handbill for a lecture on Halley's Comet held at the Birmingham Philosophical Institution on August 12 was illustrated by a chart of the expected path from that date to the end of September, by when the comet was expected to be visible to the naked eye.[16] (Figure 2).

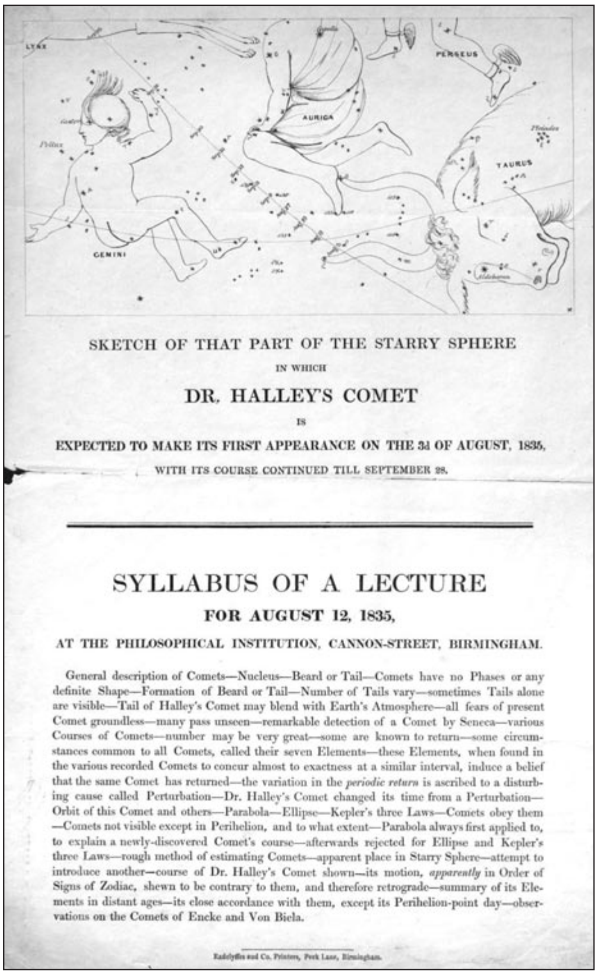
James Gargory (c.1804–1881), an enterprising Birmingham instrument-maker, advertised in mid-August 1835: 'THE COMET | ACHROMATIC TELESCOPES, for viewing the above Phenomenon in the Heavens, from One Guinea upwards.'[17] The same issue of the *Journal*, following the London press, mined the article on Halley's Comet from the *Edinburgh Review*, while the *Gazette* reprinted a piece from the London-based *County Chronicle*, provided details of the time of rising of the comet on a weekly basis from mid August to late September, with its coordinates in right ascension and declination.[18]

In late August, a correspondent to London newspapers updated earlier reports about when Halley's comet might first be seen by the naked eye, indicating that it should be seen from the 28th of the following month. Sloppy sub-editing by the *Journal*, which reprinted the story in September, contradicted earlier local newspaper coverage, for it left readers to presume that the first naked-eye view would be on October 28.[19] This was corrected in mid October:

> Halley's Comet is now visible to the naked eye; its appearance is that of a dull star of the second magnitude. It is now in *Bootes*. It will not be visible many days without the aid of telescopes.[20]

## 2. John Gill's telescopes at Snowhill Wharf 1835–6

However entertaining and theatrical the spectacle to the non-specialist, those with experience of practical astronomy would consider the illustrated lectures a poor substitute for direct observation. Well-worn programmes with set scripts were ill-suited to explaining the specifics of forthcoming events in the heavens, particularly something as important as the return of Halley's Comet. That certainly appears to have been the opinion of one Birmingham amateur astronomer, who in the mid-1830s saw a commercial opportunity in providing the public with telescopic access to the heavens. That man was John Gill (1777–1836), who first appears in a Birmingham street directory in 1818 trading as a coal dealer at Old Wharf, Paradise Street.[21]




SKETCH OF THAT PART OF THE STARRY SPHERE

IN WHICH

DR. HALLEY'S COMET

IS

EXPECTED TO MAKE ITS FIRST APPEARANCE ON THE 3d OF AUGUST, 1835,

WITH ITS COURSE CONTINUED TILL SEPTEMBER 28.

SYLLABUS OF A LECTURE

FOR AUGUST 12, 1835,

AT THE PHILOSOPHICAL INSTITUTION, CANNON-STREET, BIRMINGHAM.

General description of Comets—Nucleus—Beard or Tail—Comets have no Phases or any definite Shape—Formation of Beard or Tail—Number of Tails vary—sometimes Tails alone are visible—Tail of Halley's Comet may blend with Earth's Atmosphere—all fears of present Comet groundless—many pass unseen—remarkable detection of a Comet by Seneca—various Courses of Comets—number may be very great—some are known to return—some circumstances common to all Comets, called their seven Elements—these Elements, when found in the various recorded Comets to concur almost to exactness at a similar interval, induce a belief that the same Comet has returned—the variation in the *periodic return* is ascribed to a disturbing cause called Perturbation—Dr. Halley's Comet changed its time from a Perturbation—Orbit of this Comet and others—Parabola—Ellipse—Kepler's three Laws—Comets obey them —Comets not visible except in Perihelion, and to what extent—Parabola always first applied to, to explain a newly-discovered Comet's course—afterwards rejected for Ellipse and Kepler's three Laws—rough method of estimating Comets—apparent place in Starry Sphere—attempt to introduce another—course of Dr. Halley's Comet shown—its motion, *apparently* in Order of Signs of Zodiac, shewn to be contrary to them, and therefore retrograde—summary of its Elements in distant ages—its close accordance with them, except its Perihelion-point day—observations on the Comets of Encke and Von Biela.

*Fig. 2: Handbill for a lecture on Halley's Comet at the Birmingham Philosophical Institution in 1835, illustrated by a chart of the comet's path. The name of the lecturer was not given. (University of Oxford: History of Science Museum: Inv. No. 14012)*

When Gill advertised the 1817 opening of his retail outlet on Paradise Street, he indicated that he had been selling Tipton coal wholesale in Birmingham for 'nearly two years'.[22] He traded as John Gill & Co. from late 1820, having taken over the business and premises of a coal and coke merchant.[23] A decade later he was operating as a general wharfinger and dealer in coal and bricks, warehousing grain, a carrier for goods on the canal network, and leasing barges for carrying coal, based at the new wharfs at Snowhill.[24] The business even hired out covered wagons at 2s 6d per hour for those moving house.[25]

No matter how keen an amateur observer of the heavens he might have been, Gill was still a businessman. In 1835 October he purchased space in the columns of the *Gazette* for a long advertisement aimed at a public that by now had an increasing awareness of Halley's Comet. It was headed: 'HALLEY'S COMET may now be VIEWED through powerful NEWTONIAN and ACHROMATIC TELESCOPES, from two to five feet long, at the SNOW-HILL WHARFS, BIRMINGHAM, every fine evening after seven o'clock (Sundays excepted).' [26]

Gill was open about his own status. He claimed 'no pretension to deep knowledge in the sublime Science of Astronomy; but having the means, he is willing to exhibit to all.' This was not an open-ended invitation – there would be charges. Those with experience of telescopes could use all or any of the four telescopes for an hour for a shilling. 'From Ladies, Gentlemen, and respectable Tradesmen, Silver will be expected to view the Comet, Planets and Nebulæ; for all other objects, Three Pence each object. And from Mechanics, Three Pence the Comet and Planets, and all other objects, Two Pence each.'

The advertisement indicates that for at least the previous six months Gill had been observing and sketching spots on the Sun, claiming to have recorded 465, 'the smallest of which is stated to be larger than our globe'. His telescopes were also available for sunspot observing during the day.

2.1. *Observing other astronomical phenomena*

What Gill could not anticipate was that the return of Halley's Comet in 1835 was a relatively insignificant spectacle. It was faint, and the 'tail' was uninteresting. As the *Journal* had noted on October 17 it was like 'a dull star of the second magnitude'. Close to the horizon, and in Birmingham visible only in the early evening, it was not a crowd puller.

Gill speedily adjusted his advertising copy: 'As the Comet will not be distinctly seen after eight o'clock in the Evening, the Telescopes will be turned upon Clusters of Stars and Double Stars till ten, and after that hour upon the Planet Jupiter with his four Moons.' [27] Late in December the hour of closing was brought forward from midnight to eleven. As a memento for visitors, and as 'a pleasing monitory chimney-piece ornament', selling for six pence at the Wharf and 'at all respectable Stationers and Opticians in Birmingham and neighbouring towns', Gill published an illustrated card, which he described in detail in an advertisement, which also gave an adjusted price scale for viewing.[28] (Figure 3).

Gill indicated that astronomically speaking 1836 May would be a particularly interesting month. Firstly there was to be a large partial eclipse of the Sun on the afternoon of May 15, but as it would occur on a Sunday he indicated that admission would be restricted to those who had previously purchased the illustrated card, and then only 'for a few minutes'. As a strict Sabbatarian he added 'No cards given at the *Gates*, nor money received for *that* DAY'.[29]

Generally, the Birmingham populace could have been alerted to this eclipse, and the fact that the town was relatively close to centrality, by a map of Britain showing the expected track published in an almanac for 1836 that was advertised late in 1835.[30] The *Journal*, outlining Astronomical Occurrences for May 1836, noted that 'On the 15th, the Sun will be eclipsed nearly total [the obscuration from Birmingham was actually 84%], commencing at 2 – ending at 4½ o'clock, after[noon].' [31]

In 1836 April a Buckinghamshire vicar, William Fletcher (1794–1858), published a 40-page booklet aimed at children, including 'a moveable Diagram representing the great annular Eclipse of the 15th of May of the present year'. It was advertised in the Birmingham press just prior to the eclipse and proved popular enough for an immediate second edition.[32]

Gill had also thought ahead. From William Rogerson he commissioned a set of drawings illustrating the appearance of the eclipse as it would be seen at Birmingham. Rogerson was compiler of the annual almanac *Temporis Calendarium* and from 1825 until his death in 1853 an assistant astronomer at Greenwich Observatory. The sketches were passed to the *Journal* and used to illustrate an article that opened by indicating that this eclipse would be the greatest visible in England since 1764. This piece closed with advice on how to view the eclipse without injuring the eyes – using coloured shades as provided for octants and sextants, or 'by smoking a piece of common window glass over the flame of a candle'.[33] Although Birmingham was not in the zone of totality, it was considered likely that it would become sufficiently dark for both Venus and Jupiter to be observed.

The *Gazette* confirmed that that had indeed been the case when it printed a brief report of the eclipse:

> The state of the atmosphere was exceedingly favourable for observation, and the planet Venus was visible to many with the naked eye from three o'clock until twenty minutes past … Mr Gill of Snow-hill wharf, kindly permitted several ladies and gentlemen to view the phenomenon through his powerful telescopes, and they were thus enabled to watch the successive obscuration of the different clusters of spots upon the sun's disc, and to observe them again gradually emerging from darkness … Diagrams were drawn during the different stages containing the spots, and may be viewed on application to Mr. Gill.[34]

Gill continued to drum up customers, reminding readers of the *Gazette* that the evenings of May 17 to 20 would be of particular interest with emersions of Jupiter's fourth moon on May 18, a conjunction of the Moon, Venus, and Jupiter on the following evening, and on May 27 a conjunction of Saturn and the Moon. In addition, Mercury would be visible from May 29 to June 6.

### 2.2. *Growing numbers, more telescopes*

Expecting greater numbers of 'Persons, Families and Schools' he indicated that there would be no cheap admission to view a single object, with all customers expected to pay for an hour of guided viewing. The equipment available had been enlarged: 'There are seven telescopes at this Establishment, several of them of the finest manufacture by Dollond.' The engraving that he had printed late in 1835 was reissued in an

**TO THE PUBLIC**

THE EXHIBITION of the powerful Newtonian and Achromatic TELESCOPES, from two to five feet long, will be permanently continued at the SNOW-HILL WHARFS, Birmingham, for viewing the Heavenly Bodies, every fine Evening until eleven o'clock (Sundays excepted). For further particulars, and the very interesting Appearances of the Heavenly Bodies, the Proprietor respectfully refers to a Card Engraving, now published, and may be had at all respectable Stationers and Opticians in Birmingham and neighbouring towns, and at the Office, Snowhill Wharfs, where every explanation of the Engraving will be given, and Orders promptly attended to from the country, price 6d.

The Engraving exhibits the Sun's Disc with eighty spots; Full Moon eclipsing Saturn; Jupiter and his four Moons; Planet Saturn and Rings; a singular appearance of the Moon as seen Aug.19, 1835; the Comet of 1811, and 1835 as seen Oct. 19, eight P.M.; Diagram of Nebulæ in Orion; the Planets Herschel, Venus, Mars, and Mercury; and three Telescopes. On the back of the Card, the interesting appearances of Jupiter's four Moons for three months to come. The whole of which literally confirm the declaration of Psalm xix. ver.1. "The heavens declare the glory of God, and the firmament sheweth his handy-work;" and may be considered a pleasing chimney-piece ornament.

The Proprietor is sorry there is no particular phenomena this month to notice, but the Planet Jupiter and his Moons and our Moon in a few days will be sublime objects early in the evenings, if fine. Saturn and Ring seen at seven o'clock in the morning, and Venus next month. Every fine evening the Nebulæ in Orion and Clusters in Taurus, Cancer, and Cassiope will be brilliant.

The Eclipses of Jupiter's Moons this month are – first, 23d and 29th; second, 22d and 29th; third 24th and 31st.

Terms of admission: – Ladies and Gentlemen may exercise on all the Telescopes for one hour, and have all the objects pointed out to them they please for 1s. For views of single objects – Jupiter and Moons, 3d.; Saturn and Rings, 3d.; Venus 3d.; Mercury, 3d.; the Moon, 3d.; Double Stars, Clusters, Nebulæ, and Milky Way, 2d. each.

The whole of the Telescopes, 21-inch Globes, Orrery, Maps, Books, &c. may be examined any time of the day by Ladies and Gentlemen, for 6d. each.

Any Gentleman having a very powerful Telescope to part with may apply (post paid).

*** Instruments proved and cleaned on reasonable terms.

*Fig. 3: John Gill's advertisement for the Snowhill Wharf telescopes, from the columns of Aris's Birmingham Gazette, 1835 December 21, transcribed by the author.*

amended form 'on which is exhibited the very interesting positions and appearances of the Heavenly Bodies for this month, Jupiter's Satellites for three months, Venus for four months, and the Sun in Eclipse'.[35]

No copy of these keepsakes appears to have survived, but some of the individual woodcut blocks were reused to illustrate subsequent articles in the *Journal*. The relative positions of the Moon, Venus, Jupiter and its moons, and Saturn on May 21 and 27 appeared in successive weeks.[36] However good the original drawings, the blocks do not appear to have been suitable for newspaper work, and the images quality did not reflect the editorial comment that 'The exceeding beauty and clearness of the atmosphere for some time past, and admirable qualities of Mr. Gill's telescopes, have rendered Snow-hill quite a fashionable evening resort; and certainly no *soirées*, that we know of, can be more replete with innocent pleasure than those where the queens of chastity and love are the presiding powers, and beneficence and gravity the attendant divinities.'[37]

The combination of advertising and news stories caused an increase in numbers, requiring Gill to restructure charging and visitor management. At the end of May it cost 3d to view sunspots during the day and the same to view Saturn and his rings in the evenings. Otherwise single views of the Moon, Venus, Jupiter, double stars, clusters, or the Milky Way would cost 2d (two pence) 'to be paid on entering and receiving tickets'. For a whole evening, with multiple opportunities and expert guidance, the cost remained a shilling per person; children, with family or in school groups, were charged 6d.

The viewing yard was compartmentalized with the single viewers separated from those paying for 'the entire evening's round of views'. Furthermore, as two telescopes had been damaged: 'no person unacquainted with the use and management of telescopes, especially the Newtonian in its rack work, will be permitted to regulate the Telescopes, attendance always being on hand.'

In an attempt to cope with the perpetual problem for venues offering evening entertainment, those 'in a state of intoxication' would be refused entry, while behaviour 'in an improper manner' would result in a request to leave.[38] Given that he was running a coal wharf, Gill probably had burly employees on hand to ensure that such requests were met.

In June he announced that he had added to his instrument collection 'one of Mr. DOLLOND'S BEST FIVE FEET Achromatic Telescopes; being determined that the public of Birmingham shall have the best means of viewing the heavenly bodies within their reach and on the most *liberal terms* … this one Telescope alone having cost £125; a *better*, of its length and aperture, cannot be procured for gold'.[39]

If Gill was not guilty of a degree of hype then he must have commissioned a special mounting, for Dollond's 1829 price list for an achromatic telescope of five feet focal length with an aperture of 3¾ inches, on an equatorial mounting and wooden tripod feet, was £105.[40] However, a later (undated) broadsheet catalogue adds that instruments could be mounted on 'stands of various constructions, according to the wishes of the Purchaser, or the Price.'[41]

### 2.3. *End of paid public access to the telescopes*

In his June press advertisements Gill indicated the intention to continue to run the attraction at Snowhill Wharf, so long as his health permitted. An unnamed 'correspondent' provided the *Journal* with copy for Astronomical Occurrences for July, supplemented by four woodcuts. These and the text almost certainly came through Gill, with the piece ending by noting that solar spots 'may be seen every fine day to advantage through the powerful five foot telescope'.[42] An unattributed 'Astronomical Notice' for August drew attention to the fact that the planet Herschel [Uranus] would be visible from 10 every evening, and again to the 'rich clusters of spots on the sun', adding that readers 'may be gratified at Snowhill wharf, with the powerful five feet achromatic telescope, which bears a magnifying power of 600.'[43]

Routine press coverage of astronomical events appears to have reduced. The *Journal* in 1837 March and the *Gazette* in April and October drew attention to two forthcoming total lunar eclipses, and in both instances subsequently reported ideal viewing conditions.[44] However, John Gill's telescopes at Snowhill Wharf were no more. Their owner, and the promoter of a venue at which the public could pay to see astronomical phenomena through telescopes, died in early November 1836. His passing was recorded by a short formal notice: 'On Tuesday last [ie November 8] after two days' illness, borne with Christian resignation, Mr. John Gill, of Snow-hill Wharf, aged 59.'[45]

In mid-December there was a two-day sale at the wharf of Gill's 'Waggons, Carts, draught Horses, about 600 sacks, Fixtures, Household Furniture and other effects'.[46] The advertisement details 'two covered waggons, ... thillers' tackle ... two-sided desks ... iron chest... mahogany four-post bedsteads and hangings ... pianoforte in mahogany case ... eight day clock in oak case', but there is no mention of the telescopes with which Gill had made the wonders of the heavens available at a small fee to the public of Birmingham. In 1837 April, the wharfs, warehouses, dwelling houses, and other premises, held on a long lease for the Birmingham Canal Company, were advertised as available to let, with immediate entry.[47]

## 3. Handsworth Observatory 1838–45

Administratively, Handsworth was part of Staffordshire until 1911. However from the later part of the 18th century it was effectively a suburb of Birmingham. The manufactory of Matthew Boulton (1728–1809) at Soho was on its northern edge. The village expanded as new housing was erected for growing numbers of factory workers. Soho House, built for Boulton, and Heathfield Hall, built for his partner the engineer James Watt (1736–1819), were the most impressive of select residences designed for wealthy residents retreating from Birmingham.

The astronomical visitor attraction at Snowhill wharf may well have been the stimulus for Joseph Bembridge, as proprietor of the Heathfield Rooms, Handsworth, to propose an expansion of his activities by erecting an observatory and camera obscura, financed by the annual subscription of members:

> The elevated ground of Handsworth presents an admirable position for the contemplation of the Heavenly Bodies, as well as a Splendid Panoramic View of the Surrounding Country. To realise such advantages to the residents and visitors of Handsworth, Birmingham, and the vicinity, the Proprietor of the Heathfield Rooms is ready to devote a powerful apparatus, and, if adequately encouraged, to construct a separate building for its use.[48]

Bembridge pressed forward and on 1838 November 27 there was a formal opening of the observatory at Heathfield, Handsworth, commencing at four in the afternoon, with tea at six and an address by a visiting lecturer, together with a 'variety of interesting philosophical and chemical experiments', concluding with 'a beautiful series of astronomical diagrams.' [49]

The *Journal* sent a correspondent to cover the event, and the report opened by noting that, despite inclement weather, 'the lecture room adjoining the observatory was filled'. Speeches, lectures and demonstrations were reported. A short paragraph noted that 'Mr Bembridge, the resident proprietor, in a brief but appropriate manner, introduced to the meeting his most beautiful transparent orrery, illuminated by hydro-oxygen gas'. The meeting closed after four hours 'all highly pleased with the entertainment and the lectures, which were neither too short for explanation, not too long to satiate'.[50]

In the spring of the following year, a prospectus for the 'Observatory, Camera Obscura and Hydro-oxygen Microscope' was published, dating the formal establishment at Heathfield Road, Handsworth, to 1839 January 1. This proposal indicates that the financial base of the project had been broadened. In addition to subscribers, individuals would be admitted at a shilling, or for groups of three or more, sixpence each.[51]

Fourteen patrons were named, headed by William Legge (1784–1853), 4th Earl of Dartmouth FRS. Apart from the Scottish historian and science writer Ebenezer Henderson (1809–79), who had very recently founded a subscriber-funded observatory in Liverpool,[52] they all were local worthies.

The Earl, who resided at Pattishull, Staffordshire, was an active supporter and benefactor of many local institutions. He was, for example, patron of the Birmingham Medical Benevolent Society, of which John Read Corrie MD (1801–42), an observatory patron, was President in 1835. Legge, who owned land at Handsworth, was also a governor of Birmingham General Hospital, as too were William Chance and James Turner, two other observatory patrons.[53] The annual subscription was set at 10s for an individual, 15s for a couple, and 20s for a family. Single admission was 1s, or 6d each for groups of three of more.

These prices can be compared with annual membership subscriptions for the Birmingham Philosophical Institution, which were £1 11s 6d for all lectures, access to the museum, news room, and library (£1 1s for Ladies). When publishing these rates the Philosophical Institution also announced that it had booked John Wallis (1788–1852) of London to deliver his standard course of eight illustrated lectures on astronomy in 1839 November at their 400-seater Cannon Street lecture theatre, open to non-members at £1 1s for the course.[54]

While Gill had offered views of sunspots as a daytime attraction, Bembridge installed a camera obscura, available for viewing Birmingham and the surrounding countryside from 11 am to 3 pm with the observatory open from 7 to 10 pm 'every fine evening, Sundays excepted'. He also had a projection microscope, lit by gas, providing large magnified images, giving the Observatory an attraction that was independent of the weather. (Figure 4.)

### 3.1. *Support for the new venture*

The subscribers and friends of the new institution held their first general meeting in 1839 April with the president of the Birmingham Philosophical Institution, Handsworth resident John Corrie FRS (c. 1769–1839), the father of the aforementioned John Read Corrie, delivering an address 'on the advantages of scientific knowledge, and the vast fields of investigation which were placed within reach of all by the powerful instruments provided by Mr. Bembridge – the telescope and hydro-oxygen microscope'.[55]

Ebenezer Henderson gave tangible support, spending five weeks at Handsworth Observatory from early June that same year, offering an astronomy class, and giving a series of weekly evening lectures on astronomy at the Cannon Street Lecture Rooms of the Philosophical Institution, 'illustrated by a variety of interesting diagrams'.[56]

The Handsworth Observatory was not a scientific institution for the study of astronomy. It was an income-earning visitor attraction, supplementing fees earned from the Heathfield Rooms.[57] This judgment is underlined by the fact that neither Bembridge nor the Handsworth Observatory featured at the ninth annual meeting of the British Association for the Advancement of Science (BAAS) which was held in Birmingham in 1839 August, despite five of his patrons being closely associated with the running of that meeting.[58]

When the BAAS left, the newly founded Birmingham Athenaeum arranged for many of the industrial and scientific exhibits to be moved to the Town Hall, PROSPECTUS of the OBSERVATORY, CAMERA OBSCURA, and HYDRO-OXYGEN MICROSCOPE (magnifying two to three Millions).

HEATHFIELD ROAD, HANDSWORTH,

*ESTABLISHED JANUARY 1, 1839.*

UNDER THE PATRONAGE OF

The Right Honourable the EARL of DARTMOUTH, D.C.L. F.R.S. F.S.A.

| | |
|---|---|
| E. Henderson, Esq. F.R.A.S. LL.D. Professor of Astronomy, Liverpool. | The Rev. A. M. Wyatt, Perpetual Minister of Perry Barr. |
| John Corrie, Esq. F.R.S. | H. F. Devey, Esq. (Capt.) |
| J. R. Corrie, Esq. M.D., F.G.S. | James Turner, Esq. High Bailiff of Birmingham. |
| John Gough, Esq. of Perry Hall. | John Connolly, Esq. M.D. |
| The Rev. James Hargreaves, A.M., Rector of Handsworth. | A. Follet Osler, Esq. |
| | William Chance, Esq. |
| | John Rhodes, Esq. |
| | Bell Fletcher, Esq, M.D. |

To realise the advantages and pleasures of this establishment to the residents and visitors of Handsworth, Birmingham, and their vicinities, the proprietor, Mr. BEMBRIDGE, has spared neither time nor expense to provide Instruments of great power, and in the construction of a requisite building. He therefore solicits most humbly the support of the enlightened public by a donation, or their annual subscription of ten shillings, or for two persons of the same family fifteen shillings, or for a family twenty shillings.

Single admission to Non-subscribers one shilling, and to parties consisting of upwards of three, sixpence each. Arrangements for Schools will be equally reasonable.

The Camera Obscura is open from eleven to three, and the Observatory from seven to ten o'clock every fine evening, Sundays excepted.

The Proprietor will be happy to receive communications on the subject from such as may feel disposed to honour him with their notice.

N.B. Tickets not transferable.

*Fig. 4: Prospectus for Handsworth Observatory, from the advertisement columns of Aris's Birmingham Gazette, 1839 March 25, transcribed by the author.*

where they were seen by the 2,000 people who attended the Athenaeum's first half-yearly meeting. Bembridge had not contributed to the BAAS exhibition but the Athenaeum included his 'powerful oxy-hydrogen microscope', erected on a stage at the back of the hall, 'which at the closure of the entertainment, contributed to the amusement of the company'.[59] In 1841 Handsworth Observatory was one of the 15 members of the short-lived Midland Counties Literary and Scientific Association, 10 of which were the mechanics institutions of Birmingham and other midland towns.[60]

Perhaps stimulated by hearing at first hand of Henderson's peripatetic lecturing, Bembridge spent three days in Northampton in early January 1840 exhibiting a series of objects on his 'grand hydro-oxygen microscope'.[61] On his return he observed the comet discovered by Johann Galle at the Berlin Observatory in 1839 December, now known as C/1839 X1.

In a letter to the press he told readers where to find the comet as it rose above the horizon before dawn, advising that Jupiter and its four moons could be seen due south at about 7 am, with Saturn at about 6 am, somewhat below Venus, but of interest as the rings were at their greatest apparent opening.[62]

Of the instrument(s) he used there is little evidence, beyond the fact that at the second annual meeting of the members and friends of the Handsworth Observatory in 1840 March it was noted that a 'powerful reflecting telescope thirteen feet in length' had been added to the instrument collection that year.[63]

### 3.2. *Broadening membership and visitor appeal*

Annual subscribers had free access to the Handsworth Observatory at all times, as did members of the recently founded Birmingham Athenaeum.[64] Presumably to underline this association, Bembridge took the new telescope to the Athenaeum's AGM. The *Journal* was critical of the way that the Town Hall had been laid out: the 'scientific exhibitors … stuffed away into nooks and corners and 'the splendid reflecting telescope from Handsworth which was kindly brought down for the inspection of the meeting, was shoved under the side gallery, as if to get it out of the way.'[65] At least he got a mention!

During the summer of 1840, as an attraction to daily paying clients, the Heathfield Rooms were filled with a collection of paintings, natural history specimens, works of art, 'and other objects of instructive amusement … the splendid camera obscura, the hydro-oxygen microscope, with a magnifying power of 3,000,000, and the varied and costly philosophical apparatus'. Open from 1 to 9 pm, entry cost 6d.

For those who wanted to 'contemplate the heavenly bodies through the large and powerful telescopes' the observatory would remain open until 10.30 pm, for an extra 6d.[66] Further income was generated during the Birmingham festival week in late September when Bembridge gave demonstrations of the 'oxy-hydrogen microscope' over five evenings in the lecture hall of the Athenaeum, with customers charged a shilling (1s 6d for two persons, children half price).[67]

In 1841 April subscribers attending the third annual meeting of the observatory viewed a demonstration of the microscope after they had partaken of the 'ample refreshments' which followed the business meeting. A press report ended: 'We heartily rejoice in the growing prosperity of this truly useful and interesting institution; and as the season for suburban rambles is far approaching, we know of none that will better repay our townsmen, than a visit to this observatory'.[68]

The marriage of science and entertainment was and remains fraught. On 1841 December 1 there was a formal unveiling of a recently installed transit instrument. The chairman of the meeting, Captain William Scarth Moorsom (1804–63), engineer to the recently completed Birmingham to Gloucester Railway, spoke of the application of science to navigation, and hence to commerce, concluding that manufacturers 'ought to patronize everything that could improve science'. There was a report on the financial viability of the observatory, which the *Journal* correspondent judged to be

> far from flattering to the wealthy persons in the neighbourhood of Handsworth and the town of Birmingham; we say so, because Mr Bembridge has not had the support which his zeal for science, and the expenses he has incurred, entitle him to. The outlay of Mr. Bembridge has been considerable, and now the additional cost of the transit instrument, with the timekeeper and pedestal to fix the former upon, will cost £100, and the amount of the donations he has received towards it, is merely £20. This is to be regretted, as the different instruments are for the public advantage, and not merely for his own private benefit … [a resolution] pledged the meeting, individually and collectively, to do all in their power to obtain additional subscribers to the Observatory, and additional donations towards liquidating the amount expended by the proprietor for the new instrument … we cordially trust Mr. Bembridge will receive more support than he has hitherto done.[69]

In contrast a much shorter report in the *Gazette* was not so censorious:

> The cost of the transit instrument recently added to the astronomical apparatus of the Observatory, amounted to £40, and that the cost of the chronometer would be £45; in addition to which the expense of the erection would be £20, making a total of one hundred guineas. Towards this outlay several gentlemen had contributed the sum of £18, and it was confidently hoped that further assistance would be rendered, either by donations, or additional subscriptions to the Observatory, in order to defray the heavy expenses incurred by the proprietor.[70]

This report then went on to name 15 new subscribers, with Moorsom one of them.

Both press reports noted that speakers had drawn attention to the importance of a transit instrument for the correct determination of mean solar time. The *Journal* further noted that, with this instrument, public clocks in Birmingham could be properly regulated. This had been a topic of debate in the press during 1840.[71]

However, Handsworth Observatory was overtaken by the Birmingham Philosophical Institution (BPI). In the BPI's review of 1842 one member, the glass manufacturer Abraham Follett Osler (1808–1903), also a patron of the Handsworth observatory, was formally thanked not just for his series of lectures on chronometry, in which he indicated the need for a standard clock in the town regulated by a transit instrument, but in managing a subscription from members of the BPI and friends for the purchase of a regulator by Dent and a transit by Simms, which had been installed in the BPI's meteorological observatory.

'An eminent practical astronomer', it was reported, had made careful observations and concluded that their observatory was 1° 23′ 15″ west of Greenwich, and thus Birmingham time was 7′ 33″ later than that of Greenwich.[72] Until the electric telegraph brought Greenwich and railway time to Birmingham, it was the BPI's clock that set the time for public clocks in the borough.

### 3.3. *Relocation closer to the city centre*

The exact location in Heathfield Road of Handsworth Observatory has not been established, but there are some clues. Initially the Observatory was a landmark in the semi-rural landscape to the north of a Birmingham whose urban tentacles were inexorably smothering the surrounding countryside. A house offered for sale in the area in 1841 was described as 'opposite the Aston Villa School and the Handsworth Observatory'; while in 1842 a villa was described as at 'Clarence Place, Handsworth, near the Observatory, top of Hunter's Lane, out of borough.'[73]

Sometime between mid 1842 and early 1843 Bembridge left Heathfield Road, moving a little closer to the centre of Birmingham. By the spring of 1843 he was operating at the junction of Hunter's Lane and Barker Street.[74] No further meeting of Handsworth Observatory subscribers is recorded in the press after that of 1841 December, but Bembridge was not inactive. In 1843, giving his address as 'Observatory, Handsworth', he and his oxy-hydrogen microscope were listed as special attractions at fêtes held at the Birmingham Vauxhall Gardens for the benefit of the Original Friendly Sisters Order of Birmingham Unity in August and for the Independent Order of Odd Fellows in early September. Later that month there was to be a 'scientific Fete and magnificent exhibition … for the benefit of Mr Bembridge'.[75]

Astronomy was not neglected. In letters to the press in 1844 August and 1845 June, giving the address 'Observatory, Handsworth', Bembridge provided observations of two recently discovered comets, indicating to lay readers when and where to view them. In 1845 May he drew public attention to a forthcoming partial solar eclipse, and a transit of Mercury: 'both the eclipse and the transit will be seen to great advantage from the Handsworth Observatory.'[76]

## 4. Other early Victorian 'observatories' in Birmingham

There are 'observatories' and 'observatories'. Scientists of the period were beginning to distinguish between astronomical, meteorological, magnetic, and even tidal observatories, depending on the instruments installed and the data being collected. At that time the term 'observatory' was also used to describe what architectural historians now call a *belvedere* – a building, or part of a building, providing vistas over the surrounding landscape. An 'observatory' of this type to view the surrounding area was added to more than one Birmingham place of entertainment. At some a camera obscura was installed, underlining the fact that these were daytime viewing platforms, and had little or nothing to do with astronomy.

When Bembridge took his projection microscope to the Birmingham Vauxhall Gardens, he was associating with a long-established visitor attraction that had adapted to service a new clientele. A rural retreat for 'the genteeler sort of people' had changed its character.[77] The Vauxhall tavern put on plays, operas, and musical entertainments. There were acrobats, tightrope walkers, military bands, balloon ascents, and firework displays. The Gardens were attracting 'persons of all descriptions', so that the 'upper classes of the inhabitants have entirely absented themselves'. But, as one contemporary commentator wryly acknowledged, 'the present occupier is accumulating more money than any of his predecessors'.[78]

Frequent press advertisements for Vauxhall Gardens and the associated tavern are complemented by editorial comment, as when the *Journal* reported an attendance of 4,000 at an event in 1836 July, adding 'Fetes such as those given on Tuesday last, will render our Vauxhall Gardens inferior to no similar place of entertainment in the kingdom'.

In 1837 July the *Gazette* reported that Vauxhall Gardens 'have undergone many extensive improvements and alterations, and it is expected, from their vicinity to the Railroad Stations, that they cannot fail to attract numerous respectable visitors'.[79] The gardens did attract many visitors, but nevertheless the establishment closed at the end of the 1850 season, the site having been purchased and developed for upmarket housing.[80]

There was other competition for the evening and weekend leisure time of those with money to spend. From 1833 to 1836 the Bowling Green Inn at Holloway-Head advertised itself as having a bowling green, a quoit ground, flower and tea gardens, and an observatory, although this was for viewing the countryside, not the heavens.[81] When a new landlord took over the Bowling Green in 1840 he advertised that he had 'at considerable expense converted the old Windmill into an OBSERVATORY, which he believes, will be found an attractive object'.[82] Yet again, this was not an astronomical observatory.

In 1846, having failed to sell the tavern, the Bowling Green landlord added to its attractions by installing a camera obscura 'of great power, on top of his Observatory, where, from its commanding position and the beauty of the scenery around, he flatters himself it is equal to anything of its kind in the kingdom'. It was open from sunrise to sunset with a 3d admission charge.[83]

The landlord was no doubt aware of competition from the Galton Arms Inn, which had reinvented itself as the 'New Vauxhall Tavern and Pleasure Gardens'. When that lease was advertised for sale in 1847, it boasted 'an Observatory overlooking the town of Birmingham … extensive PLEASURE GARDENS, and most tastefully laid out with ornamental Arbours, newly constructed Fountains ... patronised by every class of the community in Birmingham and the Midland Counties ... upwards of twenty thousand people having visited these Gardens in one day, paying for admission.'[84]

In 1855, and the owner now bankrupt, the New Vauxhall Tavern was offered for sale with the observatory 'which commands views of the whole of Birmingham and the country for many miles around' listed as one of the attractions. Ominously the vendor indicated that the extensive grounds could be split and sold as building plots.[85]

Also on offer at this time was the lease of the Bowling Green Tavern with tea and pleasure grounds. Here too there was an 'OBSERVATORY, with spacious Gallery and CAMERA OBSCURA, commanding a fine view of the town, the railways and the surrounding neighbourhood, and (it being the only one in the county) it yields an income equal to the rent and expenses, by a small charge of admission'.[86]

For visitors to a tavern, the addition of a camera obscura provided a novel way of seeing the landscape around them. Indeed camera obscuras were something of a craze in the mid-19th century.[87] It is not surprising that the more enterprising licensed victuallers inserted one as part of their package of attractions.

Critically, the Heathfield Rooms in Handsworth, where Bembridge had installed a camera obscura at the original observatory, were not licensed. That made it a suitable attraction to the Cheltenham Temperance Club, on their summer 1841 outing by train to Birmingham,[88] but lack of a licence is likely to have restricted his clientele.

### 4.1. *Commerce eclipses astronomy*

Having moved his observatory, Joseph Bembridge bowed to the inevitable and he became a landlord, taking the lease of a licensed public house, the Rose Inn, 'at the corner of Hunter's lane and Barker-street'. Perhaps he was influenced to make this by his experiences demonstrating his oxy-hydrogen microscope at fetes in Vauxhall Gardens in 1843.

Despite this diversification, financial success appears to have eluded him. In 1847 June 'the ROSE INN, Hunter's Lane, with an Observatory and Camera Obscura Table erected thereupon' was offered for sale or to let, with goodwill, ale and spirit licences, and immediate possession, together with 'a large piece of LAND adjoining', and two adjacent dwelling houses.

It is not clear whether viewing the heavens through a telescope remained an option at the Rose. Bembridge's letter to the press of 1845 June is the last record of his astronomical activity.[89] Perhaps the 'observatory' became no more than a daytime viewing platform attached to a public house. The selling agent highlighted this as an opportunity to 'any ingenious and spirited individual', maintaining that the site was surrounded by 'beautiful scenery' with 'an immense population nearly adjoining' and that it had the potential to become 'a place of resort scarcely second to that princely retreat, New Vauxhall.'[90]

There were no takers, though. The 'beautiful scenery' of suburban Birmingham and beyond was fast being covered by bricks and mortar. Later in the year a different agent offered the Rose Inn for sale, with other property, and after listing the accommodation, the advertisement casually noted: 'There is also an Observatory erected at a considerable cost'.[91]

Bembridge's household furniture, bar and tap-room fittings, barrels, and brewing utensils had been auctioned in 1847 October. There was no mention of the camera obscura or any astronomical instruments.[92] As with John Gill's telescopes, the transit instrument, the 5-ft focal-length achromatic telescope, and the 13-ft focus reflector disappear from the record. A Birmingham auctioneer included in a sale of 1846 February 'an excellent large Reflecting Telescope in brass, on triangular frame, and a smaller one'.[93] The former appears not to have sold, for he was offering 'a valuable Newtonian Reflecting TELESCOPE, six inches diameter, on triangular stand', in June the following year.[94] However, there is no good reason to identify this instrument with the Handsworth Observatory.

Early in 1849, as 'formerly landlord of the Rose Inn, Barker Street, but now working as a tool maker at Sutton', Bembridge appeared as a witness in a case of burglary.[95] Other than that, he too vanished beneath the horizon.

Sometime after Bembridge's departure, and following significant rebuilding, the Rose Inn was renamed, perhaps to distinguish it from other taverns of the same name in Birmingham. It was the 'Observatory Inn' when the freehold was offered for sale in the early 1860s.[96] At the time of writing the public house still exists but gained a degree of notoriety in the second decade of this century when the sign-writer lost concentration while lettering the Barker Street frontage and painted the name as 'THE OBSERVATATORY'.[97]

**5. Conclusion**

There was, and remains, a strong justification for encouraging public interest and participation in astronomy. The enjoyment of stargazing can stimulate the acquisition of an informed interest in astronomy and related sciences. In the late Georgian and early Victorian period, John Gill and Joseph Bembridge briefly attempted to provide opportunities for the public of Birmingham to view the wonders of the heavens by providing access to telescopes – at least to those who could afford to pay for the pleasure.

Their charges were broadly similar, Gill levying a shilling for use of all or any of his telescopes for an hour, and Bembridge a similar sum for non-subscribers to be admitted to the Observatory for a session. As a comparison, when John Bird (d.1840) lectured on astronomy in Birmingham in 1838, illustrating his lectures with a large transparent orrery, reserved seats cost two shillings, others a shilling, with children half price.[98] A visit to the Theatre Royal would cost between three shillings for a seat in the best box to sixpence in the Gallery.[99]

Charges at this level were affordable by white-collar workers and professionals and to the many skilled mechanical artisans on whose Birmingham's wealth was built. Nevertheless they were out of reach of the labouring poor, where a family with four children would have to subsist on under 24 shillings a week.[100]

It is doubtful if either Gill or Bembridge found their initiatives to encourage amateur star gazing financially rewarding. Today, popular astronomy can be accessed in all weathers in Birmingham at the Think Tank Planetarium, while the Birmingham Astronomical Society has been promoting astronomy since 1950. It is currently based at Aston University, with a collection of telescopes for the use of members.

**References and notes**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2. Gibbs, F. W., 'Itinerant Lecturers in Natural Philosophy,' *Ambix*, 6 (1951), 111–17; Huang, H-F., 'Commercial and Sublime: Popular Astronomy Lectures in Nineteenth Century Britain', University College London PhD thesis 2015, https://core.ac.uk/download/pdf/29411209.pdf; Inkster, I., 'Advocates and Audience – Aspects of popular astronomy in England, 1750–1850', *JBAA* 92 (1982), 119–23; Golinski, J., 'Sublime Astronomy: The Eidouranion of Adam Walker and his sons', *Huntington Library Quarterly*, 80 (2017), 135–57.
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4. Lloyd, R. E., *A Syllabus of a course of lectures on Astronomy* (Oxford, 1819), p. 2. The *Syllabus* is known in editions from 1803; that of 1816 claims to be the 24th edition.

5. *ABG* 1833 April 15, p. 3 col. 7. Advertising the penultimate lecture of three in *ABG* 1833 May 6, p. 3 col. 6, Lloyd indicated it would open with 'a beautiful Explanation of the Theory of Eclipses … These two Lectures will form the most elegant and refined Evening's amusement to the Gentleman, the Scholar, and the Man of Business. Each evening will introduce a grand display of the most magnificent Scenery, in progressive change, highly illustrative even to the most infantine capacity, and which the Lecturer presumes to indulge the hope will *conciliate the warm patronage of the Public*.'
6. Capp, B., *Astrology and the Popular Press: English Almanacs 1500–1800* (Faber & Faber, 1979).
7. *Time's Telescope for [Year] … [with] Astronomical occurrences in every month*. Published annually in London by Sherwood, Neely, and Jones from 1814 to 1834.
8. *Temporis Calendarium*, compiled for thirty years from 1821 by William Rogerson (1797–1853), who for most of that time was an assistant at Greenwich Observatory.
9. See, for example: *BC* 1820 September 7, p. 2 col. 4, solar eclipse; *BC* 1821 October 4, p. 2 col. 5, Jupiter and Saturn; *Birmingham Journal* (hereafter *BJ*) 1826 April 8, p. 4 col. 1, eclipses of Jupiter's satellites; *BC* 1826 April 27, p. 2 col. 4, solar eclipses in 1826 and 1827; *BJ* 1826 November 11, p. 3 col. 3, forthcoming lunar and solar eclipses; *BJ* 1826 November 18, p. 3 col. 2, brief report of recent lunar eclipse; *BJ* 16 1833 March 16, p. 4 col. 3, forthcoming disappearance of Saturn's ring; *ABG* 1833 July 15, p. 3 col. 3, solar eclipse; ibid. 1833 July 22, p. 1 col. 2, for report of that eclipse.
10. *Time's Telescope for 1832* (London, 1832)*;* see especially 143–5, the whole section written by Deptford schoolmaster John Theodore Barker (fl. 1830–52). For a brief biographical note see Dews, N., *The History of Deptford* 2nd edn (1884) p. 243.
11. von Littrow, K. L., *Beyträge zu einer Monographie des Halley'schen Cometen* (Wein, 1834); see, for example, *Sun* (London) 1834 December 26, p. 3 col. 6; *Morning Post* (London) 1834 December 26, p. 4 col. 5; *Sussex Advertiser* 1834 December 29, p. 2 col. 1; *Carmarthen Journal* 1835 January 2, p. 4 col.4; *Belfast Newsletter* 1835 January 2, p. 4 col. 3. See also the review of this and two other German scientific publications on Halley's Comet by Möbius and Fischer, in *The Foreign Quarterly Review*, 15 (1835), 477–81.
12. [Lardner, D.], 'The Approaching Comet', *Edinburgh Review*, 61 (1835), 82–128; see, for example, *Western Times* (Exeter) 1835 April 25, p. 3 col. 4; *Suffolk Chronicle* 1835 May 2, p. 1 cols. 6–7; *Carlisle Journal* 1835 May 2, p. 4 col. 7. See also Lardner's Royal Institution lecture 'Dr. Lardner on Halley's Comet', *The Printing Machine*, 3 (1835), 306–8, 325–6, and 355–7; also summaries in *London Medical and Surgical Journal*, 7 (1835), 540, and *Gentleman's Magazine*, 158 (1835), 643. *Staffordshire Advertiser* (hereafter *SA*) 1835 May 9, p. 2 col. 4 reported Lardner's lecture. On 1835 October 5 Lardner formally opened the Potteries Mechanics Institution in Shelton, giving the first of three lectures on 'important discoveries in modern Astronomy, including the approaching Comet' – see *SA* 1835 September 26, p. 2 col. 1; and for lengthy summaries of the first two lectures ibid. 1835 October 10, p. 2 cols. 3–5 and ibid. 1835 October 17, p. 3, cols. 5–6 for the final lecture. Comets were a central theme of all three lectures. *Wolverhampton Chronicle* (hereafter *WC*) 1835 February 11, p. 3 col. 4, printed a detailed summary of Sir John Herschel's account of Halley's Comet.
13. le Doulcet, P. G., trans. C. Gold, *A history of Halley's Comet, with an account of its return in 1835* (London, 1835); Seares, J., *The Comet in four parts* (London, 1835).
14. *ABG* 1835 August 31, p. 1 col. 3 and 1835 September 21, p. 3 col. 7; see also *Cheltenham Chronicle* 1835 August 27, p. 3 col. 2; *Derby Mercury* 1835 September 2, p. 2 col. 3; *Coventry Herald* (hereafter *CH*) 1835 August 28, p. 1 col. 5; *Hereford Journal* 1835 September 2, p. 2 col. 5; *Worcester Herald* 1835 August 29, p. 3 col. 5.
15. *WC* 1835 June 3, p. 2 col. 3; *SA* 1835 June 6, p. 2 col. 6; *BJ* 1835 June 13, p. 3 col. 5; *CH* 1835 June 19, p. 4 col. 4.
16. University of Oxford, History of Science Museum, Inv. No. 14012. No advertisement for or report of this lecture has been found in the local press. The lecture room may have been hired externally for the lecture as it is not listed among the 1834/5 in-house lectures noted in 'Birmingham Philosophical Institution', *The Analyst, a quarterly journal of science, literature and the fine arts*, 3 (1836), 146–9, nor advertised as part of the Institutions annual programme for its subscribers – see, for example *BJ* 1834 November 1, p. 1 col. 1; *ABG* 1835 January 19, p. 3 col. 4; ibid. 1835 October 12, p. 3 col. 6.
17. *BJ* 1835 August 15, p. 2 col. 2.
18. *BJ* 1835 August 15, p. 3 col. 4; *ABG* 1835 August 17, p. 1 col. 2 (the same text appeared in *WC* 1835 August 19, p. 2 col. 6, *Worcester Journal* 1835 August 20, p. 1 col. 2, and other provincial newspapers).
19. Printed in *Morning Post* (London) 1835 August 26, p. 3 col. 5 and *London Courier & Evening Gazette* 1835 August 26, p. 3 col. 3. Compare the story in *BJ* 1835 September 5, p. 3 col. 2.
20. *BJ* 1835 October 17, p. 3 col. 2.
21. *Wrightson's New Triennial Directory of Birmingham* (Birmingham, 1818), p. 50.
22. *ABG* 1817 October 13, p. 3 col. 3.
23. *BC* 1820 November 9, p. 3 col. 3. See also *BC* 1822 January 24, p. 2 col. 3 with his detailed price list.
24. *ABG* 1830 August 30, p. 3 col. 7; ibid. 1831 January 24, p. 3 col. 5; ibid. 1834 March 3, p. 3 col. 4.
25. *ABG* 1835 June 22, p. 3 col. 4.
26. *ABG* 1835 October 12, p. 3 col. 7.
27. *BJ* 1835 October 24, p. 2 col. 2.
28. *ABG* 1835 December 21, p. 3 col. 6.
29. *ABG* 1836 May 9, p. 3 col. 4.
30. *BJ* 1835 October 31, p. 2 col. 4, and *ABG* 1835 November 2, p. 3 col. 5 both advertising *The British Calendar or Almanac for 1836*, whose London publisher trumpeted the inclusion of 'a Map of Great Britain, size 9 inches by 7, incorporating the Phenomena of the Great Eclipse of the Sun, May 15'.

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34. *ABG* 1836 May 16, p. 3 col. 2.
35. *ABG* 1836 May 16, p. 3 col. 5.
36. *BJ* 1836 May 21, p. 3 col. 5; ibid. 1836 May 28, p. 3 col. 3.
37. *BJ* 1836 May 21, p. 3 col. 5.
38. *BJ* 1836 May 28, p. 2 col. 2.
39. *BJ* 1836 June 11, p. 2 col. 3. A short announcement noting the acquisition of the Dollond instrument in *ABG* 1836 June 13, p. 3 col. 5 did not cite the cost.
40. 'A Catalogue of Optical, Mathematical and Philosophical Instruments, made by G. Dollond, optician to his Majesty, 59 St Paul's Church Yard, London,' *Astronomische Nachrichten*, 8 (1831), 42–3.
41. *A Catalogue of Optical, Mathematical and Philosophical Instruments, made by G. Dollond, optician to his Majesty, 59 St Paul's Church Yard, London* (London, n.d.) – copy in University of Cambridge, Whipple Museum of the History of Science, Inv. No. 3619.
42. *BJ* 1836 July 9, p. 3 col. 3.
43. *BJ* 1836 August 13, p. 3 col. 2.
44. *BJ* 1837 March 11, p. 6 col. 2; *ABG* 1837 April 17, p. 3 col. 3; *BJ* 1837 April 22, p. 4 col. 5; *ABG* 1837 October 9, p. 4 col. 2; *BJ* 1837 October 14, p. 4 col. 5; *ABG* 1837 October 16, p. 3 col. 2.
45. *ABG* 1836 November 14, p. 3 col. 2.
46. *ABG* 1836 December 12, p. 2 col. 4.
47. *ABG* 1837 April 17, p. 3 col. 7.
48. *BJ* 1838 August 4, p. 4 col. 1.
49. *BJ* 1838 November 24, p. 1 col. 4.
50. *BJ* 1838 December 1, p. 6 cols. 4–5.
51. *ABG* 1839 March 25, p. 3 col. 2.
52. Knie, H. H., 'Ebenezer Henderson and the Liverpool observatory', *Antiquarian Horology and the Proceedings of the Antiquarian Horological Society*, 10 (1976–8), 843–7.
53. *ABG* 1835 August 31, p. 3 col. 5; *ABG* 1835 September 28, p. 3 col. 5; *ABG* 1836 September 19, p. 1 col. 5.
54. *ABG* 1839 November 18, p. 3 col. 6. John Wallis had given his course at the BPI in the previous decade – *BJ* 1828 October 25, p. 2 col. 2. On Wallis see Huang, H-F., 'A shared arena: the private astronomy lecturing trade and its institutional counterpart in Britain, 1817–1865', *Notes and Records of the Royal Society of London*, 72 (2018), 319–41. Wells, K. D., 'Fleas the Size of Elephants: the wonders of the Oxyhydrogen Microscope', *The Magic Lantern Gazette*, 29 (2017), 3–34.
55. *BJ* 1839 April 6, p. 5 col. 2. See also Wells, op. cit. (ref. 54).
56. *BJ* 1839 June 8, p. 1 col. 4. Henderson slotted this course into his peripatetic lecture schedule, appearing locally at both the Walsall and the Wolverhampton Mechanics Institutions; see *WC* 1839 June 19, p. 3 col. 3; *WC* 1839 July 10, p. 3 col. 3.
57. I have located one indication of sub-letting, a Saturday morning dancing class held at the Heathfield Rooms by a Mr Johnstone of the Temple Row Dancing Academy – see *ABG* 1838 September 24, p. 3 col. 3.
58. The Earl of Dartmouth and John Corrie FRS were two of the four BAAS vice presidents for that year, while A. Follett Osler was one of the four local secretaries and James Russell one of the two local treasurers. Together with another patron, William Chance, all served on the local organizing committee; see *Report of the ninth meeting of the British Association for the Advancement of Science, held at Birmingham in August 1839* (London, 1840), ix. See also *ABG* 1839 April 15, p. 3 col. 6 and *BJ* 1839 April 20, p. 1 col. 2, for their presence at the first formal meeting of the BAAS Birmingham local committee.
59. *Catalogue of the Illustrations of Manufactures, Inventions and Models, Philosophical Instruments, etc contained in the second exhibition of the British Association for the Advancement of Science held at Birmingham* [Birmingham, 1839]. The exhibits were also listed in *BJ* 1839 August 31, p. 6 cols. 2–4. The Athenaeum meeting was reported in *BJ* 1839 September 7, p. 7 col. 2.
60. Society for the Diffusion of Useful Knowledge, *Report of the state of Literary, Scientific and Mechanics Institutions in England* (London 1841), 94–95.
61. *Northampton Mercury* 1840 January 4, p. 3 col. 2.
62. *Worcester Journal* 1840 January 30, p. 1 col. 2, citing *Midland Counties Herald*.
63. *Staffordshire Gazette and County Standard* 1840 March 22, p. 4 col. 5.
64. *ABG* 1839 November 25, p. 3 col. 7; *BJ* 1839 November 30, p. 4 col. 1; *ABG* 1839 December 2, p. 3 col. 6.
65. *BJ* 1840 March 7, p. 3 col. 4.
66. *BJ* 1840 May 16, p. 4 col. 1.
67. *BJ* 1840 September 19, p. 8 col. 5 and p. 5 col. 2. There had been a similar display at an Athenaeum conversazione earlier in the month, for which members were charged 1s and visitors 2s 6d – *ABG* 1840 August 31, p. 3 col. 5. The oxy-hydrogen microscope was used for public displays in London from 1833, and by the following year elsewhere in England – see Wells, K. D., 'Fleas the Size of Elephants: the wonders of the Oxyhydrogen Microscope', *The Magic Lantern Gazette*, 29 (2017), 11–17.
68. *BJ* 1841 April 24, p. 4 col. 4; see also *SA* 1841 May 1, p. 2 col. 6.
69. *BJ* 1841 December 4, p. 5 cols. 3–4.
70. *ABG* 1841 December 6, p. 3 col. 2.
71. See, for example, 'Clocks Again' in *BJ* 1840 November 14, p. 7 col. 4.
72. *ABG* 1842 December 19, p. 1 col. 3. For Osler's lectures see *ABG* 1842 January 17, p. 3 col. 6. Osler was an office bearer and benefactor of the

Birmingham Philosophical Institution and its successor, the Birmingham and Midland Institute. He was elected FRS in 1855, having received early recognition as a meteorologist for his 1835 self-recording pressure-plate anemometer and rain gauge, installed at the Institution.

73. *ABG* 1841 March 29, p. 2 col. 6; ibid. 1842 June 13, p. 3 col. 8. There was a school at the Aston Villa from 1832, but by 1849 the building had become the Villa Cross Inn – see https://theironroom.wordpress.com/2012/11/15/guest-blogger-the-original-aston-villa/
74. *ABG* 1843 April 17, p. 2 col. 8 for a sale of household furniture and effects at a property 'In Barker Street, next house to the Observatory, Hunter's lane, Handsworth'.
75. *BJ* 1843 August 5, p. 1 col. 4; ibid. 1843 August 19, p. 1 col. 2; ibid. 1843 August 26, p. 1 col. 5; ibid. 1843 September 2, p. 4 col. 1.
76. *ABG* 1844 August 26, p. 3 col. 3; ibid. 1845 May 5, p. 3 col. 2; ibid. 1845 June 16, p. 3 col. 3.
77. Pye, C., *A description of modern Birmingham* (Birmingham, [1820]), p. 56.
78. Ibid.
79. *ABG* 1837 July 3, p. 3 col. 2.
80. For the disposal and development of the site see *ABG* 1850 February 11, p. 3 col. 2; ibid. 1850 February 25, p. 3 col. 5; *BJ* 1850 August 24, p. 4 col. 6 and p. 8 col. 3.
81. The house had formerly traded as the Wellington Inn – see *ABG* 1831 May 2, p. 3 col. 3. The first mention of an observatory is *ABG* 1833 April 29, p. 3 col. 5; see also ibid. 1834 May 5, p. 3 col. 5; 1835 May 4, p. 3 col. 3; 1836 May 2, p. 3 col. 5.
82. *ABG* 1840 April 20, p. 3 col. 5.
83. *BJ* 1846 July 4, p. 1 col. 1. For the attempt at sale see *ABG* 1846, March 9, p. 2 col. 4.
84. *BJ* 1847 November 27, p. 1 col. 5; see also *ABG* 1847 December 6, p. 2 col. 4.
85. *ABG* 1855 August 20, p. 2 col. 7; *BJ* 1855 September 1, p. 1 col. 5.
86. *ABG* 1848 January 31, p. 2 col. 5; the quotation is from the advertisement in *BJ* 1850 August 17, p. 1 col. 6. See also *ABG* 1851 July 21, p. 2 col. 5.
87. Hammond, J. H., *The Camera Obscura, a chronicle* (Adam Hilger, 1981), 104–42.
88. *BJ* 1841 June 5, p. 3 col. 5.
89. *ABG* 1845 June 16, p. 3 col. 3.
90. *BJ* 1847 June 12, p. 1 col. 3; see also *ABG* 1847 June 14, p. 2 col. 8.
91. *ABG* 1847 November 1, p. 1 col. 6; also *BJ* 1847 November 6, p. 1 col. 5.
92. *BJ* 1847 October 23, p. 1 col. 6.
93. *ABG* 1846 February 9, p. 2 col. 8.
94. *ABG* 1847 June 14, p. 2 col. 8.
95. *BJ* 1849 February 10, p. 8 col. 4.
96. *ABG* 1861 April 27, p. 1 col. 2; *BJ* 1862 October 4, p. 1 col. 4.
97. Bryden, D. J., 'The Victorian Inn: An observatory pub crawl', *Bulletin* of the Society for the History of Astronomy, Issue 35 (2021 Spring), 7–15.
98. On Bird see Holmes, E., 'A lecturer on Astronomy', *JBAA* 10 (1899), 23–25. And in context Huang, H-F., 'A shared arena: The private astronomy lecturing trade and its institutional counterpart in Britain 1817–1865', *Notes and Records of the Royal Society of London*, 72 (2018), 319–41. Bird gave three separate lecture series in Birmingham in 1838: three lectures in the large committee room of the Town Hall for 5 shillings the course, or 2s for a single ticket (*ABG* 1838 September 3, p. 3 col. 5); two lectures in the Town Hall, with musical interludes on the organ, reserved seats 2s, otherwise 1s, for each performance (*BJ* 1838 November 17, p. 1, col. 4); three lectures in the former museum rooms, Temple Street, reserved seats 2s., otherwise 1s., children under 14, 6d (*BJ* 1838 December 1, p. 4, col. 2).
99. *ABG* 1838 May 28, p. 3 col. 7.
100. Wade, J., *History of the Middle and Working Classes* (Third edition, 1835), p. 573 for Birmingham: 'workmen may be divided into three classes, earning respectively about 12s, 18s, and 24s, per week, working ten hours each day, six days per week, and generally [paid] by the piece.' For cost of food etc. see *Plain Statement of the Case of the Labourer* (London 1831), p. 167. Costs, prices, and wage comparisons are notoriously difficult – see, for example, Lindert, P. H., and Williamson, J. G., 'English Workers' Living Standards during the Industrial Revolution: A new look', *The Economic History Review* Second series 36 (1983), 1–25; also Jackson, R. V., 'The Structure of Pay in Nineteenth Century Britain', *The Economic History Review* Second series 40 (1987), 561–70.

**The author**

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# Forgotten English astronomers and observatories: A snapshot of late Georgian astronomy

Kevin L. Johnson

A first-hand insight into private observatories and their owners in late Georgian England (1800–1830s) is provided by contemporary accounts. These narratives tell us not only about the observing equipment of the individuals concerned but also their social standing and motivations. More than half the names under discussion in this paper do not appear in the standard histories for the period. Researching these forgotten astronomers and their working milieu allows us to draw comparisons with their better-known contemporaries. It also helps refine our knowledge of these practitioners and the astronomical community in late Georgian England.

## 1. An anonymous list

The original impetus for this research was a handwritten list of private English observatories and their owners that I found on a file at the Science Museum, London, in the 1990s. No author was stated, but it gave as its source the Observatory entry of Rees's *Cyclopædia*, a 39-volume compendium of art, science, and literature edited by Abraham Rees (1743–1825) and published in 1819.[1] The list piqued my interest as half the people mentioned were unknown to me.

The advent of the internet gave further clues to the possible authorship of the enigmatic list. A search for observatories on the web uncovered not only the Rees's *Cyclopædia* observatory entry but also an older reference with an identical compilation of the otherwise unknown astronomers and their observatories.[2] (Figure 1). This second work, *A Philosophical and Mathematical Dictionary* published in 1815, was authored by the English mathematician Charles Hutton (1737–1823) (not to be confused with his more famous, but unrelated, Scottish contemporary James Hutton (1726–97), a pioneer of geology).[3]

### 1.1. *Charles Hutton, mathematician*

Charles Hutton (Figure 2) was born into humble circumstances, the son of a colliery overseer, near Newcastle upon Tyne. He received a basic education before embarking on a teaching career. Hutton advanced his mathematical skills through evening classes in Newcastle, becoming the most successful mathematics teacher in the district.[4] In 1760 he announced the opening of 'a writing and mathematical school' that taught applied mathematics – bookkeeping, navigational, and dialling.[5]

Hutton succeeded to the mathematical chair at the Royal Military Academy, Woolwich, in 1773 and was elected to the Royal Society the following year. He undertook the calculations for Nevil Maskelyne's pendulum experiment at Schiehallion to measure the density of the Earth. Hutton was appointed foreign secretary of the Royal Society in 1779 but was forced to resign in 1783, the removal being engineered by Joseph Banks (1743–1820) who, it is suggested, saw mathematicians as of lower status within the Royal Society.[6]

### 1.2. *Seeking the author*

Hutton's *Dictionary* of 1815 seems to predate Rees's *Cyclopædia* of 1819, but there is a twist: Rees's work was published serially from 1802–18 (a partwork, in modern parlance) and the 1819 date refers to the printing of the final set of volumes. The observatory entry in Rees's *Cyclopædia* actually appeared in 1813, two years before Hutton's *Dictionary*. There are strong similarities between the Observatory entry in both books, suggesting either common authorship or blatant copying. (It is worth noting that a first edition of Hutton's *Dictionary* was published in 1795/6, but the Observatory entry in that is far shorter and does not contain the extensive inventory of observatories that appeared in 1815.)[7]

Rees's *Cyclopædia* was a multi-author work. Although entries are not credited individually, the articles on astronomical instruments in it were authored by William Pearson, and we can presume that the Observatory

Among the private observatories of the present day, the following alphabetical list may be also mentioned.

| | | |
|---|---|---|
| Blackheath | - | Stephen Groombridge, Esq. |
| Blenheim | - | Duke of Marlborough. |
| Cambridge | - | Rev. Mr. Catton. |
| Chiselhurst | - | Rev. Francis Wollaston. |
| Derby | - | William Strutt, Esq. |
| East Sheen | - | Rev. William Pearson. |
| Finsbury Square | | Dr. Kelly. |
| Godwood | - | The Duke of Richmond. |
| Gosport | - | Dr. William Burney. |
| Hackney Wick | - | Colonel Beaufoy. |
| Hayes | - | William Walker, Esq. |
| Highbury Terrace | | Capt. Huddart. |
| Hoddesdon | - | William Hodgson, Esq. |
| Islington | - | Gavin Lowe, Esq. |
| Paragon, Southwark | | James Strode Butt, Esq. |
| Park-lane | - | Sir Henry Englefield, Bart. |
| Rose Hill, Sussex | | John Fuller, Esq. |
| Sherburn | - | Earl of Macclesfield. |
| St. Ibbs, Hitchin | - | Mr. Professor Lax. |
| Woolwich | - | Royal Mil. Acad. |

*Fig. 1: The 'mystery' list of observatories and owners from Charles Hutton's Philosophical and Mathematical Dictionary (1815).*

entry was among them.[8] Whereas Hutton would have been well-versed with international institutions, Pearson would likely have had a better knowledge of independent astronomers. Hence we are left wondering whether Hutton plagiarized the *Cyclopædia* for the second edition of his book or if he and Pearson collaborated.

*Fig. 2: Charles Hutton (1737–1823), English mathematician, from an engraving by William G. Jackman (fl.1841–60). (Smithsonian Libraries)*

1.3. *Significance of the list*

Whoever the author was of the observatory list in Rees's *Cyclopædia* he (or they) clearly had a broad knowledge of, and friendship with, colleagues within the astronomical community, which clearly overlapped with both theoretical and applied mathematics. Hutton, despite his dispute with Banks, knew a wide range of practical astronomers who were making observations and applying mathematics to their results.

Many of these names have been lost to history for various reasons, often for lack of published works. Their social status and the volatile politics of the period are also factors that would affect whether any trace of their activities is left in the historic records. An investigation and assessment of these forgotten astronomers is necessary to see if they change our view of their astronomical community.

## 2. Greenwich List of Observatories

Since its initial publication in 1986, the *Greenwich List of Observatories 1670–1850* (GLO), compiled by Derek Howse,[9] has provided a baseline for assessing the worldwide history of observatories and their instrumentation, and provides a logical starting point for assessing the Hutton/Pearson list of English observatories and astronomers.

The Greenwich list identifies the following observatories and astronomers from the Hutton/Pearson compilation of private establishments. In the order listed, they are:

- Stephen Groombridge (1755–1832), Blackheath
- George Spencer, 4th Duke of Marlborough (1739–1817), Blenheim
- Rev. Francis Wollaston (1731–1815), Chislehurst
- Rev. William Pearson (1767–1847), East Sheen
- Col Mark Beaufoy (1764–1827), Hackney Wick
- Capt. Joseph Huddart (1741–1816), Highbury Terrace
- George Parker, 2nd Earl of Macclesfield (c.1696–1764), Shirburn and the Royal Mil. Acad., Woolwich.

The last entry is a mistake as it refers to the observatory on Woolwich Common of the Rev. Lewis Evans (1755–1827). Evans pointed out the error in a letter to *The Monthly Magazine* in 1816, saying 'There is no observatory at this institution [i.e. the Royal Military Academy]. The only observatory at Woolwich is one built by myself, contiguous to my dwelling-house, on the common'. He then went on to provide a description of its scale and instruments.[10]

Under the heading of public institutions present and past the following entries can also be found in the GLO: The Greenwich Observatory or Royal Observatory of England; Dr Herschel's Observatory, Slough; The King's private observatory, Richmond; Oxford Observatory (Radcliffe); Christchurch, Trinity, and St Johns Colleges, Cambridge;[11] Portsmouth Observatory at the Royal Marine Academy; Alexander Aubert

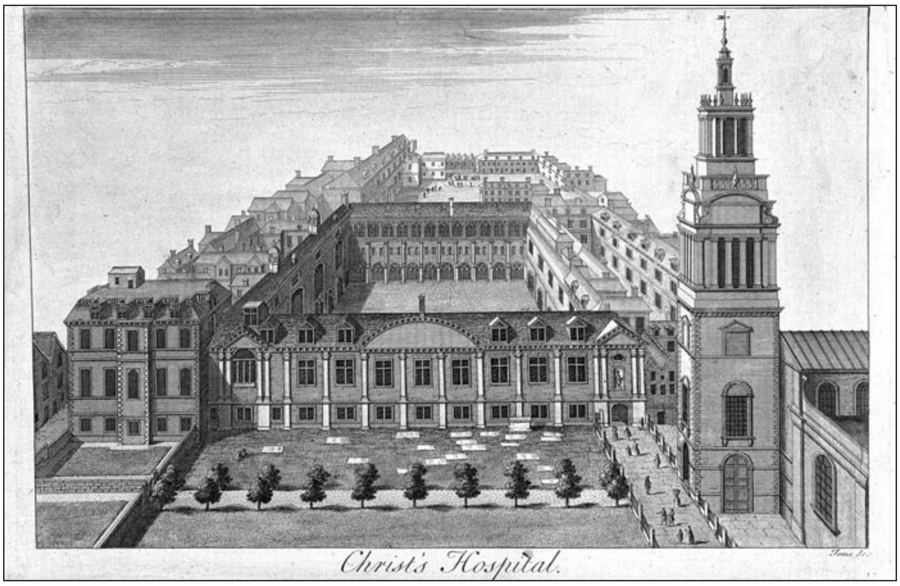


*Fig. 3: Christ's Hospital School in Newgate Street, London, seen around 1750. The square building at lower left is the Royal Mathematical School, where William Wales set up an observatory for teaching navigation in or around 1776. The church at right is Christ Church Newgate Street, also known as Christ Church Greyfriars. Its tower still remains although the rest was destroyed in an air raid during World War II. Christ's Hospital moved to Horsham in West Sussex in 1902. Engraving by William Henry Toms (c. 1700–1765). (Wellcome Collection)*

(1730–1805), Highbury House, Islington; Count Hans Moritz von Brühl (1736–1809), Harefield, Middlesex; Sir George Shuckburgh (1751–1804), Shuckburgh; and Sir Charles Greville (1749–1805), Milford, Pembroke.[12] In the case of the last entry, Wales was at that time treated as a principality of England.

2.1. *Institutions versus individuals*

The organizations and people identified by the GLO, on the Hutton/Pearson list, offer a diverse selection that can be categorized as either institutional or private individuals. It is less easy to divide them into professional versus amateur, as the difference was not well-established in the modern sense. The question of independent research in Britain has been explored at some length by Allan Chapman for the later Victorian period.[13]

Educational institutions such as universities and other teaching institutions have a clearer function with regards to astronomy, but individual astronomers have varied motivations. In trying to categorize them it would be useful to look at their social status as it has a bearing on whether any historical records for them exist.

It is notable that, of the individual astronomers recorded from the GLO, there is probably a shift from the aristocratic gentry to the rising middle classes, whose wealth was due to the expansion of trade, manufacture, and urban development as the Industrial Revolution took off in Britain. An example of the latter is Mark Beaufoy, whose money probably originated from his father's vinegar manufacturing business, as can be judged from his significant wealth at death.[14] Sir George Shuckburgh, by contrast, inherited his money, becoming sixth baronet, and succeeding to the family estates at Shuckburgh.[15]

Another notable group of people to consider are the clergy of the Church of England, well-educated and with a guaranteed income, who could independently follow an interest in astronomy, to confirm their religious beliefs rather than challenge them. The exchange between these groups, their tensions, and interests all need to be assessed when considering their working milieu and interactions within and beyond their social and intellectual communities.

## 3. Unknown observers and institutions

Having considered the entries on the Hutton/Pearson list that are identifiable on the GLO, I will now assess and analyse those unknown institutions and lesser-known figures to see if they provide a different or possibly more balanced view of English astronomy for the period.

Before considering those that are described as private observatories we first need to mention three others that are classified as prominent or institutional. They were at Christ's Hospital school; Somerset House for the Royal Society, both in London; and William Larkins (fl.1785–1800) at Blackheath.

3.1. *Christ's Hospital, London*

Established in 1552 and receiving its royal charter a year later from Edward VI, Christ's Hospital school was originally located at Newgate in the City of London (Figure 3). An observatory was established there by William Wales (1734–98),[16] who had accompanied Captain Cook on his second voyage of discovery (1772–5). On his return he was appointed master at the Royal Mathematical School (RMS), part of Christ's Hospital, founded by Charles II in 1673 to teach ships' officers navigational skills.[17] Wales established the observatory at his own expense sometime around 1776 to assist in the teaching of navigation.

An account of the observatory and its instruments was provided in 1834 by the Rev. William Trollope (1798–1862): 'Under the inspection and care of Mr Wales, not only the more common instruments were fixed for the use of the boys; but he accustomed them to make the most delicate observations; and they once assisted in observing a transit of Venus'.[18] Trollope must be mistaken on the last point as a transit of Mercury is the more likely explanation.[19]

The account also indicates that there was an excellent clock, transit, and sundry telescopes along with other instruments. However, by the time Trollope wrote, three decades after Wales's death, the observatory had gone.

It is worth noting that Thomas Simpson Evans (1776/7–1818), mathematician and son of Lewis Evans (1755–1827), was appointed master at the RMS in 1813. He had previously operated the private Blackheath observatory of William Larkins, former accountant-general to the East India Company in Bengal (see Section 3.3 below).[20] He is reported to have applied his skills to teach astronomy and navigation to the boys so that they could 'able to solve the Problem of Lunar distances properly'.[21] It is also recorded that Evans complained to the Almoners at the run-down state of the transit and clock in the school observatory.[22]

3.2. *Royal Society, Somerset House*

According to Hutton, 'The Royal Society have at Somerset House a small observatory, which is generally superintended by the secretary at the time being'.[23] Evidence for the edifice is hard to uncover; no reference of such can be found in Weld's *History of the Royal Society* (1848).[24] However, other 19th-century sources on Somerset House's past do mention it.[25]

Its description is of a temporary meridian facility, observations being made with a portable transit instrument from an anteroom window with a watch-dial set into a nearby wall as a meridian mark.

3.3. *William Larkins, Blackheath*

Details regarding the career of William Larkins (fl.1785–1800) are few beyond that he was accountant-general to the East India Company in Bengal until 1785, and he is recorded as one of the vital defence witnesses at the impeachment trial (1788–94), for bribery, of Warren Hastings (1732–1818). Larkins gave statements for the Governor-General, refuting the charges, a position he maintained despite severe cross-examination.[26]

In 1796 he was elected to the Royal Society; his proposers included Nevil Maskelyne (1732–1811), Alexander Aubert, and Joseph Huddart.[27] Retiring to Blackheath he erected an observatory at his home, Point House, West Grove, described as 'furnished with all the best instruments'.[28] In 1798 he appointed Thomas Simpson Evans, a former assistant at the Royal Observatory in Greenwich, to run his new establishment.[29]

A description of the observatory and its instruments is furnished from the auction sale catalogue of Larkins' effects after his death.[30] Instruments include a Herschel 7-ft reflecting telescope that Larkins purchased in 1799 and a 45-inch achromatic telescope by Peter Dollond 'the favourite of Wm. Larkins' acquired by William Kitchiner (1778–1827).[31, 32]

*Fig. 4: William Strutt (1756–1830), Derby industrialist. (Derwent Valley Mills)*

**4. Private observatories**

The remaining entries on the Hutton/Pearson list of active private observatories that are absent from the GLO are as follows: Thomas Catton, Cambridge; William Strutt, Derby; Dr Kelly, Finsbury Square; The (3rd) Duke of Richmond, Goodwood; Dr William Burney, Gosport; William Walker, Hayes; William Hodgson, Hoddesdon; Gavin Lowe, Islington; James Strode Butt, Paragon, Southwark; Sir Henry Englefield, Park-Lane; John Fuller, Rose Hill, Sussex; and Professor Lax, St. Ibbs, Hitchin. These will be explored in more detail below.

4.1. *Thomas Catton, Cambridge*

A cleric and fellow of St John's College, Cambridge, Thomas Catton (c.1758–1838) was in charge of the second observatory at the college. It is recorded that he observed eclipses and occultations[33] but he is not listed in the GLO. Located on the Shrewsbury Tower, the observatory's instruments included a transit by Sisson and a Shelton regulator clock along with two Gregorian reflectors and an equatorial refractor by Dollond.[34] Use of the observatory at St John's College continued until 1859,[35] by which time it was overshadowed by the new university observatory on the edge of the city founded in 1823.

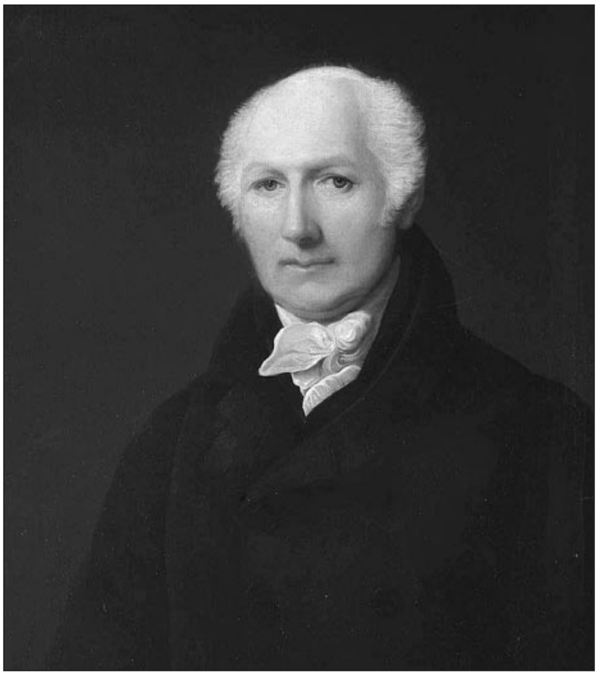
4.2. *William Strutt, Derby*
Beyond his inclusion on the Hutton/Pearson list there is little to support the existence of an observatory established by the Derby industrialist William Strutt (1756–1830). (Figure 4). Perhaps it was little more than an observing platform with portable instruments. Various biographical accounts indicate his interest in natural philosophy, but do not suggest he practised astronomy.

A successful cotton manufacturer who later became an architect and engineer, he was on good terms with Erasmus Darwin (1731–1802) and was closely involved with the formation of the Derby Philosophical Society.[36] Notable proposers for his election to the Royal Society included the engineers James Watt (1736–1836), Marc Brunel (1769–1849), and the polymath Peter Mark Roget (1779–1869), illustrating Strutt's wide range of interests.[37]

4.3. *Patrick Kelly, Finsbury Square, London*
The early life of the Irish mathematician and astronomer Patrick Kelly (1755/6–1842) (Figure 5) is poorly documented, but one source indicates he was born in Stradbally, Queen's County (Laois), Ireland. After the death of his father, a local landowner, he sold the estate and moved to England in 1775.[38] In due course he became master at the Finsbury Square Academy that he ran for many years.[39]

He provides a brief summary of the observatory established at its premises in his best-known work, *The Universal Cambist...* (1811),[40] a commercial handbook for trade that provided the first accurate determination of global weights and measures.[41] An advertisement is included, encouraging enrolment at the college. After

*Fig. 5: Patrick Kelly (1755/6–1842) in a portrait by John Hazlitt (1767–1837). (The Foundling Museum)*



describing the school, it notes 'There is also an OBSERVATORY, with an accurate and extensive apparatus, intended to give to Students in Astronomy and Navigation a practical Knowledge of those useful Sciences'.[42]

From the description it is reasonable to assume that both meridian instruments and telescopes were installed and navigation instruments were present – sextants, reflecting/repeating circles, and chronometers. He was a founding member of the Royal Astronomical Society but, despite the success of his school, extensive publications, and friendship with many of the notable scientists of the day, he was not elected to the Royal Society.[43]

4.4. *Duke of Richmond, Goodwood House*
It is assumed that Charles Lennox, third duke of Richmond (1735–1806),[44] is the person referred to on the Hutton/Pearson list at Goodwood House. However, there is very little to support the assertion that an observatory existed. It is known that the third duke had an extensive interest in science, a detail supported by the survival of private weather diaries (1800, 1802, and 1806) from Goodwood House, now archived by the Met Office.[45] Little of the Duke's other records survive – much may have been lost to fire at Richmond House, their London home, in 1791.[46] Further research is needed to resolve the extent of the duke's astronomical interests.

4.5. *William Burney, Gosport*
In common with Patrick Kelly, his Irish compatriot, Dr William Burney (c.1762–1832) founded a teaching establishment at Cold Harbour, Gosport, in 1791. The Naval Academy provided tuition for young men pursing a naval career.[47] Receiving a charter from King William IV, it was later known as The Royal Academy, and its management passed from father to son until its closure in 1904.

The presence of an observatory at the school is confirmed by publication of Burney's meteorological diary and his reports of a new comet seen at 'Observatory, Gosport, Feb. 24 1821'.[48] Despite giving detailed accounts of the weather instruments and reports on the planet Venus, the latter seem to be naked-eye observations with positions possibly determined with navigational instruments or a portable transit. It is not clear whether the observatory housed permanent meridian instruments or even a telescope.

Little further can be gleaned, as no contemporary prospectus appears to survive. Later advertisements do not mention astronomy as part of the syllabus, so it was likely limited to the more standard aspects of nautical training.[49]

4.6. *William Walker, Hayes, Middlesex*
Better known as an itinerant lecturer, William Walker (1766–1816) (Figure 6) was a celebrated practical astronomer to judge from contemporary accounts of his life, which referred to 'the celebrated Astronomical

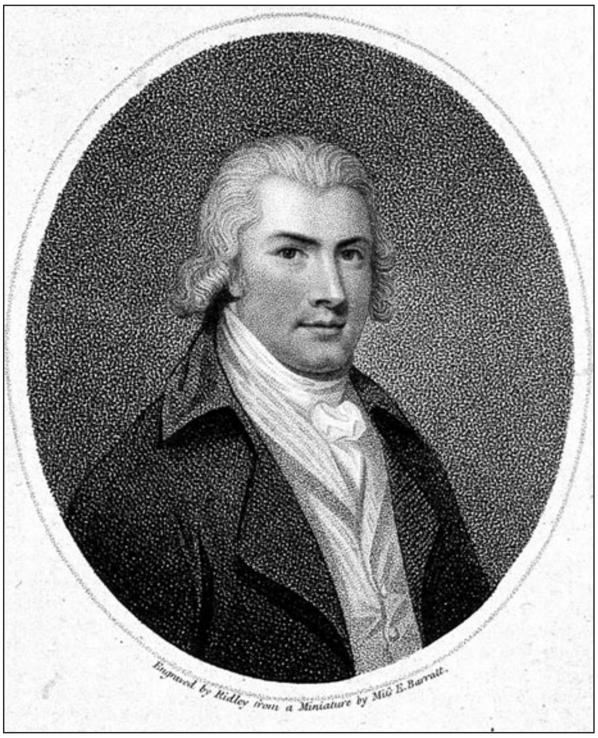
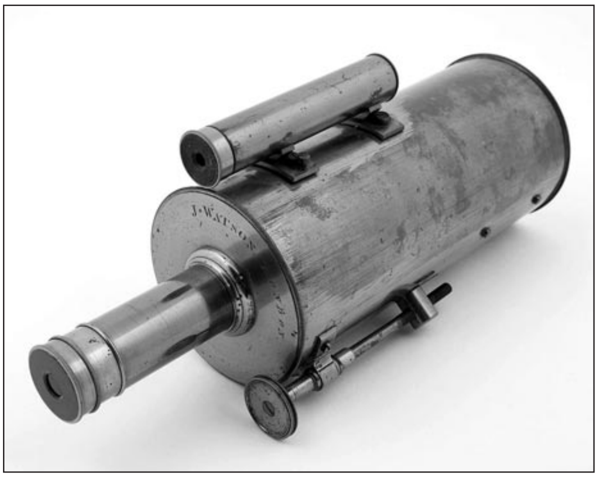



*Fig. 6: William Walker (1766–1816), Stipple engraving by W. Ridley, 1798, after E. Barratt. (Wellcome Collection)*

Lecturer, whose eminent abilities as a practical astronomer, and agreeable delivery as an orator, have amused young people'.[50]

Succeeding his father Adam Walker (1731–1821), famed for his transparent orrery the Eidouranion (see the inside front cover of this issue), he continued the family tradition of spectacular astronomy lectures. From his exchanges with William Kitchiner in 1808, it is known that Walker observed with a 2¾-inch Dollond refractor of 44-inch focus from Manor House, Hayes. He comments on its resolving power on double stars stating 'on Sept 9th, 1791, after having been exposed with the instrument near an hour in an open garden with the negative power of 180, I readily saw ε Bootis double'.[51]

*Fig. 7: The short-focus ('dumpy') Cassegrain reflector by James Watson first owned William Walker. (Science Museum, London)*




Later in 1825 Kitchiner notes that Walker had a 6-inch Cassegrain reflector by Tulley in an observatory at his home.[52] In 1794 he also acquired a 3-inch (75 mm) 'dumpy' Cassegrain by James Watson (fl.1774–1835) of London (Figure 7). After Walker's death the telescope was purchased by Kitchiner and was finally acquired by the Science Museum, London, in 1921.[53]

4.7. *William Hodgson, Hoddesdon*

The occupation of William Hodgson (c.1747–1823) is unclear, although his death notice in *The Gentleman's Magazine* records that 'He possessed a good collection of books and mathematical instruments'.[54] Whatever his career, Hodgson was a gentleman of independent means, being elected to the Royal Society in 1807.

He was also clearly a practical astronomer, as we are provided with a comprehensive list of his equipment by William Kitchiner, that inveterate collector of telescopes. Kitchiner informs us that 'Mr George Hodgson F.R.S. built an observatory at Hoddesdon, Herts. He was a very ingenious person, and purchased instruments for his observatory without any regard to the cost of them'.[55]

Kitchiner then goes on to itemize them: 7-ft Newtonian reflector by Herschel;[56] achromatic 5-ft telescope of the late Peter Dollond; ditto 46-inch telescope by Peter Dollond, 'the favourite of Mr A. Aubert'; ditto 45-inch telescope by Peter Dollond, 'the favourite of Wm. Larkins'; 30-inch achromatic telescope by G. Dollond; 30-inch Cassegrain and Gregorian reflector; 5-ft Newtonian by Tulley; 46-inch achromatic by Tulley; and 'half-a-dozen other telescopes, &c'.[57]

There is nothing to indicate how all these instruments were housed, whether in a permanent structure or moved from indoors to an outdoor observing site. Surviving records indicates that Hodgson was active observer. A letter in 1805 from him to Herschel comments 'gradually looking at all the double stars you have pointed out'.[58] It is worth noting that his extensive collection of books and instruments were 'dispersed by auction, by Mr Sotheby' in 1824 February before his death in November the previous year.[59]

4.8. *Gavin Lowe, Islington*

Few details can be assembled for the life or profession of Gavin Lowe (c.1743–1815), but his address at Paradise Row, Islington, indicates he had independent means.[60] Records of his life are limited to a posthumous paper and the history of an instrument he once owned.

His friend Thomas Firminger (1775–1861), assistant at the Royal Observatory, Greenwich,[61] published in 1818 a description of a mercurial pendulum devised by Lowe, from notes dictated to him in 1804.[62] Of more importance is a fine altazimuth circle that Lowe commissioned (1793) from Edward Troughton (1753–1833) for £120. In 1807 it was sold to Charles Greville before passing to the Rev. Lewis Evans in 1810 and was then purchased in 1828 by John Lee (1783–1866), who presented it to the Royal Astronomical Society. It was in turn used by W. H. Smyth for compiling measurements for his *Cycle of Celestial Objects*.[63]

We can assume that Lowe undertook meridian observations with this splendid instrument. It would need to have been installed in an observatory structure, along with a regulator clock, most likely at his residence at Paradise Row, Islington, then just a village on the outskirts of London – some original houses from the 1760s in the street survive. An idea of the likely structure can be gauged by comparison with those erected by Stephen Groombridge[64] or W. H. Smyth[65] for their meridian instruments.

Lowe's will of 1812 indicates that his books and mathematical and optical instruments were to be sold, while his chronometer was to be bequeathed to his nephew Dr James Andrew (c.1774–1835), Principal at the East India Company's Military Seminary at Addiscombe, Surrey.[66,67] A glimpse of Lowe's mathematical skills can be gleaned from the dedication to him by James Andrew in his *Astronomical and Nautical Tables*, who in the preface singles out Lowe as the man 'to whom I am indebted for a complete Table of Formulæ for reducing Time out of one denomination to another'.[68]

*Fig. 8: Sir Henry Charles Englefield (1752–1822). Mezzotint by Charles Turner, 1821, after Thomas Phillips. (Wellcome Collection)*

4.9. *James Strode Butt, Southwark*

Details of the occupation and life of James Strode Butt (c.1749–1826) are scarce, but some facts can be uncovered from his will and grave marker. One source indicates he 'established a reputation as an expert in the development of the astronomical instruments then used in navigation'.[69] It also confirms his partnership at Davis Wharf with Richard and Thomas Davis, and George Wood, the dissolution of which is recorded in the London Gazette (1795).[70]

These business interests suggest his profession was possibly as a London merchant. His astronomical interests, and likely confirmation of his observatory, are provided by a paper he supplied in 1805 to *A Journal of Natural Philosophy, Chemistry, and the Arts* titled 'Easy and Correct Method of verifying the Portion of a Transit Instrument'.[71] A letter from the author prefaces the paper, announcing 'A short note having appeared in Mr. Kelly's new edition of Spherics, describing my method of verifying the position of a transit instrument…'.[72] It is assumed that Butt had installed meridian instruments in an observatory at his home at the fashionable crescent called The Paragon off the New Kent Road, Southwark, on the edge of London.

4.10. *Sir Henry Englefield, Park Lane, London*

In contrast to others on the Hutton list, Henry Charles Englefield, seventh baronet (c.1752–1822) (Figure 8), has left plenty of traces in the historical records. A Catholic landowner of independent means, he left his family seat of White Knights, near Reading, allegedly due to the prejudice of the local gentry. He moved to London, living at 5 Tilney Street, Mayfair, for the rest of his life.[73]

Englefield had a wide range of interests besides astronomy. His scholarship encompassed antiquaries, natural history, and chemistry, and he held membership of most of the London learned societies.[74] The nature of his observatory or observing habits cannot be easily gleaned from his known astronomical works, *On the determination of cometary orbits*[75] and *Description of a new Transit Instrument*.[76] The topic of the latter paper would suggest that he probably had meridian instruments installed at his home. Applying his skills in designing a portable and easy-to-use transit suggests he was familiar with their operation.

The originality of the new device, similar to a broken transit, was challenged in print by the Rev. James Grooby. His letter to *The Philosophical Magazine* opined 'On receiving your last Magazine, I was not a little surprised to see in the new Transit Instrument there described, the exact representation of one I had thought of more than three years ago'.[77]

Grooby went on to say that its design had been disparaged by one 'Mr Banks', an instrument maker he had asked to make it.[78] Having not proceeded, he alleged its details were passed on to other makers, thence to Englefield after he was approached by the London optician Thomas Jones (1775–1852)[79] for a new form of portable transit. Claims of plagiarism are nothing new, but one is left wondering whether on this occasion Englefield used his contacts, within his wide circle of friends, to gain an advantage.[80]

4.11. *John Fuller, Rosehill, Sussex*

John Fuller (1757–1834), popularly known as 'Mad Jack', was an eccentric and reactionary member of the Sussex gentry who established himself as the squire of Brightling (Figure 9). As a politician he was a supporter of the slave trade, having partly inherited his great wealth from this activity.[81] As a builder of follies, he commissioned the architect Sir Robert Smirke (1780–1867) to build him an observatory, to fulfil his needs as an amateur astronomer. Alas, no contemporary account of the observatory or its instrumentation appears to have survived, despite the building still being extant although with a later dome.

However, a preliminary plan (1807) for the structure does exist and is held by the Royal Institute of British Architects (RIBA).[82] It indicates that the dome was to be fitted with a refracting telescope on an English style equatorial mount similar to that supplied to Armagh Observatory in Ireland.[83] The design also indicates a transit instrument and mural circle in separate rooms in the west wing adjacent to the central dome, with the east wing housing a lecture room and study. An annex

*Fig. 9: John (aka 'Mad Jack') Fuller (1757–1834). Engraving by Charles Turner in 1808 after a portrait by Henry Singleton. (British Museum)*

at the back of the building was to accommodate a zenith telescope.

It seems unlikely that these lavish plans were executed. The current building differs significantly from the Smirke plans; the meridian wing is absent, while a north-south extension has been added along with a circular single storey appendage on the east side.

The reason for these differences might be gleaned from an account in *The Morning Chronicle* for 1812 August 6:

> John Fuller, Esq. one of our County Members, (says the Lewes paper,) is erecting an observatory on that delightful and commanding eminence whereon a windmill lately stood on Brightling Down; and to give better effect to his astronomical pursuits, Mr Fuller has purchased that famous telescope which the late Sir George Shuckburgh so much prized for its excellence, being the best ever manufactured in England.[84]

The account appears to be gossip as Shuckburgh's equatorial telescope was given to the Royal Observatory, Greenwich, by his heirs in 1811.[85] Perhaps failure to acquire the prestigious instrument caused Fuller to scale back or cancel his original observatory plans. One source declares the observatory was governed by the Royal Institution,[86] an organization that Fuller generously endowed during his lifetime.[87]

4.12. *William Lax, St Ibbs, Hitchin*

The professional career of William Lax (1761–1836) is well documented, yet details of his observatory or observations are less clear.[88] A fellow of Trinity College, Cambridge, he was appointed in 1795 to the Lowndean chair of astronomy and geometry, then a sinecure. He then served on the Board of Longitude until its dissolution in 1828. The appointment indicates that he was seen as competent in both theoretical and practical astronomy, traits necessary to assess any methods proposed to determine longitude.[89]

After some years of teaching at Cambridge, Lax was awarded the livings of Marsworth, Buckinghamshire, and St Ippollitts, Hertfordshire, where he established the observatory cited on the Hutton/Pearson list in the garden of his house at St Ibbs, Hitchin.[90,91] That said there is no evidence as to the nature of the instruments used there or of observations undertaken. The ruined observatory is now a Grade II listed building.[92]

Lax probably used portable instruments as the small circular building appears to be ill-suited for use with fixed ones. The roof of the now partly collapsed structure was fixed with a set of small windows at the cardinal points. According to the Historic England website, the building reused materials from an observatory that once existed over the Great Gate at Trinity College, Cambridge (Lax's college).[93]

Historic England date the building to 1801 with a note of a bill indicating that Lax employed a local Hitchin glazier and plumber called Isaac Newton to work on the structure. As a result of this coincidence of names, local lore has connected the observatory with the more famous Isaac Newton, which is untrue.[94]

**5. Astronomical communities**

By uncovering the histories of these lesser-known figures, absent from the GLO, it is possible to compare their occupations with their better-known colleagues on the Hutton/Pearson list. In most aspects these are similar. Under the heading of clerics or academic figures, we find Lax and Catton, corresponding to Wollaston and Lewis on the GLO. Likewise, under the category of merchants or industrialists, there is Strutt and Butt against Groombridge, Beaufoy, and Joseph Huddart, whose wealth was due to his interests and innovations in rope manufacture.

Titled members of the aristocracy are also similarly matched, with the Duke of Marlborough, Earl of Macclesfield, and Sir George Shuckburgh versus the Duke of Richmond and Sir Henry Englefield on the GLO. The occupations of Hodgson and Lowe are unclear, but they were both evidently rich, their wealth either earned or inherited.

In the area of astronomy tuition, though, there is a contrast, with Kelly, Burney, and Walker against Pearson on the GLO list.[95] It highlights the prominence of astronomy teaching in private academies for both commerce and maritime trades. The latter were driven by the need for competent navigation by sailors in the Royal Navy and Britain's expanding merchant marine, typified by the East India Company. We can also add to the list Dr Thomas Firminger, friend of Gavin Lowe, as he is recorded as 'Master of an academy for the instruction of a limited number of young Gentlemen, in the theory and practise of Mathematics and the Mathematical Sciences'.[96]

In trying to analyse the astronomical communities that existed in late Georgian England, it is worth considering what influences were in play when Hutton and Pearson itemized their schedule of private observatories. Membership of the Royal Society gives some insight as it provides the milieu where Hutton would have met most of these individuals. Unlike today, the society was not a meritocracy; entry was regulated by your friendship and relations with existing Fellows. Your status in society was as important, namely whether you were a 'Gentleman', as your recorded achievements in the natural sciences, engineering, or mathematics.

All the people on the Hutton/Pearson list, and recorded on the GLO, were elected FRS, whereas only a quarter of the remainder were admitted to the Royal Society. The successful ones, absent from the GLO, were William Lax, Lowndean professor at Cambridge; William Strutt, a successful Derby industrialist; and William Hodgson, a collector of independent means. Those potentially excluded were all directly in business and trades who would have been seen as of lower social standing.

The sole exception was John Fuller, a very reactionary figure who inherited his great wealth – a significant proportion of it from the slave trade. It would not be difficult to imagine why he was never elected a Fellow. That said, it is clear that your background need not preclude election to Britain's premier scientific body. This can be seen with Strutt and Pearson, both working in industry and private education. Mark Beaufoy may be an exception in that he may have only inherited his wealth from an industrial source.

Social prejudices aside, it is clear that all these astronomers interacted with each other, and that Charles Hutton clearly mixed within a wide range of Georgian society. As we have seen, the aristocratic baronet Sir Charles Englefield happily interacted with the optician and instrument maker Thomas Jones who was also a Fellow of the Royal Society.[97] In many ways there were probably more contacts than in the succeeding Victorian period when class structure became deep-seated and entrenched. Earlier examples of such social mobility include Thomas Wright (1711–86), best-known from his educational texts and the orreries and other astronomical models he designed and made.[98]

**6. Conclusions**

In exploring the little-known astronomical figures uncovered from Hutton and Pearson's list of prominent private observatories, a light is shone on several aspects of late Georgian astronomy in England. It clearly outlines the demand for astronomy schooling in Britain's emerging commerce and industry, be it for merchants at Kelly's London academy or naval officers at Burney's nautical school in Gosport.

It also shows that there was a very diverse range of people involved in astronomy who established private observatories. These ranged from dilettantes like John 'Mad Jack' Fuller to Stephen Groombridge, who produced a valuable star catalogue still of use today,[99] and forgotten people like William Hodgson who confirmed William Herschel's double star observations.

Uncovering the details and activities of these neglected figures provides the basis for a better understanding of how the whole astronomy community operated and gives us an appreciation of its variety. Historical records by their very nature are selective, so we need be careful to try and see the bigger picture rather than rely solely on those who are deemed to have made a significant contribution or discovery.

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# Maria Mitchell (1818–89): From Nantucket to Vassar

Paul A. Haley

Maria Mitchell, America's first female professional astronomer, lived on the small island of Nantucket, Massachusetts, for 43 years before eventually becoming Professor of Astronomy at Vassar Female College in Poughkeepsie, New York State, a post lasting over 22 years. This paper describes the instruments and observatories she used and evaluates her astronomical work. Her life as assistant observer to her father William – himself an astronomer, chronometer expert, and teacher – was complemented by her work as a librarian, cartographer, and fire-fighter. She achieved international fame after discovering a telescopic comet in 1847 and calculating its orbital elements. Her peers rewarded her achievements in 1849 by fund-raising for a 3-inch Fitz comet-seeker. A larger sum raised eight years later secured a 5-inch Clark equatorial and observatory. She combined her library and domiciliary duties with those of a computer for the *Nautical Almanac* prior to embarking on tours of both America and Europe. After visiting the major observatories of Great Britain she visited France, Italy, and Germany. Maria Mitchell's mantra would later resonate proudly: 'I believe in women even more than in astronomy.'

## 1. A Quaker upbringing

Maria Mitchell (pronounced Ma-rye-ah) was born in Nantucket, Massachusetts, on 1818 August 1, the third child (of ten) of William Mitchell (1791–1869) and Lydia Coleman (1792–1861).[1] She had four brothers and five sisters, one of whom died aged three.[2] William and Lydia married just before the conflict of 1812–15 when the Royal Navy blockade of US ports severely limited trade routes to the island.[3]

Their first 15 years of marriage proved financially difficult with the arrival of six children. William worked in a variety of jobs, mainly teaching, and he was also an astronomer who rated chronometers for sea captains. Lydia's experience included teaching and librarianship.[4] The Quaker faith was dominant in Nantucket up to the 1820s but later declined. Maria's childhood began within a rigid belief system and ended with her increasingly questioning the Friends' 'Discipline' code.

During this time the population of Nantucket rose from 7,000 (1820) to 9,000 (1840) before reducing to 3,000 by the end of the 19th century.[5] The growth and decline of the whale-oil industry in Nantucket brought first prosperity and then economic failure to an island community 28 miles (45 km) from the US mainland. Against this backdrop Maria spent the first 43 years of her life, only moving 'off-island' in 1861 after the death of her mother. Four years later her international fame, skills and strong character led to a prestigious career at Vassar Female College in New York State, where she remained for over 22 years.[6]

Sunday worship included silent hours in the Friends meeting room with its plain walls and windows and absence of statues and artwork. The Quaker dress code, peaceful existence, simplicity, honesty, equality, and humility were enforced values. Marriage to non-Friends was not permitted, leading to both Andrew and William Forster Mitchell being disowned in 1843 and 1846 respectively. Maria also opted out when she was 25 but continued to follow Unitarian beliefs which were more aligned to intellectual exploration and science; she did however retain the dress code and used 'thee' and 'thou' in intimate conversation for the rest of her life.

William Mitchell also rebelled himself in several ways: introducing colour into their Vestal Street home by installing a water-filled globe in the parlour to cast rainbows (a study of optics and refraction); planting wild flower seeds in the garden for vivid displays (a study of botanical science); painting his Herschelian reflector mounting bright red; and using children to hold aloft painted wooden spheres representing planets orbiting at different speeds, almost dancing, during his public talks on celestial mechanics.

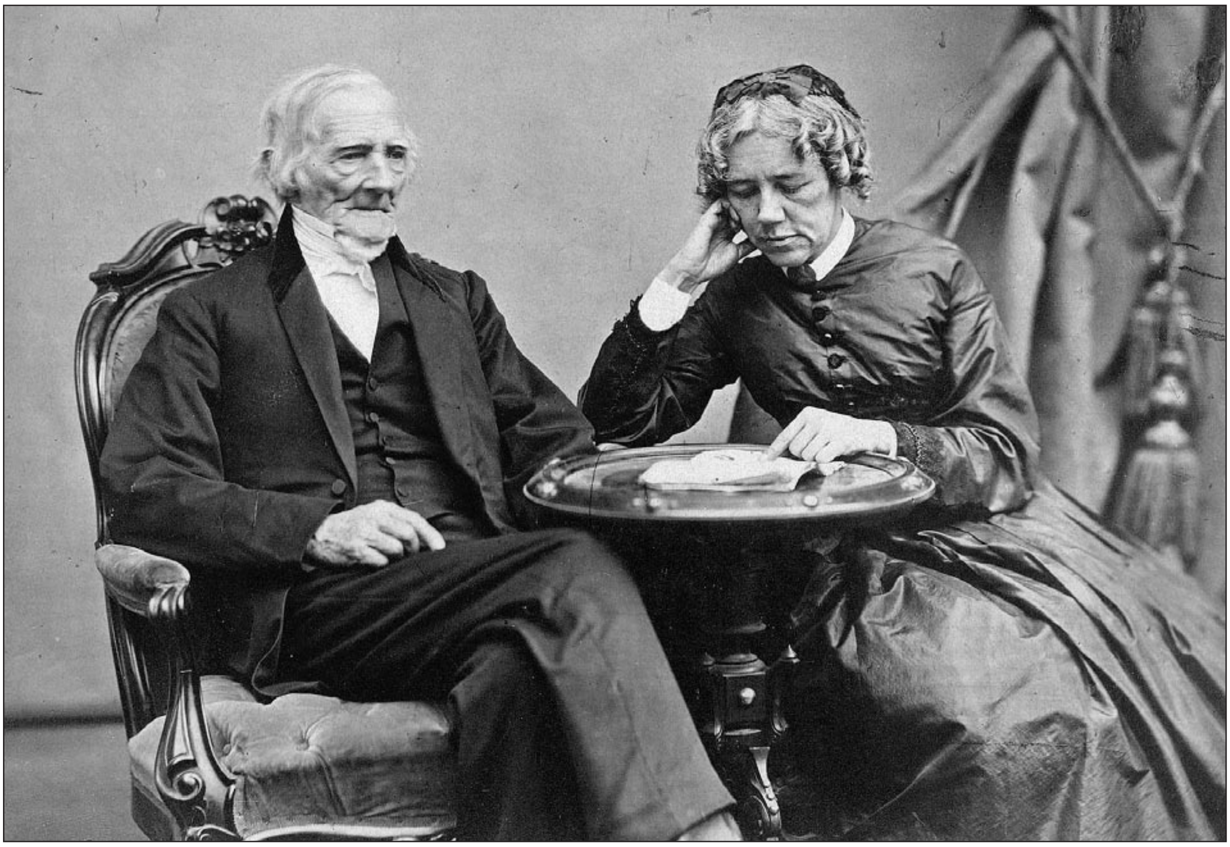


*Fig. 1: Maria Mitchell owed much of her early interest in science to her father, William, who was an astronomer, surveyor, and teacher. His concept of teaching as 'friends meeting for mutual improvement' was adopted by Maria when she became professor of astronomy at Vassar College. Here he is seen with Maria apparently reading to him in a photograph taken c.1868, a year or so before his death, when he had moved to live with her at the Vassar College Observatory. (Archives and Special Collections Library, Vassar College)*

William's preferred teaching style was holistic. For two years (1827–30) he was principal of the first public school, with 200 students, but disliked the need for discipline. He was happier founding his own private school (1830–32) with 25 boys and 25 girls, having bought a building lot for $30 (c.£480 today) on Howard Street.[7] No punishment was used and teacher and students met for mutual improvement. Both Maria and her elder sister Sally attended.

1.1. *Astronomical observations from Nantucket*

William Mitchell took an early interest in comets. In a paper entitled 'The Tails of Comets', published in *The American Journal of Science and Arts* in 1839 October, he recounts being 'impressed forcibly in my youth by the beautiful appearance of the comet of 1807, and, at a riper age, with those of 1811, 1819, 1825, and 1835, visible to the naked eye, and with others, seen at various periods by telescopic aid'.[8]

It seems probable that he shared his keen interest in comets with his three eldest children, encouraging them to become astute observers of the dark Nantucket skies; Andrew, Sally, and Maria were likely persuaded to at least glimpse the brighter examples and perhaps even learn how to challenge superstitions accompanying these celestial visitors. From their narrow roof-walk Maria might have observed half a dozen comets while at Vestal Street between 1825 and 1835 (Table 1).

Another spectacular phenomenon was the annular eclipse of 1831 February 12, the track of which passed over Nantucket. The day dawned icy and clear, too cold to spend three hours outside, so the parlour window was removed and a 2.7-inch Dollond refractor of 46-inch focus (f/17) was used with a smoked glass filter to observe the eclipse. Maria, aged 12½, counted seconds with the chronometer and their results were coordinated with others, from Monomoy and Dorchester, to determine the exact longitude of their home in Nantucket.[9] This value had wider significance, for it underpinned the rating service for the chronometers used on whaling ships which William Mitchell provided for the community. Within a year Maria was so proficient with the sextant that she could independently rate a chronometer for her father.[10]

Around this time the Nantucket Philosophical Institution (NPI) began admitting female members, and Lydia, Sally, and Maria all joined. President of NPI was the mathematician, inventor, and judge Walter Folger (1765–1849) whose astronomical clock and 5-inch f/12 Gregorian reflector were among the delights Maria enjoyed when she visited his private library.[11] She was equally impressed by his sister Phebe Folger

**Table 1**

**Comets seen by Maria Mitchell**

| Comet C/ | Discoverer | Date | Notes |
|---|---|---|---|
| 1825 N1 | J. L. Pons Marseilles | 1825 July 15 | Visible during Oct–Dec in evening skies. MM (aged 7) might have seen this comet in Scutum |
| 1828 2P (Encke) | F. G. W. Struve Dorpat | 1828 September 16 | WM and MM (aged 10) probably saw this |
| 1830 F1 | H. A. Faraguet Mauritius | 1830 March 16 | Great Comet of 1830. MM (aged 11) might have seen this at 4th mag with a 2° tail |
| 1831 A1 | J. Herapath London | 1831 January 7 | Great Comet of 1831. MM (aged 12) might have seen this comet in Serpens |
| 1832 3D (Biela) | M. Dumouchel Rome | 1832 August 25 | WM and MM (aged 13) would have searched for this in autumn skies |
| 1835 P1 (Halley) | M. Dumouchel Rome | 1835 August 6 | WM found this on September 4. MM (aged 17) would have tracked it across UMa, Boo, and Oph |
| 1843 D1 | Multiple | 1843 February 5 | Great March Comet. MM and WM observed it from the Pacific Bank with a 3.7-inch Dollond |
| 1847 C1 | J. R. Hind London | 1847 February 6 | Sungrazer. MM could have seen this |
| 1847 T1 | Maria Mitchell Nantucket | 1847 October 1 | Telescopic comet found 5° from Polaris in Cepheus with 2.7-inch Dollond. MM's first comet discovery |
| 1849 G2 | E. Goujon Paris | 1849 April 15 | Independently discovered by MM on May 19 using 2.7-inch Dollond |
| 1853 G1 | K. G. Schweizer Moscow | 1853 April 5 | MM might have observed this near the horizon |
| 1853 L1 | W. Klinkerfues Göttingen | 1853 June 11 | MM might have observed this with her new 3-inch Fitz comet-seeker. |
| 1854 F1 | Multiple | 1854 March 23 | Great Comet. Independently discovered by WM on March 30. MM observed it with her Fitz comet-seeker |
| 1854 R1 | W. Klinkerfues Göttingen | 1854 September 11 | Independently discovered by MM on September 18 with her Fitz comet-seeker |
| 1855 V1 | K. C. Bruhns Berlin | 1855 November 12 | Independently discovered by MM on December 12 with her Fitz comet-seeker |
| 1858 L1 (Donati) | G. B. Donati Florence | 1858 June 2 | Independently discovered by MM on July 1 with her Fitz comet seeker |
| 1860 M1 | Multiple | 1860 June 18 | Great Comet. Independently discovered by MM |
| 1861 J1 | J. Tebbutt Windsor, NSW | 1861 May 13 | MM would have observed this in Ursa Major in July, just before her mother's death |
| 1862 109P (Swift–Tuttle) | L. Swift, NY H. P. Tuttle, HCO | 1862 July 16 | Observed by MM using 5-inch Clark at Lynn 1862 July 19 |
| 1864 N1 | W. Tempel Marseilles | 1864 July 5 | Second bright comet observed by MM at Lynn. Spectrum observed by Donati and Huggins |

*Table 1: Maria Mitchell had seen some 20 comets by 1865, as listed here. Her father William Mitchell probably showed her the earliest examples. MM found her first comet on 1847 October 1 in northern Cepheus. She made five more independent discoveries at Nantucket (1849, 1854, 1855, 1858, 1860). By 1860 she had a 5-inch Clark equatorial with a micrometer which allowed her to measure accurate positions.*

Coleman (1771–1857), whose self-taught mathematical and navigational skills were complemented by her abilities as a watercolour artist and poet.[12]

Maria's aptitude for mathematical astronomy was further advanced in 1832 by the tuition of Cyrus Peirce (1790–1860) in Orange Street and she became his paid assistant teacher (1834).[13] On 1834 November 30 Maria timed another solar eclipse with her father.[14] She studied Ferguson's *Astronomy*, Bridge's *Conic Sections*, and Hutton's *Mathematics*, working in a small alcove below the garret.

*Fig. 2: The Mitchell family home at 1 Vestal Street, Nantucket, as seen in 1965. Maria Mitchell was born in this house in 1818 and lived there until 1836 when the family moved to the Pacific Bank at 61 Main Street. Maria observed from a narrow roof-walk on this house. The house has been a museum since 1903. (Historic American Buildings Survey/Cortlandt V. D. Hubbard/Library of Congress)*

At age 17, Maria next founded her own school for girls aged 6 to 14 (1835), emphasizing to her young students the importance of becoming good observers of natural phenomena, a theme she would return to three decades later at Vassar.

Coinciding with this was the predicted return of Halley's Comet. On 1835 September 4 her father found the comet using the small Dollond telescope, with only observers at Yale beating him to its recovery in America.[15] The apparition proved excellent for observers who were easily able to track the first-magnitude visitor as it moved from Ursa Major through Boötes to Ophiuchus, with a spectacular 20° tail developing during October. Aurorae were also recorded regularly, and the father-daughter observing pair often published their results in the *Nantucket Inquirer*.[16]

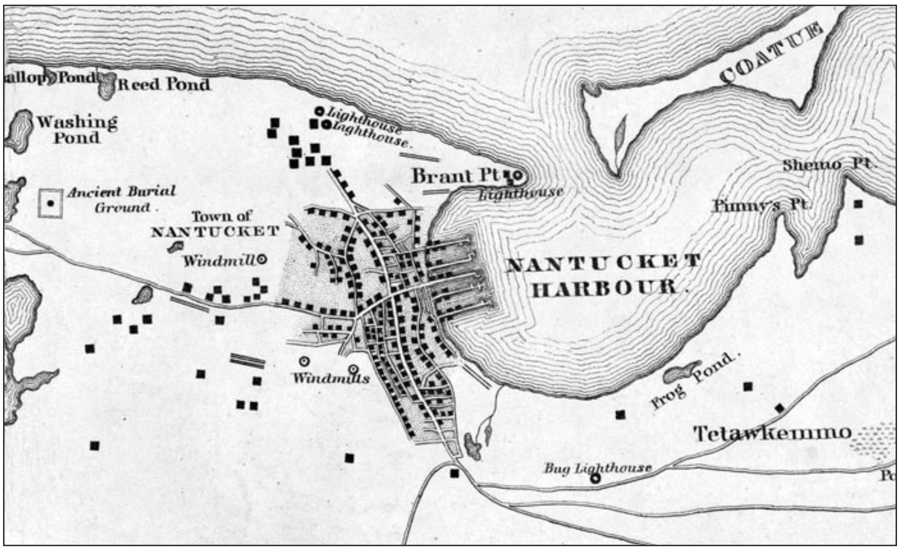
### 1.2 *Geodetic and astronomical observations*

At the beginning of 1837 the Mitchell family sold their Vestal Street home and moved to an elegant apartment above the Pacific Bank where William had been appointed cashier on a salary of $1,200 (c.£19k today).[17] The flat roof of the bank provided a larger, safer space for an observing site and a small wooden observatory store was constructed. Here, William consolidated his work for the United States Coastal Survey (USCS), whose superintendent (1832–43) was surveyor Ferdinand Rudolph Hassler (1770–1843); in return for celestial and geodetic measurements for latitude and longitude he was able to upgrade his instruments and earn an additional $150 per annum.[18]

Cartography on Nantucket was developed significantly by William Coffin (1798–1838) whose detailed town map (1834) was produced at a scale of 1:3000. For the whole island Coffin recruited the Mitchells and borrowed a repeating circle from West Point Academy.[19] Initially William was busy with banking, insurance, and astronomical work so while Maria helped survey the island her older sister Sally drew the map. Their combined efforts underpinned publication of the 1:40000 scale map (1838) a few months after Coffin's death (Figure 3). The magnetic declination was measured as 9° 02′ 19″ W and a pair of meridian stones were erected two years later on a north–south line, one placed outside the Pacific Bank and the other 100 yards south down Fair Street.[20]

Installed in two wooden huts behind the Pacific Bank were transit instruments, one for meridian work and the other for prime-vertical observations. On the roof a 3.7-inch Dollond of 60-inch focus (f/16) was mounted equatorially on an old ship's mast. Installation of this so-called 4-inch telescope was achieved with the help of mathematician Elias Loomis (1811–89) who used similar apertures at the Western Reserve College in Hudson, Ohio. These instruments facilitated thousands of observations of meridian altitudes for time

Fig. 3: *Nantucket Harbour in 1838, showing the town and five main wharves. This map was based on the survey work of cartographer William Coffin and three members of the Mitchell family, namely William and his daughters Sally and Maria. Nantucket Island lies about 30 miles south of Cape Cod off the New England coast of America. (Norman B. Leventhal Map & Education Center, Boston Public Library)*




and latitude together with Moon culminations and occultations for longitude.

The father-daughter partnership jointly observed planetary motions, sunspots, meteors, and aurorae; investment in a larger celestial globe helped with interpretation of their observations. During the auroral display of 1840 May 29, the best since 1827, they timed a prominent arch as it moved steadily across Arcturus near the meridian in 2½ minutes.[21]

Less satisfactory were their observations of the bright Sun-grazing comet (C/1843 D1) in 1843 March; the Mitchells had only an annular micrometer and believed their results lacked precision.[22] They had more success in 1844 August, recording 30 meteors in 45 minutes and faint auroral streamers.[23] The following month a spectacular solar halo with a 20° radius was observed.[24]

In 1845 they began reviewing the *Cycle of Celestial Objects* by William Henry Smyth (1788–1865), whose descriptions of the tints of double stars and nebulae visible in a small telescope proved well-suited to Maria's keen perception of colour.[25] Meteorological records taken by Maria for the period from 1843 April to 1845 July resulted in her first published paper.[26]

During the 1840s William Mitchell further developed his friendship with William Cranch Bond (1789–1859) who ran a family chronometer business in Boston. Bond used similar equipment to Mitchell in his private Dorchester Observatory (1823–39) at his home near Boston, and they both kept detailed meteorological records.

Their collaboration for longitude comparisons began with the 1831 solar eclipse. Three years later Bond had a US Navy contract to rate its ships' chronometers for the ports of Boston and Portsmouth. In 1839 October Bond was appointed Astronomical Observer at Harvard University (an unpaid position) and for two years was assisted by his eldest son, mathematician William Cranch Bond, Jr (1821–41).

On the early death of his brother, George Phillips Bond (1825–65) switched his interests from wildlife and nature to astronomy to help his father; George graduated (1845) and the father-son pair were on payroll from 1846 April.[27] From 1839 to 1844 the Bonds lived at Dana House, Cambridge, where a cupola observatory was installed on the roof.

In 1842 October a letter from Bond to William Mitchell detailed the plans underway for a large new telescope at Harvard.[28] The Bonds moved to the new observatory site in 1844 September and determined their latitude using a prime-vertical transit telescope, to a precision of one arc-second.[29]

The two families corresponded regularly and exchanged occasional visits, with Maria and George becoming good friends. The isolation of Nantucket was reducing with improved train, coach, and steamboat services; it became possible to leave Boston at 7 a.m. and reach the island by 4 p.m. Maria began to journey farther afield, including a first visit to Poughkeepsie, New York, in 1844 September.[30]

### 1.3. *The Nantucket Atheneum*

In 1836 autumn 18-year-old Maria was offered the job of librarian at the newly founded Nantucket Atheneum, a private membership library, with a starting salary of $60 rising to $100 after two years.[31] The position was a major recognition of her skills and potential for expanding the role of women and science in the Nantucket community.

During the period 1820–60 women's access to education in America expanded rapidly. Despite its geographical isolation, Nantucket was at the forefront of these changes. The Atheneum, with its white wooden Doric columns, was located in Pearl Street, between the Pacific Bank and the harbour, and included a library for shareholders, a meeting room, art gallery, and museum. It was open for 15–20 hours per week during afternoons and on Saturday evenings, allowing Maria time to complete her household duties and calculations in the mornings.

The library provided her the means to self-educate, by learning Latin and German and further extending

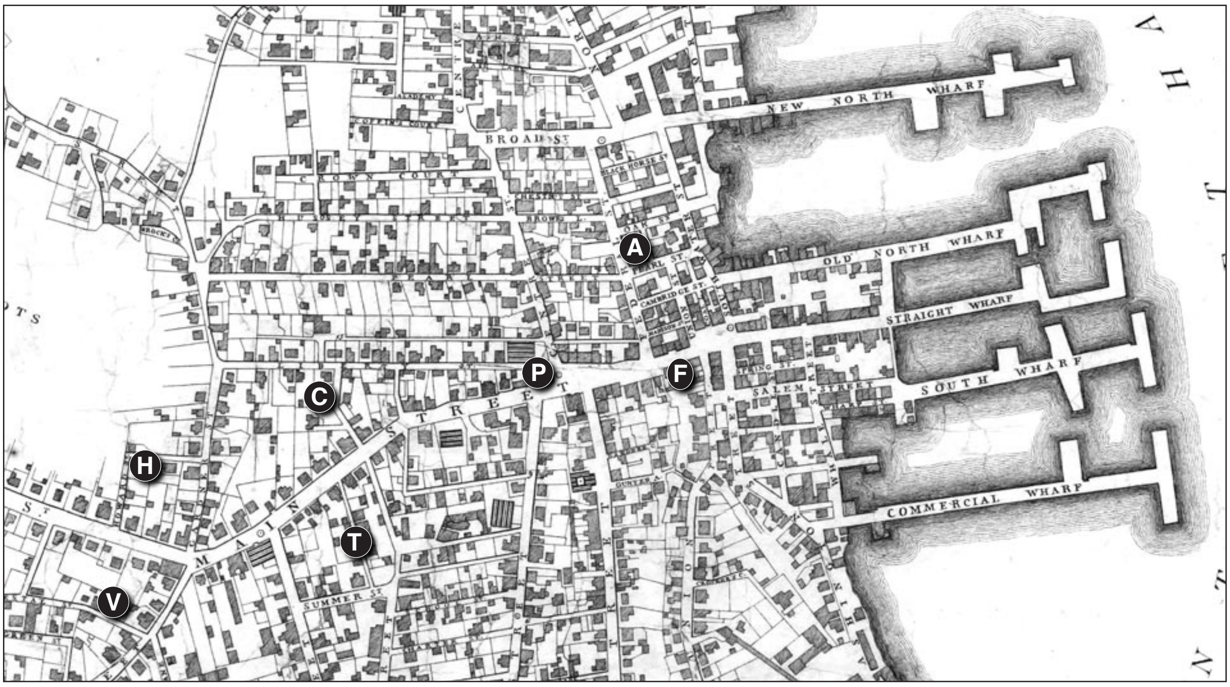



*Fig. 4: Central Nantucket on the 1834 street map by William Coffin. The lettered dots indicate where Maria lived and worked: V = Vestal Street home (1818–36); H = William Mitchell school in Howard Street (1830–32); C = Coffin School, where Maria's observatory was built (1858); T = Maria Mitchell school in Trader's Lane (1835); P = Pacific Bank home (1837–61); A = Atheneum, Pearl Street (1836–56); F = Geary's hat store on Main Street where the 1846 fire started. The fire consumed the four northern wharves and the adjacent streets, spreading inland almost as far as the Pacific Bank.*

her mathematical knowledge. She mastered calculus and studied textbooks including Gauss's *Theoria Motus Corporum Coelestium*, Laplace's *Mécanique Céleste*, Bowditch's *American Practical Navigator*, and Airy's *Gravitation*. Each text was subjected to thorough analysis, with every statement tested; Maria noted that Airy's work was accurate but clumsy.

In addition to her own studies Maria developed the reading of young people in Nantucket as she expanded the Atheneum's collection of 3,200 books. She also read novels, Shakespeare, and poetry, becoming a joint-founder of the Coterie literary club.[32]

The Lyceum movement delivered regular public lectures designed to broaden the culture of the Nantucket community by inviting radical thinkers as speakers.[33] In 1841 August the Atheneum also hosted a three-day anti-slavery convention.[34] In this intellectually free environment, Maria's decision to stop attending Quaker meetings, and consequently to be disowned by the Friends, was an inevitable consequence. In the words of the author Renée Bergland, Maria became 'radiantly intelligent, ferociously witty, and demonstrably knowledgeable'.[35]

Within the Mitchell family the death of the first grandchild, William Mitchell Barney, in 1842 September proved a sad blow.[36] In 1845 her father, whose work with the USCS was nationally recognized, was proposed for director of the US Naval Observatory, Washington, with Maria as his assistant, but the Mitchells wanted to remain loyal to their Nantucket roots.[37] But a decade after Maria began at the Atheneum a calamitous event occurred that would change everyone's lives.

### 1.4. *The Great Fire of 1846*

On 1846 July 13 the Nantucket heatwave continued unabated. Waterfront wharves bustled with activity around the markets, shops, and candle factories. For once the on-shore easterly breeze carried the stench of the whale-oil refineries away from the town; up the hill orderly groups of people wearing black and grey dress bade good-evening to their friends and returned home. The skies were overcast so the small observatory atop the Pacific Bank remained closed and the Mitchell family retired to their beds.

Around 11 p.m. a watchman in South Tower, Orange Street, spotted flames leaping above William Geary's hat store in Main Street. Church bells sounded the alarm. Over the next seven hours one-third of the town succumbed to the inferno and the commercial heart of Nantucket was destroyed (Figure 4).

As Maria Mitchell joined her family outside the Pacific Bank she would not have expected the fire to almost completely erase her decade of work at the Atheneum, but it too was engulfed. Altogether 250 buildings, seven factories, twelve warehouses, and three of the town's four wharves were consumed.

Fuelled by the wooden houses and high winds, fire spread across 36 acres of the town, making 800 people homeless but thankfully causing no loss of life. Casks of inflammable whale-oil on the wharves burst open,

**Table 2**

**Observations of Maria Mitchell's comet (C/1847 T1)**

| 1847 | Location | Observers | Instrument aperture inches | RA h m | dec ° ′ | δ au | *r* au | Notes |
|---|---|---|---|---|---|---|---|---|
| Oct 1 | Nantucket | MM and WM | 2.7″ refractor | 02 35 | 81 09 | 0.40 | 1.15 | 7th mag at 22h 50m, above Polaris |
| Oct 2 | Nantucket | MM and WM | Transit, 2.7″ and 3.7″ refractor | 00 11 | 84 22 | 0.38 | 1.13 | Meridian transit at 23h 46m; diffuse, no tail |
| Oct 3 | Nantucket<br>Rome | MM and WM<br>de Vico | 2.7″ and 3.7″ refr.<br>6.2″ Cauchoix | 22 11 | 84 52 | 0.35 | 1.11 | Brightening. Independent discovery at Collegio Romano |
| Oct 4 | | | | | | 0.32 | 1.09 | Cloudy |
| Oct 5 | Nantucket | MM | 2.7″ and 3.7″ refr. | 18 11 | 79 58 | 0.30 | 1.07 | Transited 5th-mag. 40 Dra; comet central at 22h 54m, ×100 |
| Oct 6 | Nantucket | MM | 2.7″ and 3.7″ refr. | | | 0.27 | 1.05 | Naked-eye until moonlight too strong |
| Oct 7 | Camb. US<br>Cranbrook | Bonds<br>Dawes | 15″ Merz<br>6.3″ Merz | 17 11<br>17 12 | 70 01<br>70 16 | 0.25 | 1.03 | First observation at HCO<br>Naked-eye 'discovery' near ω Draconis |
| Oct 8 | Cranbrook | Dawes | 6.3″ Merz | 16 59 | 64 30 | 0.23 | 1.01 | 5th mag., near ζ Draconis |
| Oct 9 | Camb. US | Bonds | 15″ Merz | 16 44 | 55 32 | 0.22 | 0.99 | 1.5° tail. New Moon in Libra |
| Oct 10 | South Villa | Hind | 7″ Dollond | 16 39 | 48 13 | 0.20 | 0.97 | 1° tail; ½ ° coma; near τ Herculis |
| Oct 11 | Camb. US<br>Camb. UK<br>Cranbrook<br>Hamburg | Bonds<br>Challis<br>Dawes<br>Rümkers | 15″ Merz<br>11.6″ refr.<br>6.3″ Merz<br>4″ Repsold | 16 32<br>16 33<br>16 33<br>16 32 | 36 38<br>36 51<br>37 42<br>36 48 | 0.19 | 0.95 | Bond orbit results for 7th, 9th, and 11th<br>Northumberland telescope<br>4th mag; 30′ coma; near M13<br>Mrs Mary H. C. Rümker 'discovery' |
| Oct 12 | Vienna<br>Camb. UK | Littrow<br>Challis | <br>11.6″ refr. | 16 29<br>16 28 | 29 33<br>29 00 | 0.19 | 0.93 | Closest to Earth, near ζ Herculis |
| Oct 13 | Cranbrook | Dawes | 6.3″ Merz | 16 24 | 19 42 | 0.19 | 0.91 | Near γ Herculis. Pogson orbit using Dawes results from 7th, 11th, and 17th |
| Oct 14 | Camb. US<br>Vienna | Bonds<br>Schaub | 15″ Merz | 16 21<br>16 21 | 09 51<br>11 23 | 0.20 | 0.89 | |
| Oct 15 | Camb. US<br>Cranbrook<br>Leiden | Bonds<br>Dawes<br>Kaiser | 4.2″ Merz<br>6.3″ Merz<br>6.0″ Merz | 16 18<br>16 18<br>16 18 | 02 36<br>04 00<br>03 57 | 0.21 | 0.87 | Using Troughton micrometer |
| Oct 16 | Vienna | Littrow | | 16 18 | −02 09 | 0.23 | 0.85 | Moving rapidly south |
| Oct 17 | Cranbrook | Dawes | 6.3″ Merz | 16 18 | −07 54 | 0.25 | 0.83 | Near ν Ophiuchi |
| Oct 18 | Leiden<br>Camb. US | Kaiser<br>Bonds | 6.0″ Merz<br>4.2″ Merz | 16 17<br>16 11 | −12 21<br>−13 19 | 0.27 | 0.81 | Near ξ Scorpii; last observations before perihelion |
| Dec 10 | Rome | de Vico | 6.2″ refr. | 15 10 | −09 55 | 1.42 | 0.75 | First sight after perihelion, near β Librae |
| 1848 Jan 3 | Königsberg | Busch | 6.5″ helio. | 15 41 | +08 48 | 1.42 | 1.23 | Extremely faint. Near α Serpentis. Last observation |

*Table 2: C/1847 T1 or 'Miss Mitchell's comet' was unusual in having a highly inclined hyperbolic orbit. Before perihelion it was only visible in northern skies for 18 days, passing closest to the Earth at 0.19 au on 1847 October 12, by when its brightness had increased from 7th to 4th magnitude. Perihelion was on November 14, 0.33 au from the Sun. After perihelion it was recovered by Rome observers on December 10 and then faded rapidly. This table is based on the published results of 15 observers in the northern hemisphere; no records of the comet's visibility in southern skies have been found.*

adding to the whale-oil slicks in the harbour so that even the sea appeared to be alight. On the south-west corner of the fire footprint the brick-built Pacific Bank survived, but its wooden observatory store on the roof was burnt down and observing records lost.[38]

The initial cost of the Great Fire was estimated at $1 million (c.£16 million today), but the long-term cost was far greater. The infrastructure damage contributed directly to a rapid demise of Nantucket as a whaling community, and a consequent fall in population.[39]


*Fig. 5: The Nantucket Atheneum, where Maria Mitchell worked as librarian from 1836 to 1856, was rebuilt in Greek Revival style in 1847 after the Great Fire. This photograph, taken in 1962, shows it little changed from Maria's day. (Historic American Buildings Survey/Cervin Robinson/Library of Congress)*

1.5. *Rebuilding, and the 'Nantucket comet'*

Three months after the Great Fire, with rebuilding of the Atheneum underway, Maria visited Cambridge to meet with the Bonds and hear news of the 'Great Equatorial' for Harvard. On 1846 October 21 details of the discovery of an eighth planet had been received and she became one of the first Americans to observe Neptune, using the Bonds' 3-inch f/15 equatorial.[40]

A new hypothesis to explain the structure of the Milky Way had been proposed by Johann Heinrich von Mädler (1794–1874), the director of Dorpat Observatory, and George Bond was keen to discuss the validity of the idea during Maria's visit.[41] He respected her expertise in mathematical astronomy and she would have had little difficulty in reading the German original and providing a critique of the hypothesis.[42] Maria was impressed by George Bond's observations of Saturn's rings and his pair of short-focus comet-seekers and she resolved to begin her own comet quest.[43]

After their return home the Mitchells learned of their selection by the USCS as a key geodetic station, the understanding being that Nantucket should be one end of a great arc in the determination of the figure of the Earth.[44] This was important news as it would involve replacement of their cumbersome prime-vertical transit by a more efficient zenith telescope.[45]

More immediate business was the reopening of the Atheneum just six months after the Great Fire. Donations included 1,800 books for the library, and regular public lectures were quickly reinstated.[46] At the Pacific Bank their roof-top wooden observatory store was rebuilt by the New Year allowing astronomical work to resume, with Maria conducting systematic comet-searches using the 2.7-inch Dollond refractor on an altazimuth tripod mount. Maria typically searched for 2–3 hours with slow horizontal and vertical sweeps of the sky using a 2° upright field of view.

Her diligence brought a major result when on 1847 October 1 Maria, aged 29, found a telescopic comet (C/1847 T1) at 10h 50m, 5° from Polaris in the constellation of Cepheus (Table 2). The 7th-magnitude visitor was then 1.15 au from the Sun but only 0.4 au from the Earth.[47]

Fortunately four of the next five nights were clear and a waning Moon facilitated dark skies. Maria and her father used all three instruments at their disposal, noting on October 2 that 'its change of space was manifest, and at 11h 46m 55s its meridian passage was taken by a transit instrument, the right ascension being 0h 11m 08.96s and declination +84° 22′ … no appearance of condensation of light towards its centre, nor any indication of a train could be detected.'[48]

Despite his daughter's reluctance William Mitchell mailed a letter to Cambridge, explaining: 'Last evening it had advanced westwardly; this evening still further, and nearing the pole … it does not bear illumination, but Maria has obtained its right ascension and declination, and will not suffer me to announce it … pray tell me whether it is one of George's; if not, whether it has been seen by anybody'.[49]

On the following night the 'diffuse nebula' began to reveal its secrets: 'Its motion and brightness had much increased [6.5 mag?] … the observations of this evening were much interrupted by passing clouds, and during a period of obscurity, the comet must have passed very near the star 7851 [mag. 5.5] of the Catalogue of the British Association.'[50]

On the same evening, 4,000 miles east, the Italian astronomer Francesco de Vico (1805–48) at Collegio Romano was making his own 'discovery' of the comet, using the 6.2-inch Cauchoix refractor of the Jesuit observatory.[51] Clouds obscured the sky on October 4 and the following day William Mitchell had to leave Nantucket for a business trip. Working alone Maria had more success: 'On the 5th, the evening was delightful … it was evident that the comet would transit a fixed star of the fifth magnitude … at 10h 54m the star appeared to be exactly in the centre of the comet … using a power of 100'.[52]

On this night she would have realized the comet had a highly inclined orbit as it had moved rapidly south into Draco; this meant that northern observers would have a limited time to make their observations. Its increasing brightness suggested it was also moving closer to the Earth. Calculations later showed it was then 0.3 au distant. On 1847 October 6 Maria noted: 'The comet was manifest to the naked eye … moving rapidly toward the Equinoctial [celestial equator] and slightly diminishing its Right Ascension.' [53]

The Bonds at HCO observed the comet on six nights between October 7 and 18, initially using the newly installed 15-inch and later a 'five-foot equatorial'.[54] William Bond recorded their initial observations: 'Last evening [October 7] we obtained positions of the Nantucket Comet … it is quite bright with considerable condensation of light – fills the field of the telescope with a power of 180 … moving rapidly – at a rate of 6 degrees daily towards the sun'.[55]

On October 9, when the 5th-magnitude comet was only 0.22 au from Earth and 0.99 au from the Sun, they noted that 'it exhibited a faint train, a degree and a half in length, and opposite to the sun'.[56] Two nights later the Bonds noted 'a faint tail of two degrees in length in the comet-seeker of 4-inch aperture'.[57]

On the other side of the Atlantic, William Rutter Dawes (1799–1868) at Cranbrook, Kent, observed the comet from October 7 to 17 on six nights using a 6.3-inch Merz refractor, recording 'a hazy star of the fifth magnitude, near ω Draconis. Examination with the 8½-foot refractor proved it to be a large comet, its rapid motion being speedily detected'.[58]

The following night John Russell Hind (1823–95) at South Villa observatory in Regent's Park, London, measured its position with the 7-inch Dollond refractor owned by George Bishop (1785–1861), estimating the size of the coma as ½°.[59]

On October 11, at the time of its closest approach to the Earth, Dawes noted that 'it had the light of a star of the fourth magnitude, near η Herculis. The nebulosity in the telescope extended over 30′, nearly round, much condensed in the centre, but without stellar nucleus. A star of the tenth magnitude was distinctly seen through the exact centre of the comet.' [60]

Maria Mitchell's comet was now clearly visible to the naked eye near the great globular cluster M13 in Hercules, enabling Mary Hannah Crockford Rümker (1809–89) at Hamburg observatory to make her own independent 'discovery'.[61] On his 12-day business trip William Mitchell had come to believe that 'Maria was the first in America so far as we have been able to ascertain'.[62] Meanwhile on her island Maria had followed it as far as Nantucket skies would permit before

**MISS MITCHELL'S COMET.**

***Elements.***

**Miss Mitchell has computed the following Elements of the Comet discovered by her on Oct. 1, 1847.**

Perihelion Passage, 1847, Nov. 14·499, Greenwich M.T.

| | ° | ′ | ″ |
|---|---|---|---|
| Longitude Perihelion .............. | 274 | 10 | 6 |
| Node .................... | 189 | 35 | 29 |
| Inclination .......................... | 71 | 33 | 32 |

Per. Dist. = 0·341348. Motion Retrograde.

*Fig. 6: Maria's mathematical skills enabled her to calculate the orbital elements of her comet, C/1847 T1. These were published in the leading astronomical journals of the day, including the Monthly Notices of the Royal Astronomical Society in 1848 January (above). The eccentricity of the orbit turned out to be slightly more than 1, meaning that it is hyperbolic and so the comet will not return.*

the weather broke. Although she would never see 'her' comet again, the discovery would bring far-reaching consequences.

## 2. International recognition

The last observation of C/1847 T1 was made at Königsberg observatory on 1848 January 3, by which time its orbital elements had been calculated by a dozen astronomers, including Maria herself (Figure 6).[63] First to publish was the German astronomer Heinrich Louis d'Arrest (1822–75) on October 18 in No. 616 of the *Astronomische Nachrichten*. He used the October 11 Hamburg position with two from Berlin observatory (October 14 and 16) to calculate elements for what he called 'Comet von de Vico', still being under the impression that it had been discovered in Italy.[64]

In the 1847 October RAS *Monthly Notices* all doubt over the discoverer was put to rest when details of 'Miss Mitchell's Comet' were published, with elements by George Bond using HCO observations from October 7, 9, and 11. An ephemeris by d'Arrest for December 10–20 predicted the comet's imminent return to northern skies.[65] In the *Astronomische Nachrichten* the Dutch astronomer Frederik Henry Kaiser (1808–72), director of Leiden observatory, published his results using positions for October 11, 15, and 17.[66]

The November *Monthly Notices* included positional measurements by James Challis (1803–82) at Cambridge together with elements by both Rümker, using positions from October 3 (Rome) and October 11 and 17 (Hamburg), and Norman Robert Pogson (1829–91), using Dawes' measurements for October 7, 11, and 17.[67] Maria's elements duly appeared in *MN* the following January,[68] and her father summarized her comet discovery in *The American Journal of Science and Arts*.[69]

Alexander Dallas Bache (1806–67), who had succeeded Hassler as superintendent of the USCS in 1843, was among many scientists congratulating Maria, writing to William Mitchell on 1847 October 18: 'Now if she determines the orbit also it will be another jewel'.[70]

*Fig. 7: The five Mitchell sisters in a daguerreotype taken c.1849. From left: Anne (aged 30), Maria (32), Phebe (22), Kate (17), and Sally (34). At that time Sally was the only one who was married. (Courtesy of the Nantucket Maria Mitchell Association)*

The Bonds supported Harvard president Edward Everett (1794–1865) to make a claim for her discovery to be recognized internationally, as she qualified for the 20 ducats gold medal offered by Frederick VI King of Denmark.[71] Maria reinforced her claim by determining the elements of the hyperbolic comet orbit, as Bache had hoped, and submitting details to astronomical journals in both Europe and America.[72]

2.1. *Danish comet medal*

News that her claim was successful came when a red-sealed official letter from Denmark arrived in Nantucket on 1848 October 6. Six months later, a delighted Everett contacted the Mitchells to say the inscribed gold medal had arrived in Cambridge, and Maria's life changed forever.[73]

Several key developments were forthcoming:

(i) election to the American Academy of Arts and Sciences (1848 May), the first woman member;[74]

(ii) an invitation (1848 August) by Charles Henry Davis (1807–77), superintendent of the new *American Ephemeris and Nautical Almanac*, to become a computer. The job involved calculating the daily positions of Venus, on a salary of $500; her acceptance made her the first professional astronomer in the US, a job she continued for 19 years;[75]

(iii) a gift of $100 from Joseph Henry (1797–1878), director of the Smithsonian Institution, Washington;[76]

(iv) a campaign (1849 autumn) by Boston merchant Jonathan Ingersoll Bowditch (1806–89) to fund her a telescope.[77] Maria ordered a comet-seeker by Henry Fitz (1808–63): a 3-inch refractor of 25-inch focus (f/8) with a field of 4° at low power which also facilitated her growing interest in observing star colours;[78]

(v) election to the American Association for the Advancement of Science (AAAS, 1850 August), the first female member.

The year 1848 began with storms preventing much observation. Maria's friendship with the Bond family increased, especially with William Bond's second wife Mary, their daughter Selina, and sons William and Joseph.[79] In March the Mitchells collated reports of a spectacular fireball seen over Nantucket.[80] In July Maria's comet discovery was celebrated at the first women's rights convention, in Seneca Falls, New York.

Her growing celebrity status began to prove challenging during the summer months as island visitors to the Atheneum wished to meet her; in contrast, the Nantucket winters continued to be desolate and windy. In the autumn, just as news of her gold medal arrived, William Mitchell requested on loan from the USCS a zenith telescope to replace the prime-vertical instrument. Bache also arranged for Maria and her younger brother Henry to spend three weeks at Mount Independence, Maine, the following summer to learn more about surveying techniques.[81]

Maria continued her search for comets with the little Dollond, finding a second one of magnitude 6 on 1849 May 19 in Ursa Major (C/1849 G2).[82] At Cambridge George Bond was being even more successful, finding 12 comets by 1853.[83] Their friendly rivalry led to regular correspondence and exchange of observing practices.

In 1850 July George and his brother Richard journeyed to Nantucket to show the Mitchells the first daguerreotype of a star (Vega), a project which had taken four months to achieve.[84] Their friends used similar technology to produce a family photograph of the five Mitchell sisters (Figure 7).[85]

2.2. *Visits and visitors*

In 1850 August Maria took the three-hour steamboat trip to Hyannis to connect with carriage and train to visit New York. She met with Elias Loomis, professor of natural philosophy and mathematics in the University of the City of New York, who was completing his book *The Recent Progress of Astronomy: Especially in the United States*. Inclusion of a chapter on 'Miss Mitchell's Comet' further enhanced her fame.[86]

In 1850 the German scientist Alexander von Humboldt (1769–1859) had produced the third volume of his monumental book *Kosmos*, a copy of which had been acquired for the Atheneum library. Maria was intrigued to read of the proposal by Samuel Heinrich Schwabe (1789–1875) that sunspots followed a 10-year cycle.[87] It is likely that Maria and Loomis would have discussed this finding and the possibility of a link with aurorae.[88] Maria was to meet Humboldt six years later in Berlin.

In 1851 the Mitchells observed the partial solar eclipse of July 28 for two hours from the bank roof, while a visit from Bache to Nantucket that summer resulted in Maria writing a detailed paper on the work of the USCS.[89]

Another visitor, the Prussian-born artist Herminia Borchard Dassel (1821–57) who had a studio in New York City, specifically wanted to produce oil portraits of the Mitchell family. Maria was painted with an idealized telescope (Figure 8), and her father and younger sister Kate were also captured by the artist.[90]

In 1852 May Maria travelled to see her brother Henry in Washington. They visited the US Naval Observatory, directed by Matthew Fontaine Maury (1806–73). This was the national institution for not just astronomy but also meteorology, hydrography, navigation, and oceanography, subjects in which the two Mitchells were already experienced.[91] They viewed the impressive 9.6-inch f/19 Merz and Mahler equatorial on its sandstone column. Maria would see two more examples of the 'Dorpat-7' in Italy and Germany six years later.[92]

That same month Maria wrote to George Bond, teasing him about his latest discovery: 'If you must do such an ungallant thing as to see a comet before me for the twelfth time, I wish you would make what amends

*Fig. 8: Maria Mitchell was portrayed in 1851 by Herminia Borchard Dassel (1821–57). She is pictured looking through the 3¼-inch Troughton and Simms portable zenith telescope that was loaned to her by the US Coastal Survey to measure the latitude of Nantucket more accurately.*

you can by letting me know its place … we have heard nothing from you since your return from Europe … I talked of you often while in Washington', adding a note regarding his prospective wife, 'Miss [Harriet] Harris in whom I am much interested and of whom everyone speaks so highly.' [93]

## 3. Maria's final years on Nantucket

During the early 1850s the Atheneum library continued to open weekday afternoons and Saturday evenings. Maria's responsibilities included cataloguing the 5,000 volumes, developing a foreign-language section (1853), and overseeing the introduction of gas lighting (1854).[94]

Clear nights were used to investigate star colours and monitor the minima of Algol (from 1853 December 25 to 1856 October 25).[95] Using her 3-inch Fitz telescope Maria typically spent a couple of hours comet-searching each night; this included identifying unfamiliar nebulae, including two in Leo in 1854 March. In the same month a 'beautiful comet with bright, well defined nucleus and train' was spotted by her father in the evening twilight near the northern border of the zodiacal light.[96] Her own enjoyment of this brief visitor was hampered by breaking a screw on her Fitz comet-seeker.

Perseverance earned Maria her third discovery of a comet in 1854 September (C/1854 R1) just a week after it had first been seen in Göttingen.[97] With seven years' practice of calculating orbits she found discrepancies, reporting on October 21: 'I went to the Atheneum at 9.30, and having decided that I would take the Newark and Cambridge places of the comet, and work them up, I did so, getting to the three equations before I went home to dinner at 12.30. I omitted the corrections of parallax and aberrations, not intending to get more than a rough approximation. I find to my sorrow that they do not agree with those from my own observations.' [98]

Maria was now broadening her contacts internationally. John Russell Hind (1823–95) had succeeded William Rutter Dawes (1799–1868) in 1845 as observer for George Bishop (1785–1861) at his Regent's Park observatory. Hind had discovered 10 minor planets between 1847 and 1854 using the 7-inch Dollond and in 1853 had become Superintendent of the *Nautical Almanac*. He responded to Maria's enquiry by sending her regular copies of the RAS *Monthly Notices* and also a copy of *Astronomical Observations taken at the Observatory, South Villa, Regent's Park, London during the years 1839–51*.[99]

Maria enjoyed her nightly sessions on the bank roof, explaining 'the aurora borealis is always a pleasant companion and grateful seriousness; a calm to the troubled spirit; a meteor seems to come like a messenger from departed spirits; and the blossoming of trees in the moon-light becomes a sight looked for with pleasure.' [100]

She had no fear of spiders and bugs, but rats under the transit-house were poisoned. In 1855 January the fine threads in the meridian transit had broken. Several hours work ensued: she found her own hair too coarse and affected by humidity changes; baby hair, courtesy of nephew Clifford Mitchell, was finer but too curly. Her solution, after advice from George Bond, was to use spider web from the Atheneum.[101]

Friends and family changes were important factors in Maria's life during the 1850s. After his European tour George Bond survived a serious illness and then married in 1853 January. Her sisters Sally, Anne, and Phebe as well as brother Henry had all married and Kate became engaged; in 1854 September only Maria, Kate, and Anne were still at home. Then in 1855 February her mother fell ill and she also lost three good friends in quick succession.[102]

In 1855 spring Maria visited the newly opened Astor Library in New York to learn how it managed its 80,000 volumes and was surprised to find that it lacked an efficient cataloguing and retrieval system. She also noted with some satisfaction that daily visitors numbered only 100, half the number achieved at Nantucket.[103]

### 3.1. *Resignation from the Atheneum*

By the summer Maria was feeling increasingly restless at the Atheneum and reached an important decision – to undertake a grand tour of Europe. The idea was discussed in August with Davis in Cambridge as she journeyed to the four-day AAAS meeting in Providence where two of her other mentors, Henry and Bache, were also consulted.[104]

One lecture proved particularly interesting, given by Joseph Henry on 'Coloured Projections from the edge of the Sun as observed during Solar Eclipses.' Maria had already observed several partial events and undoubtedly resolved to observe these 'prominences' herself at a future date.[105]

To consolidate her friendship with Henry she volunteered to join his Smithsonian Meteorological project by sending daily records from the Atheneum for temperature, rainfall, and barometric pressure. The library trustees subsequently approved a $50 annual increase to her salary, partly in recognition of her further development of her card-catalogue system at the Atheneum.

Maria's fourth comet discovery (C/1855 V1) came on 1855 December 12 during a period of stormy weather when her attempts to safely observe on the Bank roof were almost thwarted by strong winds.[106] In a letter from her father to William Bond at HCO he requested help: 'I hope George … [will] obtain some positions, as our instruments can not be depended on. The comet seeker is a beautiful instrument of its kind, but not so situated as to enable us to measure well.' [107]

Increasingly frustrated by her inadequate equipment, she wrote to William Bond in 1856 September to seek loan of some instruments, but this proved impossible. Bond instead offered her the chance of observing from HCO, which she had to decline due to her mother's health.[108]

In 1856 October, after 20 years of service, Maria resigned her Atheneum post to concentrate on planning her trip. Her initial departure date proved impossible when the Navy rejected her request for leave from her computational duties, leading to a four-month delay. While waiting she sent her observations of the minima of Algol taken with her 3-inch Fitz telescope to the editor of the *Astronomical Journal*, Benjamin Apthorp Gould (1824–96), and her third published paper (and first astronomical paper) duly appeared in 1856 November (Figure 9).[109]

Gould also sent her a copy of *A Catalogue of 53 Variable Stars*, by Norman Pogson of the Radcliffe observatory, Oxford, with the suggestion that monitoring variables like T Cancri might prove worthwhile.[110] In December she finally received approval to continue her Venus ephemeris work while she was travelling abroad.

## 4. The search for a new direction

During 1856 Maria contracted with Richard Kellogg Swift (1813–83), a Chicago banker and philanthropist, to act as chaperone to his eldest daughter Prudence Elizabeth Swift (1838–1920), known as Prudie, for an initial trip through the American southern states followed by a longer European 'grand tour'.[111] To reach Chicago she travelled west from Nantucket to meet her sister Phebe Kendall at Meadville, Pennyslvania, visiting Niagara Falls en route. Her brother-in-law Joshua Kendall had a teaching post at a theological seminary; five years later Maria's enquiry on his behalf to Vassar Female College, which was then under construction, would initiate their interest in her as a potential recruit.

A stage-coach journey further west brought her to

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## LETTER FROM MISS MITCHELL TO THE EDITOR.

*Nantucket*, 1856, *November* 3.

I SEND you the times of the minima of *Algol* as observed by me. The later observations are undoubtedly the best, as I have been more careful of the condition of the chronometer, have made notes of the changes of light at shorter intervals, and have been able to improve in my methods of observing. I have taken care not to know the exact time at which the phenomenon was expected to occur, that I might not be biased in my judgement.

I have taken for minimum the instant of greatest faintness, and not the middle point of a long period of dimming.

The observations have been made mostly with a comet-seeker constructed by Mr. FITZ of New York, but I have at times used a telescope of larger power belonging to the Coast-Survey. I have compared the star with the neighboring stars of nearly equal size, first with the eye, and then with the glass, sometimes assisting my judgement by throwing the instrument out of focus and comparing the haloes around the stars, and sometimes by illuminating the field and observing which star first disappeared under the same degree of light; in each case making a note.

I have discontinued the observation as soon as I have been quite confident that the star was steadily brightening, but I have at other times made notes of its relative brightness when apparently at its mean and at its maximum.

I have never seen a sudden and great change; that the diminution of light is irregular, I have not a doubt; that the color of the star changes, I am inclined to believe; and I have at times noticed an appearance of haziness around it when it was near its minimum, as if its light came to us through a medium varying in density, perhaps a revolving atmosphere.

MINIMA OF *ALGOL*.

Nantucket Mean Time.

| | | d | h | m | s |
|---|---|---|---|---|---|
| 1853, | Dec. | 25 | 6 | 38 | 30 |
| 1854, | March | 1 | 7 | 25 | 0 |
| " | " | 21 | 7 | 40 | 0 |
| " | Oct. | 22 | 8 | 40 | 0 |
| 1855, | June | 11 | 14 | 43 | 48 |
| " | Sept. | 5 | 14 | 52 | 27 |
| " | " | 8 | 11 | 48 | 30 |
| " | " | 11 | 8 | 38 | 48 |
| " | Nov. | 13 | 10 | 20 | 28 |
| " | Dec. | 6 | 8 | 51 | 46 |
| 1856, | Oct. | 25 | 9 | 1 | 38 |

MARIA MITCHELL.

*Fig. 9: In 1856 Maria's observations of the variable star Algol appeared in The Astronomical Journal, America's leading astronomical publication, made with the 3-inch Fitz refractor she purchased with funds raised by the Boston merchant Jonathan I. Bowditch. Her Will suggests the telescope remained on Nantucket when she moved to Lynn. Apparently it was sold by her nephews and is now lost.*

Chicago to meet the Swift family in 1857 March.[112] A party of three now travelled south-west across Illinois to Saint Louis: Maria (aged 39), Prudie (aged 19), and a 'Mr Smith' (aged 44), really Richard Kellogg Swift travelling incognito.[113] Here they embarked on a paddle-steamer voyage down the Mississippi river to New Orleans. It is unknown if Maria knew of her employer's true intentions for the 1,200-mile voyage of 12 days – he was probably on an espionage mission!

The only astronomical opportunity of the trip involved a late afternoon observation of the solar eclipse of 1857 March 25, for which the Mississippi was considered a prime location for American observers. The eclipse was observed during docking at a coal-station. In Maria's words: 'Mr. Swift having brought with him a broken piece of glass from one of the windows of the [steamboat] Magnolia, I smoked it over a piece of candle … and prepared to observe the eclipse. I expected to see the moon on at 5:20 … in 10 minutes after, was so far on that I think my time cannot be much wrong. It was a little cloudy, so that we saw the sun only "all flecked with bars".'[114]

The American tour continued for two more months, during which time Maria's attitude to slavery was informed through first-hand experience. By early June Maria and Prudie had travelled through the southern states and journeyed to Washington. Here she visited the Smithsonian Institution to see Joseph Henry whose offer to provide her with a 'letter of introduction' to European scientists was invaluable.

Having missed her sister Anne's wedding to schoolmaster Alfred Macy in May she returned to Nantucket in time for the wedding of their youngest sister Kate to Owen Dame (1833–96) on July 9. The newly married couple settled in Lynn, Massachusetts, a small city to the north of Boston which a few years later would also become home for Maria and her father.

By the final week of June Maria had returned to New York to complete preparations for her European tour. She was keen to learn first-hand what was happening in European science, especially to discover how different astronomers were addressing the central questions in astronomy of the time. She needed to determine an area of research for herself, including the equipment and methodology.

Arrangements were eventually agreed for her to continue her *Nautical Almanac* work on Venus during her travels. She would also continue as chaperone to Prudie. As she accumulated further letters of introduction, from Everett, Bache, and the Bonds, all that remained was to book tickets for the Atlantic crossing, commencing July 22.

On browsing a copy of Emerson's *United States Magazine* she was startled to find her name mentioned in connection with a fund-raising target of $3,000 (Figure 10).[115] That such a campaign might be mounted on her behalf was a mighty endorsement of her potential for further enhancing the achievement of American women in science; it certainly would have been on her mind as together with her young charge they set out across the Atlantic.

4.1. *European tour: England and Scotland*

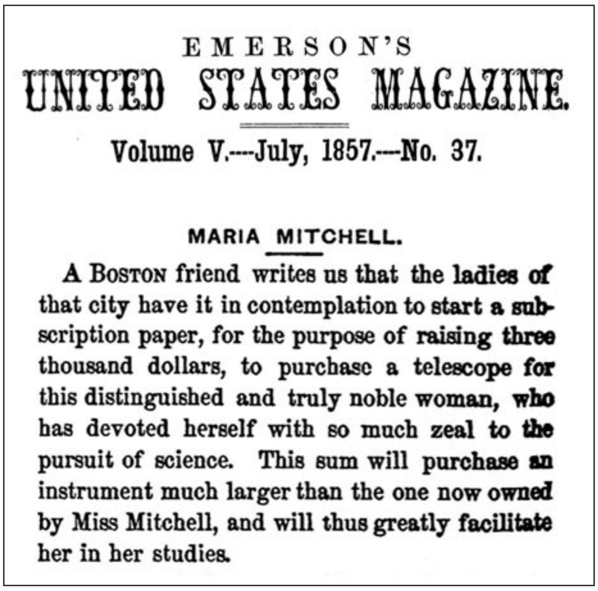
On Sunday 1857 August 2 a hundred passengers disembarked from the paddle-steamer S/S *Arabia* at the Port of Liverpool after an 11-day crossing from New York. Among them were Maria Mitchell and Prudie Swift. Prudie was excited by the prospect of visiting both the UK and Europe, but she would never achieve the latter and would make her return trip home just three months later. Maria would spend a further seven months completing her dream and also determining her true vocation.

Maria first spent four months in the UK (1857 August–December) during which time she visited eight observatories and met over a dozen astronomers. First was former Liverpool cotton merchant John Taylor (c.1777–1857) and his *cometarium*, a device which could display the apparent orbital path of a comet. Taylor had been an early advocate for an observatory in Liverpool.[116]

Maria next visited John Chapman Hartnup (1806–85), director of the Liverpool Observatory. The nautical focus of the facility was familiar but the chronometer testing service operated on a much larger scale than at Nantucket.[117] The observatory's 8-inch equatorial (1848) on its massive English mounting had been designed with astrometric precision by George Biddell Airy (1801–92); Maria would have envied its suitability for measuring cometary positions, timing Jupiter satellite events, and tracking minor planets. When Hartnup showed his collodion lunar photographs she was able to compare them with images of Mizar and Alcor, recently captured by George Bond at HCO, an achievement not yet accomplished in any observatory in Europe.

The next day included a visit from Nathaniel Hawthorne (1804–64), the American consul and novelist, a meeting which would prove fortuitous four months later in Paris. Coincidentally his sister-in-law in Boston, Massachusetts, was leading the fund-raising campaign for Maria's new telescope.

Four days after Maria's arrival in Liverpool she took a four-mile stage-coach ride east to Sandfield Park to visit William Lassell (1799–1880). The visit had been suggested by George Bond who, like the wealthy British amateur, had also observed the 1851 solar eclipse from Sweden. Lassell's large equatorial reflecting telescopes were installed within 15-ft and 30-ft domes. The 24-inch reflector had revealed new satellites of the outer planets and the telescope also performed well at Valletta, Malta. Lassell was making ambitious plans to cast a 48-inch speculum.



EMERSON'S

UNITED STATES MAGAZINE.

Volume V.—July, 1857.—No. 37.

MARIA MITCHELL.

A Boston friend writes us that the ladies of that city have it in contemplation to start a subscription paper, for the purpose of raising three thousand dollars, to purchase a telescope for this distinguished and truly noble woman, who has devoted herself with so much zeal to the pursuit of science. This sum will purchase an instrument much larger than the one now owned by Miss Mitchell, and will thus greatly facilitate her in her studies.

*Fig. 10: In 1857 an ambitious fund-raising campaign, led by the American educator Elizabeth Palmer Peabody and the 'women of America', was launched to raise $3,000 for a telescope for Maria Mitchell. She used the funds to purchase a 5.0-inch f/14 equatorial from Alvan Clark. She observed with it from Nantucket for two years before transferring to Lynn after the death of her mother in 1861.*

Maria found him very genial and pleasant but doubted she could be happy observing high-altitude objects suspended on a ladder hung from a rotating dome.[118] Lassell described the success William Rutter Dawes (1799–1868) was having with objectives made by her countryman Alvan Clark (1804–87).[119] She also met the Lassell family, finding three of the girls already showing an interest in astronomy.[120] During her UK and Europe tour Maria closely examined equatorial telescopes and meridian instruments produced by two dozen different manufacturers (Table 3), before deciding that Alvan Clark could furnish her with an excellent American telescope.

Over the next week Maria and Prudie travelled to London via Manchester and Worcester, taking up lodgings near Regent Street for their three-week stay. Maria began visiting sites associated with Isaac Newton (1642–1727), including his sarcophagus at Westminster Abbey; she would later examine his prototype reflecting telescope at Burlington House. Her letters of introduction produced invitations to both the Royal Observatory at Greenwich and the home of W. H. Smyth at Aylesbury. Airy organized a trip down the Thames to Greenwich for the two Americans.[121]

Altogether five overnight visits to the Airy family were completed, probably aided by Maria's decision to present the Astronomer Royal with one of her precious double-star photographs of Mizar and Alcor, which he clearly treasured.[122] She carefully studied the Greenwich instruments and the dome designs housing them: the 3.7-inch altazimuth (1847) in its 10-ft cylindrical dome, used for lunar work; the 6.5-inch Sheepshanks

**Table 3**

**Observatories and astronomers visited by Maria Mitchell on her European tour 1857–58**

| Observatory | Astronomer and date | Equatorial and maker | Meridian instrument and maker | Notes |
|---|---|---|---|---|
| Liverpool | J. C. Hartnup<br>1857 August 4 | 8.0″ f/18<br>Merz, Simms, and Maudsley | 4.0″ f/15 transit<br>Troughton and Simms | Chronometers and astrometry |
| Bradstones, Liverpool | W. Lassell<br>August 6 | 9.0″ f/12 reflector<br>24.0″ f/10 reflector<br>Lassell (both) | N/A | Planetary observing |
| Greenwich | G. B. Airy<br>Aug 21–Oct 23<br>(five visits) | 3.7″ f/13<br>Simms and May<br>6.5″ f/11<br>Cauchoix and Grubb | 8.0″ f/17 transit circle<br>Merz, Simms, and Ransome<br>5.0″ f/23 zenith telescope<br>Dollond and Ransome | 12.3″ f/17 under construction |
| Hartwell, Aylesbury | W. H. Smyth<br>September 6 | 5.8″ f/18<br>Dollond and Tulley | 3.5″ f/17<br>Jones | Porrima.<br>John Lee, owner |
| Calton Hill, Edinburgh | C. Piazzi Smyth<br>Sep 29 and Oct 3 | 3.5″ f/15 | 6.4″ f/15 transit<br>Fraunhofer and Repsold | Tenerife expedition |
| Horselethill, Glasgow | J. P. Nichol<br>c. October 5 | 22.0″ f/27 reflector<br>15.0″ f/20 reflector<br>Ramage and Grubb (both) | 6.0″ f/16 transit circle<br>Ertel | Planetary observing |
| Cambridge | J. Challis<br>Oct 31–Nov 2 | 11.7″ f/24<br>Cauchoix, Simms, and Ransome | 4.5″ f/21 mural circle<br>Troughton and Simms | W. Whewell<br>J. C. Adams |
| Collingwood, Kent | John Herschel<br>November 13–15 | MM was welcomed by the whole Herschel family, who had eight children still living at home. Given letter of introduction to Mary Somerville | | |
| Radcliffe, Oxford | M. J. Johnson<br>c. November 20 | 7.4″ f/17 heliometer<br>Repsold<br>4.5″ f/27 Simms | 4.0″ meridian circle<br>4.0″ transit<br>Jones (both) | Meteorology.<br>Heliometer not seen |
| Paris | U. J. J. Le Verrier<br>Dec 9 and 14 | 14.9″ f/18<br>Lerebours and Brunner | 6.5″ f/15 circle<br>Gambey<br>6.0″ f/15 transit<br>Cauchoix and Gambey | Equatorial not seen |
| Campidoglio, Rome | I. Calandrelli<br>1858 March 18 | Small portable instruments | 6.0″ f/16 meridian circle<br>Ertel and Scarpellini | Solar eclipse (cloudy) |
| Collegio Romano | A. Secchi<br>April 9 | 9.0″ f/19<br>Merz<br>6.3″ f/15<br>Cauchoix | 4.0″ f/15 meridian circle<br>Ertel<br>3.7″ f/15 transit circle<br>Reichenbach | Sun/planets, spectra |
| Florence | M. Somerville<br>April 19–24 | MM described her meetings with MS as the highlight of her tour. They confirmed her ambition to educate women in mathematics and astronomy | | |
| Berlin | J. F. Encke<br>May 6 and 7 | 9.5″ f/18<br>3.0″ f/8 comet seeker<br>Fraunhofer (both) | 4.0″ f/15 meridian circle<br>Pistor and Martins | *Akademische Sternkarten* star charts |
| Berlin | A. Humboldt<br>May 7 | MM had been inspired by reading Humboldt's *Kosmos*. She had learned of Schwabe's work on sunspots, and would later photograph sunspots at Vassar | | |
| Bonn | F. Argelander<br>c. May 12 | 6.4″ f/16 heliometer<br>Merz | 4.3″ f/18 meridian circle<br>Pistor and Martins | *Bonner Durchmusterung* and variables |

*Table 3: Maria Mitchell's grand tour of Europe in 1857–58 included visits to 13 observatories and meetings with many astronomers and other scientists. She kept detailed notes of the instruments viewed, the observing programmes being undertaken, and the questions being investigated. She returned to Nantucket with a clear idea of areas of research that would later underpin her work at Vassar College. She examined the work of 20 instrument-makers during her 10-month tour, but preferred the option of an Alvan Clark equatorial on her return home.*

equatorial (1838) used for comets, eclipses, Jovian satellites, and lunar occultations; the impressive 8-inch transit circle (1851) on the prime meridian, with its telegraph connection; the 5-inch reflex zenith tube (1851) used for observing Gamma Draconis; the Dent barrel chronograph (1854); and construction of the 12.3-inch Merz f/17 equatorial on an English mount within a 32-ft cupola dome. Maria was also keen to learn more of the various longitude expeditions underway linking Greenwich to observatories across the world.

In early September she took a train to Aylesbury and stage-coach to the village of Stone to visit the Smyths. Maria and her father had spent hundreds of hours working their way through Smyth's *Bedford Catalogue*. Observing double stars, especially close binary pairs, was one area Maria was keen to develop further and she enjoyed hearing Smyth recount observing the perihelion passage of Gamma Virginis (1836). The Smyths continued to measure the star with the same 5.8-inch equatorial (1830) on its English mount at nearby Hartwell House.[123]

A fortnight in the Lake District in mid-September en route to Scotland included completion of 'Airy's challenge' – an ascent of a fell called the Old Man of Coniston.[124] Their week in Edinburgh was enlivened by another astronomical couple: Charles Piazzi Smyth (1819–1900), the Astronomer Royal for Scotland, and his wife Jessica (1812–96), who organized dinner guests and inspection of the Royal Observatory on Calton Hill. Maria and Prudie then moved on to Glasgow where, at the Horselethill Observatory directed by John Pringle Nichol (1804–59), Maria viewed the Ertel transit circle (1843) and two large Ramage reflectors.

Returning from Scotland the women visited 'Shakespeare country' around Stratford upon Avon. In addition to her astronomical interests Maria took every opportunity of learning more about 'four great men': Newton, Shakespeare, Milton, and Johnson.[125]

Back in London another overnight visit to Greenwich was arranged to allow her to meet Friedrich Georg Wilhelm von Struve (1793–1864) and his son Karl from Pulkova observatory, the 'astronomical capital of the world'.[126] Struve's work on double stars and geodetic work were both admired by Maria and she was pleased to find that he was also familiar with her astronomical background.

It was now decision time for the two Americans. For Prudie a November sailing from Liverpool was booked because of the American financial crash which had bankrupted her family; for Maria a continuation of her tour into Europe remained her ambition, so she awaited news from Nantucket. A trip to Trinity College, Cambridge, at the end of 1857 October was their final outing together.

Maria found William Whewell (1794–1866) dismissive of American opinions but astronomers James Challis (1803–82) and John Couch Adams (1819–92) were more helpful; the arrival of Airy's wife Richarda, who was visiting her sons, provided an additional bonus. Maria knew the difficulty Challis had encountered searching for Neptune with the Northumberland telescope, and the advantage German astronomers secured using their more detailed star maps. She was interested to see Adams's calculations for the planet, but was less impressed by the fuss over the wearing of ceremonial robes.

A week after their visit to Cambridge the two women parted at Liverpool.[127] Maria next travelled to Collingwood, Kent, to meet Sir John Herschel (1792–1871) and Lady Margaret Brodie Stewart Herschel (1810–84), enjoying the welcome given by their eight children still at home. Sir John proved an excellent listener and showed Maria examples of his Cape illustrations. The 18-inch f/13 reflecting telescope was stored in his barn, but no longer used.

Two unexpected gifts were a page from Caroline Herschel's observing notebook and an invaluable letter of introduction to Mary Somerville whom she hoped to meet in Europe.[128] Maria's final observatory visit was to the Radcliffe in Oxford where she met director Manuel John Johnson (1805–59). They discussed meteorological measurements and she was shown the main buildings, but not the 7.4-inch Repsold heliometer (1848) used for measuring star positions.[129] A fortnight later she received the encouraging news from Nantucket that her mother's health had not further deteriorated and she booked her Channel crossing from Folkestone to Boulogne.

4.2. *European tour: France, Italy, and Germany*

Maria spent six weeks in Paris, making a couple of visits in mid-December 1857 to the Observatoire de Paris where she met Urbain Le Verrier (1811–77). With her bad French and his bad English they talked little, but he showed her the transit instrument, the mural circle, the computing room, and his private office. 'It was evident that he did not expect me to understand an observatory,' she wrote. 'We did not ascend to the domes.'[130]

At this time she was seeking travelling companions to extend her tour into Italy. The situation resolved itself when she again met Nathaniel Hawthorne whose family was about to leave for Rome. Maria quickly developed a close bond with his wife, the illustrator Sophia Amelia Peabody Hawthorne (1809–71), and their three young children. She had previously recommended Ann Adaline Shepard (1835–74), known as Ada, a language graduate from the co-educational Antioch College, Ohio, to the Hawthornes, as both governess for their three children and the family's interpreter abroad; Maria and Ada became good friends over the three winter months.[131]

A five-day journey in mid-January 1858 included stage-coaches to Lyons, Marseille, and Genoa, then a tugboat to Leghorn (Livorno), and another stage-coach to Civita Vecchia and Rome. Maria rented rooms for three months, visiting ruins on the drier days and artworks on wetter days.

In 1858 March her request to visit the Collegio Romano observatory, directed by Angelo Secchi (1818–78), resulted in him bringing her some negatives of Saturn's rings; permission for a daytime visit in April was eventually granted. Cloudy weather obscured the March 15 solar eclipse but she met Ignazio Callandrelli (1792–1866), director of Campidoglio observatory, and his student entourage using three small telescopes on the East Tower. She viewed the 6-inch Ertel meridian circle (1827) and noted the mutually respectful interaction between Callandrelli and his students, intending to adopt a similar approach in her future work. Three days later she made a second visit to the papal observatory, observing the crescent Moon and Jupiter in the evening twilight.[132]

Holy Week ended with a firework display on the Pincian Hill and just three days before leaving Rome she finally had a late-afternoon tour of the Jesuit observatory on the roof of the church of St Ignatius of Loyola. Secchi's three domes included a 9-inch Merz refractor (1854) in the 23-ft cupola dome; a 5-ft Ertel meridian circle and 4-ft Reichenbach transit circle in a 20 × 16-ft meridian room; and the 6.2-inch Cauchoix refractor (1825) in a third turret.

Secchi had realized his tower location undermined the stability needed for positional astronomy so instead he observed the Sun, Moon, planets, and double stars; he was also a pioneer in spectroscopy and photography. In the evening twilight they observed the Moon, Venus, Jupiter, and Saturn. Maria noted that the main equatorial was essentially very similar to one at the US Naval Observatory in Washington.[133]

After three months in Rome Maria journeyed north for what she hoped would be the highlight of her trip – a meeting with the distinguished scientist and mathematician Mary Fairfax Somerville (1780–1872) in Florence. Together with Caroline Herschel, Mary Somerville had been elected an honorary member of the RAS in 1835. With her second husband, William Somerville (1771–1860), she had lived in Italy from 1833, and Florence from 1849.

Maria Mitchell was the sole female member of the American Academy of Arts and Sciences (1848) and both women were skilled in mathematics and astronomy, although separated by nearly four decades in age. Mary Somerville had translated and developed Laplace's *Mécanique Céleste* (1825), publishing *The Mechanism of the Heavens* (1831) which Maria had studied at the Atheneum library; she had then published *On the Connection of the Physical Sciences* (1834) and *Physical Geography* (1848).

Between 1858 April 19 and 24 the two pioneering women met several times, courtesy of the letter of introduction given to Maria by Lady Herschel. Maria noted her mentor's strong Scottish accent and the beautiful rose bushes in her garden, which would later be replicated at Vassar.[134] The two women discussed recent discoveries in chemistry, the discovery of gold in California, nebulae, the tails of comets, the satellites of the planets, and the possibility of life elsewhere in the Solar System.[135]

Maria was inspired by these meetings in Florence, receiving the confirmation she needed that women scientists needed the encouragement of women role models; as Bergland has noted, 'Mary Somerville would be a touchstone for Mitchell for the rest of her life'.[136]

Time and dwindling funds limited Maria's time in Florence, but she did visit Arcetri hill to see the tower home where Galileo Galilei (1564–1642) had spent his last decade; she noted his index finger and instruments displayed in the museum.[137] After a week in Florence Maria travelled via Ferrara and Padua to Venice, then by boat to Trieste and omnibus to Vienna. A week later she reached Berlin and was invited to the observatory by Johann Franz Encke (1791–1865). Instruments seen included the 9.5-inch f/18 Fraunhofer equatorial (1829) with which Neptune was discovered and a 3-inch Fraunhofer heliometer which she was encouraged to handle.[138]

Maria saw examples of the copper engravings produced for the *Akademische Sternkarten* (1859) which was nearing completion. This early example of international collaboration had involved 24 astronomers over three decades. The Berlin star charts mapped the sky within 15° of the celestial equator to show stars visible in a 3-inch comet-seeker; the engravings were at a scale of half an inch to a degree.

The following day Encke showed Maria the old tower observatory. She then used her letter of introduction from Everett to meet briefly with Alexander von Humboldt (aged 89) who questioned her on the Harvard experiments on photographing stars and how the method might be useful for discovering more minor planets, 53 of which were then known.[139]

Crossing to south-east Germany Maria next met Friedrich W. A. Argelander (1799–1875) at the Bonn observatory. She viewed the 6.4-inch f/16 Merz heliometer (1841) with which Friedrich A. T. Winnecke (1835–97) was studying the Praesepe star cluster. A 3-inch Fraunhofer comet-seeker giving a 6° field at ×10, similar to her own Fitz instrument, was used by assistants Eduard Schönfeld (1828–91) and Karl N. A. Krueger (1832–96) for a new star atlas, the *Bonner Durchmusterung*. Maria was also interested in Argelander's investigations of variable stars. He had introduced the R–Z lettering convention for variables for which a small telescope could produce useful research.

### 5. From Nantucket to Lynn and beyond

On 1858 May 17 Maria crossed the Channel from Ostend to England, making a final visit to Greenwich a week later before sailing back to America from Liverpool on June 3. By mid-June she had reached Nantucket and a few days after full Moon she resumed her nightly

*Fig. 11: Maria Mitchell c.1865, probably taken in her first year as professor of astronomy at Vassar College. She remained at Vassar for over two decades until her retirement in 1888. (Archives and Special Collections Library, Vassar College)*

vigils on the roof of the Pacific Bank, making her own independent discovery on July 1 of Donati's comet (C/1858 L1) which had been discovered by the Italian astronomer Giovanni Battista Donati (1826–73) the night before she left England.[140]

Tracking the passage of the comet into Ursa Major by mid-September, by which time it had brightened to third magnitude with a 2° tail, proved both exciting and frustrating. Lacking the tools to make precise positional measurements the exact determination of its orbital elements was impossible. Her Fitz instrument provided a spectacular low-power field (c. 4°) but lacked the magnification necessary to reveal the delicate changes occurring in the nucleus as perihelion approached. Maria had now resumed caring full-time for her mother and could only listen to her father's reports from using the 15-inch Harvard refractor.[141] Donati's comet would prove the final factor in Maria's decision on a new telescope.

5.1. *An observatory for Maria*

Maria's travels were intended to complete her self-education and also identify possible areas for astronomical research. She had increased her academic standing by meeting European astronomers, touring observatories, and experiencing different cultures. Her grand tour enhanced her reputation both through the personal contacts she made with leading scientists and philosophers and also by her willingness to immerse herself in new cultures. She was proud to receive a bronze medal of merit from the small republic of San Marino, Italy.[142] With her 3-inch Fitz telescope she could continue her comet searches, study star colours, and make variable star observations, but her 'Donati experience' helped her determination to also have her own observatory.

The New England fund-raising campaign had secured $1,000 by 1857 August while Maria and Prudie were in London and was further boosted by the educator Elizabeth Palmer Peabody (1804–94) galvanizing support from 'the women of America'.[143] The $3,000 target was initially linked to the possible purchase of the Sharon Observatory, at Darby, Pennsylvania, which had been established by John Jackson (1809–55).[144] Despite the probable excellence of the instruments Maria declined the opportunity when she discovered the 6-inch f/17 equatorial was undriven and accessories were limited.[145]

On 1858 September 1, Nantucket celebrated the opening of the first transatlantic cable. Seeking to finalize her decision on a telescope, Maria wrote to William Bond the following day, producing a reply from George a fortnight later:

> I am sorry that a six-inch object glass is out of the question … light is so indispensable for faint comets and asteroids … it will not be well to sacrifice excellence in the micrometer … with good illumination of the wires in a dark field [you] will then be able to observe everything you can see … the additional $100 [for] the best Star Catalogues − Bessel's and Argelander's − which are expensive and as necessary almost as a telescope.[146]

Maria, now aged 40, wisely decided to purchase a well-equipped 5-inch f/14 Alvan Clark refractor rather than seek a larger aperture. Funding arrangements were secured over the next few months enabling Maria to place her order in 1859 January, just seven months after returning home.[147]

Her choice of instrument-maker was limited in America to either Fitz or Clark. Clark's prices for a 5-inch equatorial were typically $800 to $1,500, and he offered more refinements suitable for positional astronomy, including a Bond spring governor to regulate the clockwork drive.[148] Maria was keen to secure an excellent micrometer to enable measurements of double stars and planetary satellites.

Writing again to the Bonds in 1859 January she explained: 'I am expecting to see Mr Alvan Clark in about ten days … having economised by taking a five inch glass instead of a six, I am not disposed to let any economical considerations come into its accessories. I want to make the best of measurements … will Mr. Clark's micrometer made on a plan of his own read the accuracy which he claims for it?' [149]

Just a few days after Maria placed her order came news that William Cranch Bond had died on January 29. George was appointed his successor as director of HCO, a post he would occupy for just six years before he died of tuberculosis. The news of William's death was particularly upsetting for Maria's father – the two had been close friends for many decades, and most recently were planning how to use the new telegraph to improve the measurement of the longitude difference between HCO and Nantucket.

Maria next had to find a suitable site for her observatory. By invitation of the trustees of the Coffin School (her brother-in-law Alfred Macy ran the school from the late 1850s) Maria's observatory was built behind the Coffin schoolhouse on Winter Street, with an accessible driveway to Liberty Street.[150] The former oil refining and candle-making buildings had all been cleared to leave an open outlook and the building was set up during the summer.

Maria maintained her correspondence with her friends abroad. A letter from the Smyths included recommendations of what to observe with her new telescope: 'We are much pleased to hear of your acquisition of an equatorial instrument under a revolving roof … I would recommend a batch of neat, but not overclose, binary systems, selected so as to have always one or the other on hand', adding the suggestion of trying in the future a micrometer with a rock-crystal prism.[151]

The equatorial arrived and was operational by 1859 September, as a *Scientific American* report explained:

> The mechanism of this telescope is probably not excelled by those manufactured in Europe. Its focal strength [sic] is between five and six feet, and the clear aperture of the object-glass is five inches. It is mounted equatorially, according to the German method, and furnished with graduated circles for the determination of the positions of the heavenly objects. The circle for measuring right ascensions is divided to single minutes, but by means of a vernier reads to five seconds of time. The declination circle, by means of the vernier, reads to ten seconds of arc; but, by accompanying microscopes, single seconds may be determined with tolerable accuracy. It is furnished with clockwork on the plan of Fraunhofer, and so regulated by Professor Bond's spring-governor as constantly to counteract the effect of the earth's rotation, keeping the object in that part of the field of view which may best comport with the convenience of the observer. It has eight eye-pieces, with powers ranging from seventy-five to three hundred and fifty. It is furnished also with a filar-position micrometer of excellent workmanship. The telescope plays upon a stand, composed of slabs of iron intersecting each other at right angles, and resting on four points adjusted by foot-screws. This rests on a pier of solid masonry, surmounting a mass of granite. The base of the pier is laid so low that the severest frost cannot affect it, and the whole is isolated from the surrounding earth by beach sand, securing it from the tremor to which it would otherwise be exposed from passing carriages … Miss Mitchell has constructed her observatory in such a manner as merely to shelter the instrument. On entering it, however, it is found to possess all the needful equipments of a more costly establishment. It is a circular building, eleven feet in diameter and scarcely more in height, covered with an ordinary roof made to revolve on cannon balls. By this means, a narrow aperture in the roof is easily brought to the point of the heavens under inspection.[152]

Heralding completion of Maria's observatory the Nantucket skies conspired to deliver a spectacular auroral display at the end of August with colourful streamers from the east extending to all parts of the sky.[153]

On 1859 September 1 she began a three-year project on double stars using her Clark filar micrometer. By the end of the year five pairs had been measured for position angle over nine nights and one distance found (for 28 Aquarii, separation 52.12″). Maria included colour estimates of the stars, following the advice of W. H. Smyth; her results were later published in *The American Journal of Science and Arts* at the end of 1863.[154] During the autumn Maria calculated the geographical position of her observatory as: longitude 4h 40m 25s, latitude 41° 01′.[155]

In 1859 March the French amateur astronomer Edmond Modeste Lescarbault (1814–94) believed he had observed a transit of an intra-Mercurial planet and informed Le Verrier at the Observatoire de Paris. Two years after meeting the observer in Paris Maria read of his provocative announcement to the Académie des Sciences in 1860 January of the discovery of Vulcan, a hypothetical planet he believed explained the perihelion precession of Mercury.

As Lescarbault used only a 3.7-inch telescope the announcement encouraged astronomers worldwide to search for Vulcan. In April Maria wrote to her sister Phebe to report that her search from Nantucket had drawn a blank.[156] Better news was the arrival from the Smyths of a copy of *The Cycle of Celestial Objects, continued at the Hartwell Observatory to 1859*, which became a much-valued possession.

The *Nantucket Inquirer* became a frequent repository for Maria's observations at this time, beginning with her note of the Mars occultation of 1860 May 10.[157] In the same month Maria's fourth paper was published in the *Atlantic Monthly*, her strong admiration for Mary Somerville captured in her opening sentence: 'There have been in every age a few women of genius who have been the successful rivals of men in the paths which they have severally chosen.'[158]

In 1860 June an unexpected bright comet with a 20° tail (C/1860 M1, the so-called Great Comet of 1860) was noted by many observers including Maria (her sixth 'discovery') as it moved southwards from Auriga,

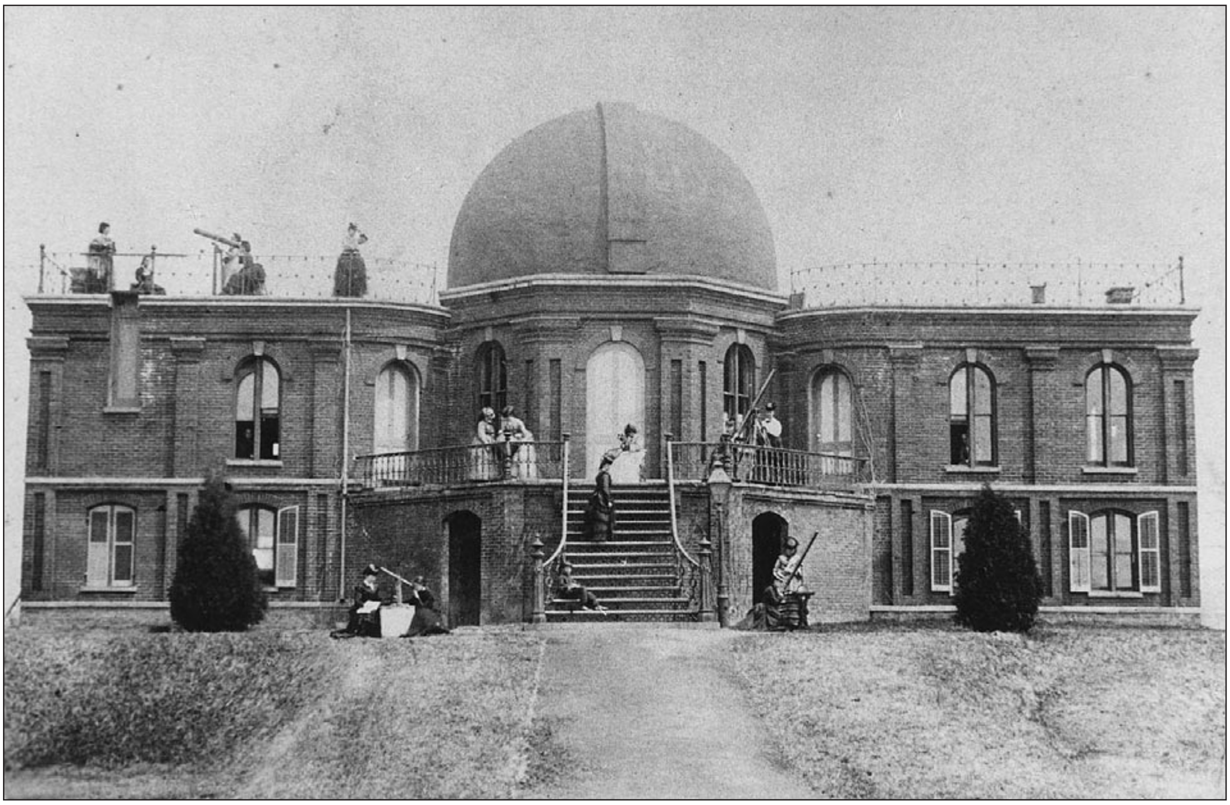


*Fig. 12: Vassar College Observatory in the early 1870s with students engaged in observing exercises. The two women at top left of the steps are using Maria Mitchell's unique sunspot photographic apparatus. Maria Mitchell lived in the red-brick building beneath the dome, with her father living in the basement. Maria Mitchell was appointed professor of astronomy and director of the observatory in 1865. Her first observations were to determine the observatory's exact latitude and longitude. (Archives and Special Collections Library, Vassar College)*

passing closest to the Earth on July 11. A week later the solar eclipse of 1860 July 18 encouraged astronomers from around the world to mount expeditions to observe the spectacle (totality 3m 39s), including the Labrador eclipse expedition in America.[159] From Nantucket, Maria saw a partial (c.35% phase) eclipse from 07.20 to 09.33 a.m. Double-star measurements were made during eight months of the year with 17 pairs observed over 23 nights, including measuring distances as small as 3.5″ (Zeta Aquarii).

5.2. *Moving 'off-island' to Lynn*

Maria had now moved temporarily into her mother's room to provide the nursing care required. During this challenging year the Nantucket population continued to decline, reducing to 6,000, a 40% fall over the decade. The once-impressive whaling fleet now comprised only six ships. The Mitchell family welcomed the November election of Abraham Lincoln (1809–65) with his anti-slavery campaign as President, but the Civil War began in 1861 April leading to a further exodus of men from Nantucket.[160]

Her double star observations in Nantucket that year included eight pairs over eleven nights, the last of them involving position angle measures of Gamma Virginis (Porrima) on 1861 June 14 and 18. A month earlier a bright comet, C/1861 J1, was found by southern hemisphere astronomer John Tebbutt (1834–1916) which after perihelion became circumpolar in northern skies. The Earth crossed the comet's tail at a distance of only 0.13 au on 1861 June 30, and the comet brightened to magnitude −2.

This was the last comet Maria observed during her 43-year Nantucket period. A week later on July 7 her mother Lydia, aged 67, passed away after her six-year illness. Within three months Maria and her father had moved permanently off-island to Lynn to be closer to her youngest sister Kate and family as well as the science communities of Boston and Cambridge.

Maria's observatory was dismantled during the summer after just two years and moved to the garden of a small cottage at 145 Essex Street, Lynn, costing $1,650. It was re-erected near a pear tree orchard and operational by 1862 May. William Mitchell (aged 70) received permission from Bache (USCS) to take his borrowed instruments to Lynn; he also retained the weather instruments from the Smithsonian for further use.[161] Financially Maria had her $500 salary from the *Nautical Almanac* and her father had a $300 pension, enough to be able to employ a girl to help with housework.

Lynn was a small, thriving, industrial city with a population of about 20,000 (over three times that of Nantucket). It was situated on the New England coastline between Boston and Salem; its extensive salt

*Fig. 13: Maria Mitchell's living room in the Vassar College Observatory led via a door and up some stairs into the dome above, where a 12-inch equatorial refractor was housed. Here Maria sits on the stairs with six students in a photograph taken in 1886. (Archives and Special Collections Library, Vassar College)*

marshes reminded them of the Nantucket coastline with the bonus of an abundance of bird life. Red brick chimneys sprouted above factories that manufactured leather shoes. Boston was a 30-minute steam-car ride away, or 90 minutes by horse carriage, opening up a much richer social, cultural, and scientific life.

Despite all the family upheaval Maria began to consider future possibilities. Troy Female Seminary, New York (1821), was the first American women's higher education institution, founded by Emma Hart Willard (1787–1870); in its first four decades over 9,000 boarding and day students had been educated there. In 1861 November Maria corresponded with George Bond about the possibility of Troy acquiring an observatory, but no further action was taken.[162]

Maria would also have become aware during the year of the 'magnificent enterprise' underway at Poughkeepsie, New York State, funded by entrepreneur Matthew Vassar (1792–1868).[163] Securities of $408,000 to a Board of Trustees for Vassar Female College (VFC) had been provided in 1861 February and a groundbreaking ceremony in 1861 June initiated the building of a five-storey boarding college.

In the last week of 1862 May Maria resumed her double star project, observing 15 pairs over 26 nights during the following 12 months. These included six doubles that she had previously measured and nine new pairs. Measures of position angle and occasionally separations (from 3.3″ to 66.8″) were again accompanied by colour estimates.

During the summer Maria calculated the geographical position of her Lynn observatory as: longitude 4h 43m 44s, latitude 42° 28′.[164] In 1862 August she observed her first comet from Lynn, the periodic comet 109P/Swift–Tuttle (the parent body of the Perseid meteor stream) which became a second–magnitude circumpolar object with a 25° tail; the clearer skies of her new location were later reported to her brother Henry.[165]

In the same month she had an unexpected letter from VFC trustee Rufus Babcock (1798–1875) requesting an invitation to visit.[166] The outcome proved very positive with Babcock reporting to Matthew Vassar: 'She is by far the most accomplished astronomer of her sex in the world … she has moreover a breadth of culture … has travelled a year in Europe … [in her observatory] handling her long and well adjusted telescope with masterful ease, accuracy and success.' [167]

Maria was unaware of her 'interview' and three months later was surprised to receive a second letter from Babcock, admitting he considered her 'being suited to fill the Chair of Astronomy in the Vassar Female College', adding he had already obtained three good testimonials and 'the way is all open now for a direct negotiation with you so soon as our President, Mr Jewett, shall return from Europe.' [168]

**6. Vassar Female College, Poughkeepsie**

The circumstances of the appointment of Maria Mitchell have been reviewed in detail by her biographers, so here I will expand on the decisions taken about the observatory and its equipment.[169] In 1863 April VFC president Milo Parker Jewett (1808–82) ordered an achromatic objective of 12 inches aperture from Henry Fitz (1808–63) in New York. The cost of the mounting was estimated at $2,500 and for the whole observatory a budget of $12,000 (~£192k today) was agreed, to include an equatorial room, transit room, prime-vertical room, library, and lecture room; provision was also made for sidereal clocks and a chronograph, along with filar and ring micrometers.

By 1863 July the price for the Fitz objective was confirmed as $1,600 with the whole telescope costing $4,100. VFC trustees were assured the facility would be the fourth-largest in America, but this was only true in terms of the diameter of the dome.

Considering that Maria had spent $3,000 on a 5-inch Clark equatorial with a single building it is likely that she became concerned as 1863 progressed that compromises were underway. The issue was further compounded when news came of the death of Henry Fitz in November, with assurances being made that his son Harry would complete the contract.[170]

During the same year 1863 Charles Samuel Farrar (1825–1903) was appointed interim chair of astronomy with a remit to develop plans for the observatory; he subsequently became Vassar's first professor of mathematics, physics, and chemistry.[171] Maria's opinions would not be sought for a further year.

Consultation during August with astronomer Lewis Morris Rutherfurd (1814–92), who had used several Fitz lenses and was the likely third party involved in the choice of a Fitz instrument for VFC, and Elias Loomis enabled building work to commence in 1863 September. The site chosen was on a slightly elevated rocky outcrop to the north-east of the main college building. The large central dome weighed 1.5 tons and was covered in sheet tin. The observatory had three wings, to the south, east, and north (Figure 12).

Opportunities for women's higher education in America steadily improved during the mid-19th century. Researcher Virginia Penny (1826–1913) listed over 500 potential jobs in her book *The Employments of Women: A Cyclopedia of Women's Work* (1863) which included quotes from Maria in the opening pages where she asserted that women could use 'the same delicacy of touch and of perception that makes them good at the needle, would make them efficient in the delicate manipulations of the micrometer … I have no doubt many of the computations professedly made by men, are really the work of women employed as assistants … my own observatory is wholly a private affair, and supported entirely by my own means, which are my daily earnings as computer to the *Nautical Almanac*. I employ no assistant.'

Penny also recognized that for her *Nautical Almanac* work Maria had pay parity with male computers. During the summer Maria completed her paper on her double star project (her fifth published work) covering nearly 40 pairs observed over 70 nights using powers of 75–200×.[172] Her skills as a mathematician led to tutoring her nephew Mitchell Barney on algebra and helping her brother Henry with cubic algebraic equations. Anticipating the need to resume her teaching skills Maria circulated Lynn residents about a series of talks at her observatory on astronomy and also made enquiries of Joseph Henry at the Smithsonian regarding his networks.[173]

During 1855–61 Jewett had been the chief advisor to Matthew Vassar. The situation changed after Jewett's return from an eight-month tour of Europe (1862/3) and he later resigned his post. In 1864 April VFC trustee John Howard Raymond (1814–78) was promoted to become the second President of VFC with special responsibility for curriculum organization.

In 1864 March Maria wrote again to Babcock after his assurance that her father could accompany her to VFC and that she could continue her work for the *Nautical Almanac*:

> My Father's comfort is of the utmost importance in my eyes … I have known nothing of the plan for an observatory … if I do not find a good instrument, that I shall be allowed to take my own … I should hope, in time to find students who would tax my utmost powers … some girls who shall go far beyond me … if the pupils are few, there will be observatory work … its Latitude and Longitude must be accurately determined … [adding with regard to the perceptive faculties of women] … the same delicacy of eye and touch is needed to bisect the image of a star by a spiders-web, as to pierce delicate muslin with a fine needle … a girl's powers of steady endurance of monotonous routine is great … I think as <u>observers</u> in any department of natural science they would be excellent.[174]

Accompanying the 12-inch f/16 Fitz equatorial was a 3.7-inch f/17 Young transit circle which was mounted in a meridian room in the East wing of the building.[175]

Maria remained keen that the observatory should be equipped with at least one quality telescope but was uncertain whether it would prove to be the main equatorial or the meridian instrument. In 1865 April the Civil War ended, and Matthew Vassar was able to complete his massive undertaking.

During the summer Maria observed her second comet from Lynn when C/1864 N1 passed very close to the Earth, at a distance of just 0.09 au on August 8.[176] On 1865 January 18 she observed the occultation of Spica.[177] Within a month she also learned of the loss of two close friends, Edward Everett (January 15) and George Bond (February 17).[178] In March VFC president Raymond formally offered MM the post of Professor of Astronomy at a salary of $800 with board for herself and her father. She accepted and the appointment was duly approved on 1865 April 12.

## Conclusion

Researching possibly the most famous American woman astronomer has proved an absorbing task. The writer was keen to develop some new interpretations of her life and hopefully make at least one 'discovery'. Previous biographies have explored her networking, the award of her gold medal, her fight for women's rights, her journals and letters, and even her poetry. What seemed to be lacking was a chronological timeline of her astronomical work.

In tackling this the writer quickly realized the confusion that existed over the instruments she used at different times. Her 'comet-seeker', essentially a short-focus and low-power telescope with a wide field, was variously described and often misrepresented. The writer has endeavoured to show that Maria Mitchell benefitted from two fund-raising campaigns: first to allow purchase of a 3-inch f/8 Fitz refractor on an altazimuth mounting; second to allow purchase of a 5-inch f/14 Clark equatorial and observatory.

Another area deemed weak in the literature was the sequence of events relating to the observations of her 1847 comet. This required a careful literature search to identify the key players and dates when this visitor, with its highly inclined orbit, was observed. Other areas of relatively new research include details of the instruments that she viewed during her grand tour (1857/8) which subsequently allowed her to reject one proposed observatory setup in favour of her own choice of instrument-maker.

In delving into the origins of her American trip (1857) the writer identified for the first time the true identity of Chicago banker 'Mr. Swift', speculated on the espionage nature of his involvement, and also answered the question of 'what ever happened to Prudie?' The story remains unfinished and forthcoming papers in *The Antiquarian Astronomer* will endeavour to examine Maria's Vassar College years (the 'Female' label being dropped within a year) and the impact she had on so many young women. This will include the work of her successors Mary Watson Whitney (1847–1921), Caroline Furness (1869–1936), and Maud Worcester Makemson (1891–1977), who all contributed so much to Maria Mitchell's legacy. It will also examine the instrument difficulties she experienced and her novel solution to the problem of how her students could obtain sunspot photographs. A description of how this work was tackled is available.[179]

## Acknowledgments

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## References and notes

1. Mitchell, H., 'Memoir: Maria Mitchell', *Proc. Am. Acad. Arts Sci.*, 25 (1889), 331–43.
2. In addition to Maria (1818), William and Lydia had nine other children: Andrew Mitchell (1814–71) who married Ann Elizabeth Swain (1814–59) in 1843; Sally Mitchell (1816–76) who married Matthew Barney (1814–97) in 1838; Anne Mitchell (1820–1900) who married Alfred Macy (1831–74) in 1858; Francis Macy Mitchell, known as Frank, (1823–91) who married Ellen Mitchell (1832–91); William Forster Mitchell (1825–92) who married Charlotte Dow (1823–92) in 1846; Phebe Mitchell (1828–1907) who married Joshua Kendall (1828–1913) in 1854; Henry Mitchell (1830–1902) who married Mary Dawes (??–1866) in 1854, plus two more; Eliza Mitchell (1830–34); and Eliza Catharine Mitchell, known as Kate, (1833–1907) who married Owen Dame (1833–96) in 1857. Maria herself never married.
3. The War of 1812 was a US/UK conflict (1812 June to 1815 February). Maria Mitchell's [MM] first astronomical observation might have been her

father showing her Comet Tralles (C/1819 N1) in 1819 July; she would have been 11 months old and the first-magnitude comet had an 8° tail. Both William Mitchell [WM] and William Folger (1765–1849) observed C/1819 N1 from Nantucket. Some superstitious islanders believed it an evil omen, later linked to the tragedy of the Nantucket whaling ship *Essex*, as recounted in the book *In the Heart of the Sea* by Nathaniel Philbrick (2000) and film of the same name (2015) by Ron Howard.

4. WM's jobs included farming, refining whale-oil, barrel-building, justice of the peace, executor of wills, insurance broker, and instrument repairs, but especially teaching and later a bank cashier.

5. Historical population figures for Nantucket (from Wikipedia): 1820 (7,266); 1840 (9,012); 1890 (3,268); 1900 (3,006); 1920 (2,797).

6. Books on Maria Mitchell consulted include: *Maria Mitchell: Life, Letters, and Journals*, by Phebe Mitchell Kendall (1896); *Sweeper in the Sky: The Life of Maria Mitchell, First Woman Astronomer in America*, by Helen Wright (1949); *Maria Mitchell: The Soul of an Astronomer*, by Beatrice Gormley (1995); *Maria Mitchell: A Life in Journals and Letters*, by Henry Albers (2001); *Among the Stars: The Life of Maria Mitchell*, by Margaret Moore Booker (2007); and *Maria Mitchell and the Sexing of Science*, by Renée Bergland (2008) – hereafter Kendall (1896), Wright (1949), Gormley (1995), Albers (2001), Booker (2007), and Bergland (2008) respectively.

7. The author has used a currency conversion of £1 = $5 for this paper, with the assumption that costs have risen by a factor of 70 since 1815; by a factor of 80 since 1840; and by 90 times by 1870.

8. Mitchell, W., 'The Tails of Comets', *Am. J. Sci. Arts*, 38 (1840), 35–40. See also Mitchell, W., 'Additional Remarks on the Tails of Comets', *Am. J. Sci. Arts*, 40 (1841), 59–68.

9. The Vestal Street geographical coordinates were calculated as: latitude 41° 16′ 32″ N, longitude 70° 7′ 42″ W.

10. Nantucket whaling ships travelled across the globe often on voyages of two years or more. Captains relied on accurate chronometers for determining their longitude at sea. The appeal of harpooning a whale excited many teenage boys and Andrew Mitchell was drawn to sea at this time in his uncle's ship. MM used the sextant and whale-oil lamp to measure star altitudes on the meridian, reducing her measures to correct each chronometer – her first paid job.

11. Mitchell, W., *A Brief Memoir of the Late Walter Folger*, (1855). Folger was a keen observer of comets on Nantucket, beginning with sextant observations for position, motion and parallax of C/1807 R1 and continuing with C/1811 F1. Prior to the 1829 return of Comet Encke he calculated a detailed ephemeris covering ±500 years which MM (aged 10) would have seen during her visits.

12. Siblings Walter and Phebe Folger were closely related to WM. Phebe Folger was a significant role model for MM who many years later praised her independent spirit and accomplishments, which included teaching her husband Samuel Coleman navigational skills to become a ship's captain. Phebe and Samuel married in 1798 and moved off-island to a farm near New York (1811); they had three children but Samuel was at sea for 19 years of their 27-year marriage.

13. During her time at Peirce's 'School for Young Ladies' MM's younger sister Eliza Mitchell (1830–33) died. In 1833 her mother Lydia had nine children at home, including baby Kate. Older sister Sally was employed as a teacher in 1833 on a salary of $300. MM was popular with young children and a gifted storyteller.

14. Michell, W., 'Observations on the Solar Eclipse of November 30th, 1834', *Am. J. Sci. Arts*, 28 (1835), p. 192. MM's timing of the eclipse duration was 2 hours 31 minutes 30.6 seconds.

15. Ibid., p. 156. Halley's comet was first seen in America on August 31 by Loomis and Olmsted at Yale College, using a 5-inch refractor. By October it was of first magnitude with a 20° tail.

Biographers of MM have consistently implied that her first astronomical observation was the solar eclipse of 1831 February (aged 12½); the writer suggests that her keen eyesight would have detected at least a couple of comets before then. She would also have been fascinated by her father's stories of previous visits of comets Encke, Biela, and Halley.

16. *Nantucket Inquirer*, 1835 November 18. The aurora was seen at 11 p.m.

17. The Pacific Bank was a central red-brick building. WM did not receive a salary increase but had free use of the dwelling house as he was in effect the bank manager. He purchased a large celestial globe and continued to rate chronometers for whaling captains.

18. The United States Coastal Survey (USCS) started in 1807 as the official chart-maker for US nautical charts. Hassler was superintendent (1832–43) and was succeeded by Alexander D. Bache; Bache had been president of the central high school in Philadelphia for three years, where he had founded a fine observatory.

19. The repeating circle/altaz circle was probably one of the two Troughton geodetic instruments (1812) ordered by Hassler and delivered in 1815. It had two 24-inch telescopes mounted on a 17-inch circle which could be rotated through a right angle. The Mitchells kept it until 1861; it helped fix the exact location of the two meridian stones.

20. Strelnitski, V., et al., 'Historic Meridian Stones on Nantucket & Elsewhere', *The American Surveyor* (2006 May). The south meridian stone was originally fixed outside 40 Fair Street, home of retired whaling captain Seth Pinkham (1786–1844), but it has been moved slightly since; today it is the location of the Nantucket Preservation Trust.

21. Mitchell, W., 'Auroral Belt of May 29, 1840', *Am. J. Sci. Arts*, 39 (1840), p. 383 (also the *Nantucket Inquirer*, 1840 June 2). The Mitchells hoped other observers might have also seen this event to give a parallax determination of the height of this aurora. The aurora on 1827 August 28 occurred when Maria

was aged nine and may have also been seen by the Mitchell family.

22. Comet C/1843 D1 was best seen from the southern hemisphere. Near perihelion (February 27) it was visible in daylight. A painting by Charles Piazzi Smyth (1819–1900) at the Cape of Good Hope showed a double tail 25° in length in early March.

23. Herrick, E. C. (communicated by), 'Observations made at New Haven on the Shooting Stars of the August Meteoric Period, 1844', *Am. J. Sci. Arts*, 48 (1845), p. 316.

24. Mitchell, W., 'Phenomenon', *Nantucket Telegraph*, 1844 September 10; Maria observed the halo from the steps of the Atheneum. Another unusual solar halo was recorded by the Mitchells in 1847 April: *Nantucket Inquirer* April 5.

25. Mitchell, H., (1889), op. cit. (ref. 1), p. 335.

26. Mitchell, M., 'Supplement to Prof. Loomis's Paper', *Am. J. Sci. Arts*, 49 (1845), p. 406. MM determined the average cloudiness of different months at Nantucket, supplementing a more detailed meteorological paper by Loomis on pp. 266–83 of the same volume.

27. William Cranch Bond [WCB] received $1,500 and George Phillips Bond [GPB] $640 (c. £24k and £10k/year respectively) and they had a free home. MM described it as 'a small round building and in it was a small telescope'.

28. Initially Harvard University allocated $6,000 for the new telescope (1842 summer) but after the daylight comet (1843 March) revealed the limitations of the Harvard equipment public subscriptions raised $20,000 and a generous donation from David Sears funded the Observatory Tower.

29. WCB shared his experience (1844 December) of latitude measurement, using a prime-vertical transit telescope, with WM during a visit to Nantucket in early 1845. The two men corresponded regularly and collaborated where possible. For example when signal rockets were to be used for longitude measurements WM suggested that MM might observe them from Nantucket in his absence. Letter from WM to WCB, 1844 May 14.

30. Maria and Anne were visiting Priscilla Price Haviland (1822–95) who lived a few miles east of Poughkeepsie. The two sisters travelled by paddle-boat from New York north up the Hudson river then took a stage-coach (letter, 1844 September 19). They returned via Harvard College library, the Bonds at HCO, Boston, and Providence. Two decades later the Poughkeepsie journey would become very familiar to MM.

31. The Athenaeum movement began in Liverpool (1798); the Greek word 'Athenaeum' came from Athena, the goddess of wisdom. The Boston Athenaeum began in 1807. The NPI principle of 'equal education for everyone' supported Nantucket social and literary life with a generous schedule of lectures and provision for artefacts. The Nantucket branch used the alternative spelling Atheneum. WM was later president of the NA trustees.

32. The Coterie literary club comprised 22 men and 22 women from Nantucket who met at the Atheneum. Maria contributed a weekly poem to the group.

33. An example of the public lectures at the original Nantucket Atheneum was in 1846 May and June when Ralph Waldo Emerson (1803–82) gave six talks on Plato, Swedenborg, Montaigne, Shakespeare, Napoleon, and Goethe.

34. MM had two cousins, Lucretia Coffin Mott (1793–1880) and Anna Gardner (1816–1901), both of whom campaigned for women's rights and the abolition of slavery.

35. Bergland (2008), p. 31.

36. William Mitchell Barney was MM's first nephew.

37. WM was elected a Fellow of the American Academy (1842). The USNO proposal was made by Harvard mathematician Benjamin Peirce (1809–80). The USNO director chosen was Matthew Fontaine Maury (1806–73).

38. The view east from the Pacific Bank roof, across the smouldering heart of Nantucket, must have been sensational. A major fire in Nantucket had occurred before: in 1838 June 2 flames were seen in Union Street at 2 a.m., with the resulting fire lasting four hours and causing $100,000 of damage. WM noted that the 1846 fire 'destroyed my observatory, deranged my instruments, and scattered and destroyed some of my results' (letter, 1847 October 29).

39. Nantucket also suffered from ever-shifting sandbars leading to silting of the harbour. In addition, the California gold rush (1848–55) enticed young people away, as did the discovery of petroleum in Pennsylvania (1859). Its waterfront properties were not rebuilt after the Great Fire and the whaling industry relocated to New Bedford on the mainland, after which Nantucket had to rely more on tourism.

40. Jones, B. Z., and Boyd, L. G., *The Harvard College Observatory: The First Four Directorships*, 1839–1919 (Harvard University Press, 1971), 63–64. Neptune had been discovered by Galle on September 23. WCB extrapolated its motion towards a group of 8–10 stars and used an annular micrometer to identify the 7th-magnitude planet's displacement.

41. Mädler, J. H., 'Die Centralsonne', *Astronomische Nachrichten*, 24 (1846), 213–40. A copy reached Cambridge just prior to MM's visit. Mädler reobserved Bradley's catalogue (1805) of 3,222 stars with a 4.2-inch Reichenbach meridian circle for evidence of proper motion and suggested that the Solar System orbited a point in the Pleiades cluster near Alcyone every 25 million years.

42. GPB disagreed with Mädler's hypothesis and no doubt benefitted from MM's knowledge of works by Gauss and Airy on celestial mechanics and gravitation.

43. Between 1846–51 GPB found 12 comets at HCO. He used the Bowditch comet-seeker which gave a 2.1° field on a Merz equatorial. In 1857 it was modified into a broken-back altazimuth using a large prism to give a 4.5° field; it was then used by the Tuttle brothers. See Schmidt, R. E., 'The Tuttles of HCO: 1850–62', *The Antiquarian Astronomer*, 6 (2012), 74–10.

44. Mitchell, H., (1889), op. cit. (ref. 1), p. 335.

45. 'Review of the Annual Report on the U.S. Coast Survey', *Am. J. Sci. Arts*, 5 (1848), 307–18. The USCS Annual Report 1846–7 included selection of astronomical stations to use new zenith telescopes for latitude by Talcott's method. The zenith distance of culminating stars at similar altitude either side of the zenith was measured, a process needing only a few minutes compared with the lengthy prime-vertical transit method which required clear conditions for many hours.

46. The enlarged Atheneum had a 450-seat lecture hall, an exhibition space on the second floor and smaller rooms for books, the museum, and meetings. WM and MM used their networks to secure donations of books by subscription for the new NA. The inaugural lecture in the new hall was in 1847 March, but the building had been erected so quickly that it later developed damp problems. The Nantucket Philosophical Society, with WM president, used the Atheneum.

47. The JPL Small-Body Database Browser provides an excellent tool for investigating C/1847 T1 (Mitchell). Orbital elements (by Palmer) cover a 74-day data arc (1847 October 7 to December 20) with the animated orbit diagram illustrating the highly inclined hyperbolic orbit. The HORIZONS Web-Interface can produce a detailed ephemeris for any location; the writer chose 'Nantucket' as the observer location and used table settings for 'heliocentric range', 'observer range', 'target-observer-moon angle/illumination', 'skip daylight', and an elevation cut-off of 10°. This revealed that the comet was only visible from northern skies up to October 18. A further search enabled the period October 1 to January 3 to be usefully examined.

48. Mitchell, W., 'On the Comet of 10th month, (October 1st) 1847', *Am. J. Sci. Arts*, 5 (1848), 83–85. Details of the Mitchells' transit instrument are unknown; probably a 1.5-inch f/15 telescope with a set of wires to use with a chronometer.

49. Albers (2001), p. 26. WM wrote to WCB late evening on October 2 but it was not received by WCB until October 7 when the Bonds made their first observation.

50. *The Catalogue of Stars of the BAAS* (1845) listed the RA and NPD of 8,377 stars for 1850.0. The publication was led by Francis Baily (1774–1844) and completed by the British Association after his death. Use of this resource shows the Mitchells were fully up to date with contemporary references, despite their modest-sized instruments.

51. De Vico had become director of Collegio Romano in 1839. During 1844–46 he discovered six comets. European astronomers initially assumed he had discovered MM's comet.

52. Mitchell, W., (1848), op. cit. (ref. 48). The reduced value for the comet position was probably the most accurate the Mitchells obtained: RA 18h 11m 13.40s and dec +79° 57′ 57″.6 and might have been one of the three positions Maria used to calculate the orbital elements.

53. Ibid.

54. Albers (2001), p. 27, undated letter from GPB to MM. 1847 September proved an exhausting month for the Bonds with the installation of the 15-inch Merz objective into the tube and first light on September 22.

55. Ibid., WCB diary entry for 1847 October 7. C/1847 T1 was the first comet observed with the new 15-inch equatorial at HCO. The letter from WM had been received that morning and the Bonds also observed M42 for the second time.

56. Ibid. News of the new Harvard telescope being operational led to hundreds of visitors to the observatory. The public were treated to a 30-second view of Saturn and the fact that MM's comet was now a naked-eye object with a $1\frac{1}{2}$° tail helped to make for a memorable evening. Some of the public were able to compare the comet with M31.

57. Bond, W. C., 'Observations on Miss Mitchell's Comet of Oct. 1, 1847', *Proc. Am. Acad. Arts Sci.*, 1 (1848), p. 183; part of Bond's presentation on 1847 November 2 at the Academy monthly meeting.

58. 1847MNRAS..8..9.

59. Dawes had been Bishop's observer up to 1844 May, when he moved to Campden Lodge, Cranbrook, to set up his own observatory. Hind replaced him as observer in 1844 October, discovering two comets (1846 and 1847) and asteroid Iris (7) on 1847 August 13. A week after his observation of 'Miss Mitchell's comet' he discovered a second asteroid, Flora (8), on 1847 October 18.

60. Ibid.

61. Mrs Rümker was the English wife of Georg Friedrich Wilhelm Rümker (1832–1900), director of the Hamburg observatory; she was also an astronomer and regularly swept for comets.

62. Albers (2001), p. 26, diary entry for October 16, the last time the comet was visible from Nantucket.

63. Presumably a few southern observatories also observed the comet.

64. 1847AN..26..249. d'Arrest was an assistant at Berlin observatory; the following year he moved to Leipzig observatory. He was fascinated by cometary orbits and had also been a major player in Neptune's discovery.

65. 1847MNRAS..8..9.

66. 1847AN..26…277.

67. 1847MNRAS..8..25. A more detailed ephemeris for December by Rümker was also included.

68. 1848MNRAS..8..130. Despite the accuracy for the comet's position on October 5 Maria elected not to use this date for her calculations; one possibility is that the uncertainty in her 'observer location' might have undermined the results.

69. Mitchell, W., (1848), op. cit. (ref. 48). This also include elements calculated by Harvard mathematician Benjamin Peirce, using positions for October 7, 11, 14, and 18.

70. Albers (2001), p. 27, letter from Bache to WM, 1847 October 18.

71. Mitton, J., 'Maria Mitchell, the Danish comet medal and early American astronomy', *JBAA*, 130

(2020), 349–56, has a more detailed analysis of Edward Everett's role in securing the gold medal for Maria.

72. 1847MNRAS...8...10; 1848MNRAS..8S..81 'Notice of discovery of Miss Mitchell's comet'; 1848MNRAS..8..130M, 'Elements of Miss Mitchell's comet'.

73. A 20-ducat gold medal contained about 70 grams of gold, $50 value (c. $4,000, or £3,000, today). Maria Mitchell's gold medal is now in the possession of the Maria Mitchell Association in Nantucket.

74. Maria was the only woman member until 1943 when four more were elected.

75. Davis had witnessed MM fire-fighting three years earlier at Nantucket and subsequently learned of her mathematical skills. *The Nautical Almanac* was a new federal bureau designed to 'raise the nation's scientific standing, promote astronomy, and improve navigation' (Bruce, R. V., *The launching of Modern American Science* (1987), p. 178). Davis proved to be an excellent mentor and friend to MM. After three years' work she completed the calculations for her first Venus ephemeris in 1851 October. *The American Ephemeris and Nautical Almanac* was first published the following year containing data for 1855.

76. In 1848 September MM wrote a comet memoir for Joseph Henry, but it was never published. The gift consolidated their long friendship.

77. When Nathaniel Bowditch, author of *The American Practical Navigator*, died in 1838 his son Ingersoll continued editing the work for two decades. As an overseer of Harvard College he regularly met WM and learned of MM's limited access to telescopes suitable for comet-searching. The campaign target was $1,200; Ingersoll Bowditch and Edward Everett were two subscribers but the total raised is unknown. MM's choice of comet-seeker was between a German Merz instrument or an American design by Henry Fitz.

    Note: Wright (1949) ch. 8 included a letter, dated 1849 April 19, from Nantucket physician Charles Frederick Winslow (1811–77) to Susanna Hickling Lewis Willard (1806–69) of Boston supporting her intention to canvass Everett to help the campaign; subsequent biographers have repeated this suggestion. However, this letter is for the funding of MM's Fitz refractor and not the later more costly Clark instrument.

78. Henry Fitz had begun making telescopes by 1845; a fully equipped 5-inch refractor for Erskine College cost $1,050 (1849). MM's 3-inch f/8 comet-seeker on an altazimuth mount would have cost c.$200 (£40, c.£3.2k today). It was similar to one purchased for the Friends Observatory, Philadelphia.

    The writer is grateful to Jascin L. Finger of the Maria Mitchell Association for sending a copy of MM's Will. The Fitz 'comet-sweeper' passed to three of her nephews; they subsequently sold the instrument and its whereabouts are unknown.

79. During the warmer summer months Mary and Selina Bond visited Nantucket and met with MM at the Atheneum. They would have travelled by railroad from Boston to Hyannis, on the southern shore of Cape Cod, before making the three-hour journey across Nantucket Sound.

80. Reported by WM at the 1848 April 4 meeting of the Academy (*Proc. Am. Acad. Arts Sci.*, 1 (1848), p. 329). The fireball was seen at 2.30 a.m.

81. Henry Mitchell had recently joined the USCS. Bache recruited him and Maria for specialist training in surveying techniques at Mount Independence, Maine (1849 summer). She was trained to use a zenith telescope to accurately determine latitude. This instrument is partly shown in Figure 8. It demonstrates MM's significant contribution to geodesy, a fact not previously appreciated by her biographers. Two decades later (1872 spring) she borrowed the same instrument again to measure the latitude of the Vassar College Observatory, working with Mary Watson Whitney.

82. This was Goujon's Comet, discovered on April 15 in Paris. It moved from Hydra rapidly north through Leo into Ursa Major; closest to Earth on April 23, reached perihelion on May 26 and was last seen on September 22.

83. *The American Almanac* (1853), p. 81.

84. The Vega image was obtained with photographer John Adams Whipple (1822–91).

85. A crop of this image, showing just MM, has been widely used by her biographers. Its exact date is uncertain.

86. Loomis, E., 'Miss Mitchell's Comet', *The Recent Progress of Astronomy: Especially in the United States* (1850), 109–12.

87. Humboldt, Alexander von, *Kosmos*, vol. 3 (1850), a treatise on science and nature which inspired MM. The 644-page volume is mainly text but has several tables of astronomical data. Schwabe's table (p. 402) and proposal of a solar cycle followed 18 years' observation of the Sun (1826–43), using 2.8-inch and 4.8-inch Fraunhofer f/15 refractors, at Dessau.

88. Loomis published a series of papers (1859) on the aurorae and the link between geomagnetism and the solar cycle.

89. Mitchell, M., 'The United States Coast Survey', *Christian Examiner*, 52 (1852), 77–96. MM's first detailed paper.

90. Dassel was from Königsberg, Prussia (the modern Kaliningrad). She was pregnant during her Nantucket trip and named MM as her child's godmother. Four years later MM visited her Manhattan studio to meet the three-year-old child.

91. Henry Mitchell entered the USCS at the age of 19 (1849) and initially worked on triangulation surveys. By 1854 he had transferred to the hydrographic branch and begun work on tidal surveys around Nantucket. This USNO visit is not documented in MM's journals (which resumed in 1853) but deduced by the writer from a comment she made on seeing the Collegio Romano equatorial (1858). MM also visited Washington in 1857 but Henry was then busy finishing an investigation of tides and currents at Hell's Gate, a narrow strait in New York harbour, so their visit was most likely in 1852.

92. The author has coined the term 'Dorpat 7' to include the seven Fraunhofer–Merz instruments of similar dimensions constructed 1824–58. The prototype was commissioned by Friedrich Georg Wilhelm Struve (1793–1864) for Dorpat Observatory. Copies were made for Berlin, Kazan, Kiev, Washington, Collegio Romano, and Palermo. MM would see two of these during her travels of 1857/8; she would also meet with Struve twice at Greenwich in England. See: SHA *Bulletin* 33 (Spring 2020), 42–43.

93. Booker (2007), p. 106, letter from MM to GPB, 1852 May 20. GPB married Harriet Gardner Harris (1829–58) on 1853 January 23, and their first daughter was born eight months later on October 21.

94. Her sister Anne, a gifted linguist who spoke seven languages, helped select the 75 volumes for the foreign books section. She taught languages at the reopened Coffin School in Winter Street (1854–57), which educated c.100 children aged 8–12, before marrying teacher Alfred Macy.

95. Kendall (1896), p. 169; 1856AJ..5..7M.

96. Mitchell, W., 'A beautiful comet', *Nantucket Inquirer*, 1854 March 31.

97. Comet C/1854 R1 was discovered by Wilhelm Klinkerfues (1827–84) at Göttingen (September 11) and then independently by Bruhns (12th), R. van Arsdale at Newark (13th), and Donati (18th) so MM was the fifth person to find this diffuse object which was last seen on December 3. She found it close to two nebulae in Ursa Major; it resembled these but on September 21 it showed motion over a three-hour period (Kendall (1896) p. 31). MM, now aged 36, persevered with computing its parabolic orbit, using measurements from Cambridge and Washington; this was the seventh year she had been calculating orbits to compare with her own observations, but the lack of a micrometer was a limitation.

Two other significant events in 1854 September for Maria were the marriages of Phebe to Joshua Kendall on September 14 and then her youngest brother Henry to Mary E. Davies a week later.

98. Kendall (1896), 16–17.

99. Booker (2007), p. 115.

100. Kendall (1896), p. 36.

101. Kendall (1896), 34–41.

102. Lydia Mitchell's illness began 1855 February 26 and lasted six years until her death on 1861 July 7. MM took on the majority of the nursing role, with her sister Sally covering her trips in 1857/8. In 1855 MM lost three good friends: Ida Russell, Phebe Vinton, and Miss Bonsey.

103. Booker (2007), 122–3.

104. MM was the first woman elected to the AAAS and she was warmly welcomed at the Providence meeting. Details of the event were published in the *Providence Journal* of 1855 August 14–22.

105. Booker (2007), p. 124. MM later led two solar eclipse expeditions with Vassar College students, in 1869 and 1878.

106. Comet C/1855 V1 was discovered by Bruhns on November 12 in Berlin. This was MM's fourth comet and she observed its nightly motion of using her Fitz comet-seeker; at times the December gales made her exposed position difficult.

107. Booker (2007), p. 127, letter from WM to WCB, 1855 December 21.

108. Booker (2007), p. 130, letter from MM to WCB, 1856 September 11.

109. Mitchell, M., 'Letter from Miss Mitchell to the Editor', *Astronomical Journal*, 5 (1856), p. 7.

110. Gould's reply to MM was dated 1856 November 8 and written while he was working at Harvard for the USCS on longitude measurements. Pogson observed 53 variable stars (1851–54) while observer at the Radcliffe Observatory (vol. XV of the *Radcliffe Observations*); seven of them were his own discoveries using the 7.2-inch equatorial. MM would learn more about variable stars at Bonn observatory (1858) when she met F. W. A. Argelander.

111. Richard Kellogg Swift (1813–83). Previous biographers have incorrectly recorded RKS as 'H. K. Swift' and not realized his true identity. It is probable that MM's contract was agreed via MM's brother Frank, who had relocated to Chicago in 1856 with his wife Ellen to set up a business. The initial departure date was 1856 October 22 but the Navy at first refused MM permission to continue her Venus computations while abroad.

112. RKS married Melissa Amanda Tibbils (1819–95) in 1835. Four years later, accompanied by their first child Prudence, they joined other pioneers in Chicago. RKS established a banking business (Swift Brothers) and became a Captain in the Illinois militia (1846–53). A year before MM's trip his rank had risen to Brigadier-General. By 1857 March three more children had enlarged the family who were then living in a newly built residence in Michigan Avenue, Chicago. RKS was also a physicist, experimenting (before Samuel Morse) with sound and electricity; he was also a founder member of the Academy of Sciences in Chicago.

113. Albers (2001), 73–80. It is interesting to speculate whether Brigadier-General Swift, travelling as 'Mr Smith', was actually on a month-long reconnaissance mission to the southern states. MM's journal notes him always disembarking at every stop to obtain copies of local newspapers (Booker (2007), p. 143). The Mississippi river became a vital strategic objective for both the Union and Confederate forces during the American Civil War. After ensuring his daughter and chaperone had departed on their next steamboat on the Alabama river RKS returned from New Orleans to St Louis, the typically 25-day journey up-stream at 10 mph giving him ample opportunity for further reconnaissance. In 1861/2 he played an important military role in the defence of Cairo, Illinois, at the intersection of the Ohio and Mississippi rivers.

114. Albers (2001) pp. 77–78. The solar eclipse was viewed through clouds just before sunset, not far from New Madrid.

115. Emerson's *United States Magazine*, 4 (1857 July 9); last para in Wright (1948) ch. 6. $3,000 was a substantial figure ~£600 (c. £48k today).

116. Schmidt, R. E., and Dearden, P., 'The Liverpool Observatory at Waterloo Dock, Part 1: Origins and controversy', *The Antiquarian Astronomer*, 13 (2019), 2–22. John Taylor was an amateur astronomer and also helped develop the design of celestial globes. See also Kendall (1896), p. 86, and Booker (2007), p. 166.

117. Nantucket had around 90 ships (1840), with typically six docked on any day, compared with some 21,000 at Liverpool (1851), with hundreds in dock on any one day.

118. Kendall (1896), p. 87; Booker (2007), p. 167.

119. In 1856 Dawes moved from Wateringbury, Kent, to Hopefield, Buckinghamshire. At the former he compared a 7.5-inch f/15 Clark ($950 in 1854) with an 8-inch f/15 Clark during the Saturn oppositions of 1855–56; at the latter site he would continue testing Clark objectives, using a 7.2-inch (1858) before finally installing an 8.2-inch equatorial a year later.

120. Brück, M., *Women in Early British and Irish Astronomy*, (Springer, 2009), p. 99 (hereafter, Brück (2009)). The girls were Jane Lassell (1831–1920), Caroline Lassell (1833–1919), and younger sister Charlotte, one of whom had observed Maria's comet in 1847. Jane and Caroline donated their father's '2-foot reflector' to Greenwich (1883) and were also members of the BAA.

121. Albers (2001), p. 86, letter from GPB to Airy; Booker (2007), pp. 163 and 172, letter from GPB to Smyth, Thames trip. Both Richarda Airy (1804–75) and Annarella Smyth (1788–1873) were instrumental in ensuring their American guests were treated well and introduced to the leading people of the day.

122. Booker (2007), pp. 164 and 175. GPB had given MM copies of his double-star photographs to show in London; he also gave her a copy of the Saturn memoir that his father and he had completed at HCO. In 1857 July GPB wrote to WM explaining his photographic methods (with Whipple); WM shared key facts with MM, enabling her to have accurate information for her various meetings.

123. Brück (2009), p. 111. Smyth described MM as 'a young lady, industrious and vigilant, a good astronomer and mathematician'. He published his Porrima results in *Speculum Hartwellianum* (1860). For a detailed description of the Lee equatorial see Peeling, R., 'The story of the Lee Equatorial and Smythian telescopes', *The Antiquarian Astronomer*, 14 (2020), 51–65.

124. Albers (2001), p. 96; Booker (2007), p. 178. Airy's 'challenge' was an ascent of the 'Old Man of Coniston', for which he gave MM a detailed description, and was completed by pony with a guide from Coniston Waters, with the last half mile completed on foot. Poetry was a lifetime's passion for MM; in the Lake District she visited Wordsworth's tomb at Grasmere and also met with Kate Southey, daughter of the late poet laureate, at her cottage near Keswick.

125. Albers (2001), p. 92.

126. Albers (2001), p. 99; Booker (2007), p. 183.

127. MM now lost her stipend from the Swift family, requiring her to seek cheaper lodgings. Previous biographers have not explored Prudence Swift's life further. She returned to New York with an American family on 1857 November 11, after her three months abroad. In 1860 she married Charles H. King and they had one son, Howard Swift King (1861–1931). In 1869 she married William Henry Christian (1841–1916) and they had two daughters while living in Chicago: Daisy E. Christian Dipper (1870–1918) and Nora Christian Wilson (1872–1950). WHC was a postmaster from Stephenville, Texas, and served under Prudie's father during the Civil War campaign for strategic control of the Mississippi. Prudence E. Swift Christian died in Seattle in 1920.

128. 'Maria Mitchell's Reminiscences of the Herschels', *The Century*, 38 (1889), p. 903; Booker (2007), p. 187.

129. Booker (2007), p. 188.

130. Kendall (1896), 142–3; Booker (2007), p. 190.

131. Booker (2007), 196–8.

132. Albers (2001), p. 120; Booker (2007), p. 213. The Campidoglio observatory on Capitol Hill (1823) had a 6-inch Ertel/Scarpellini meridian circle (1827), installed by Calandrelli (1853) in the east tower for positional astronomy.

133. Booker (2007), p. 218. This was the second of the 'Dorpat 7' series that MM viewed, Washington having been the first.

134. Booker (2007), p. 224; Albers (2001), p. 124.

135. Bergland (2008), p. 150.

136. Bergland (2008), p. 152.

137. Bergland (2008), p. 138; Booker (2007), p. 228.

138. Booker (2007), p. 230. This was the third of the 'Dorpat 7' instruments that MM viewed.

139. Booker (2007), p. 232. The Everett letter was dated 1856 October 11.

140. Bond, G. P., *An Account of Donati's Comet of 1858* (Cambridge, 1858), p. 6. See also: *The Mathematical Monthly* vol. 1 by J. D. Runkle, with two further papers by GPB on Donati's comet: 1858 November, 61–67, and 1858 December, 68–113, the latter with good illustrations.

The first three American observers to see the comet, all working independently, were: H. P. Tuttle at HCO on the evening of June 28; H. M. Parkhurst at Perth Amboy, N. J., on June 29; and MM at Nantucket on July 1.

141. For a comet specialist like MM there is a surprising lack of observations of Donati's Comet in the literature. Her sister Phebe at Meadville, Pennsylvania, made an accurate crayon drawing of the comet which was later sent to the Bonds by WM and also exhibited at the Nantucket Agricultural Society fair in 1859.

142. Kendall (1896), p. 170; Booker (2007), p. 238.

143. Booker (2007), pp. 235 and 243. EPP was a strong advocate of the German system for early years education and opened her first kindergarten for children aged 4–6 years in Boston (1860). MM acknowledged, 'I count in my own life, outside of family relatives, three aids given me on my journey, they are prominent to me: the woman who first made the study-book charming; the man who sent me the first $100 I ever saw, to buy books with; and another noble woman, through whose efforts I became the owner of a telescope; and of these the first was the greatest' (Kendall (1896), p. 7). The three people were: Elizabeth Gardner, Joseph Henry, and Elizabeth Palmer Peabody.

144. The New England campaign to purchase the Sharon Observatory for MM also involved the Unitarian minister Edward B. Ball of Providence, and was supported by both Loomis and WCB. Key science patrons were: John Carter Brown of Providence, Edward Everett, J. Ingersoll Bowditch, and Francis Peabody of Salem (uncle of EPP and SH). After raising $1,000 the campaign was boosted by Elizabeth Palmer Peabody (1857 August) when she launched a subscription invitation to the 'Women of America', in particular her local Boston community. When MM returned home (1858 June) she was delighted to hear of the fund-raising efforts but less pleased with their choice of observatory.

The Sharon Female Seminary, Philadelphia, was founded by Jackson who installed (1846) in a 34-ft tower a 6.3-inch f/17 Merz undriven equatorial ($1,800, c.£28k today), and a 3.2-inch f/15 Merz–Young meridian circle ($800/£160, about £13k today). Jackson died in 1855 and the trustees advertised the observatory for $3,000. It is a testimony to Maria's good judgement that she declined this opportunity and followed her own plans.

145. EPP was the sister of artist Sophia Peabody Hawthorne (1809–71) with whom Maria had travelled to Rome during the winter (Booker (2007) pp. 237 and 523). EPP later reported to MM (1860 May) 'the Sharon observatory is scattered and sold … it is a pity it is gone'.

146. Booker (2007), p. 241, MM to WCB 1858 September 2; GPB to MM 1858 September 16.

147. MM's 1859 January trip was preceded by a visit to the Bonds at Cambridge to learn more of their photographic work. This was a sad time for GPB whose wife had died December 12 and their youngest of three daughters also died early in 1858. More bad news would soon follow with the death of WCB on January 29.

148. Charles Baker Adams (1814–53) at the Lawrence Observatory, Amherst College, Massachusetts, installed a 7-inch f/15 Clark equatorial (1853) with a Bond spring governor to regulate the drive. It was fitted with 12-inch graduated circles with verniers enabling RA to 2s and dec. to 30″. The total cost was $1,800 and Alvan Clark was awarded an honorary masters degree in the following year. See also: Todd, D., 'Early History of Astronomy at Amherst College', 1903PA…11…322T.

149. Albers (2001), p. 133. MM had saved $300 by choosing a 5-inch aperture rather than 6-inch.

150. Tristram Coffin (c.1609–81) was a Massachusetts immigrant from England. He led a group who purchased the island of Nantucket (1659) for '£30 and two beaver-hats' and his family and descendants settled there. Admiral Sir Isaac Coffin (1759–1839) of Boston gave an endowment to begin the Coffin School (1829–46) which in a new building on Winter Street (1854–98) taught both sexes. MM invited some of the children into her observatory to show them Venus through her telescope during the day (see Bergland, ix–xi).

151. Kendall (1896), p. 168, letter from W. H. Smyth to MM, 1859 July 7.

152. *Scientific American*, 1 (1859), p. 234.

153. Booker (2007), p. 248; *Nantucket Weekly Mirror*, 1859 September 3.

154. Mitchell, M., 'Observations on some of the Double Stars', *Am. J. Sci. Arts*, 36 (1863), 38–40.

155. Ibid.

156. Gormley (1995), p. 78, letter from MM to Phebe Kendall, 1860 April. The perihelion precession of Mercury would later be explained by Einstein using the theory of relativity. Le Verrier continued to believe in the existence of Vulcan.

157. Bergland (2008), p. 155. This would have been seen at low altitude (c.20°) from Nantucket as the declination of Mars was then −22°; it was not reported by other American observers and was a conjunction event for sites further west.

158. *Atlantic Monthly*, 5 (1860 May), 145–55. The paper was reprinted in the *Nantucket Inquirer*.

159. 'Eclipse of 1860, July 18', 1860AJ..6..135H. Includes sunspots sketched by William Brydone Jack (1817–86) at Frederickton, New Brunswick. The Labrador eclipse expedition included many of MM's friends with teams from the USCS and the Smithsonian. This solar eclipse was also photographed by de la Rue at Rivabellosa, Spain, who made 40 collodion plates.

160. Nantucket recruits numbered 80 by 1861 September with 400 eventually involved in the conflict, of which 73 would never return from the southern states.

161. Albers (2001), p. 135, letter from Bache to WM 1861 September 7. The repeating circle was returned to the USCS store. WM resigned his cashier post at the Pacific Bank and his trustee responsibilities at the Atheneum and the Coffin school and sold his small farm at Cato.

WM had consolidated his strong links with Harvard College in 1848, becoming chair of committee for visiting HCO in 1855 and overseer in 1857. (Booker (2007), pp. 256 and 526).

162. Albers (2001), p. 136.

163. Matthew Vassar (1792–1868) was born near Norwich, England. His family emigrated (1896) to a farm five miles from Poughkeepsie, New York.

164. Mitchell, M., (1863), op. cit. (ref. 154).

165. Booker (2007), p. 258, letter from MM to HM, undated but probably late 1863. In 1862 Henry

Mitchell purchased the property next door to his sister, aiding the regrouping of many members of the Mitchell family at Lynn, but later in the same year he enlisted in the Union army.

166. Albers (2001), p. 140, letter from RB to MM, 1862 August 21. At this time RB knew of her letter to MV, re a teaching position for her brother-in-law Joshua Kendall who was still in Meadville, and believed she was enquiring about a position at VFC.

167. Booker (2007), p. 266, letter from RB to MV, 1862 September 8.

168. Albers (2001), p. 143, letter from RB to MM, 1862 October 15. Testimonials from Alphonsus Crosby (Salem National School), B. Peirce (Harvard), and Alexis Caswell (Brown University). At this stage most VFC trustees and President Jewett were opposed to MM being appointed.

169. Albers (2001), 138–54; Booker (2007), 265–71. The Civil War delayed the completion of VFC by about a year.

170. Henry Fitz died 1863 November 6 from tuberculosis. His son Henry Giles Fitz (1847–1939), known as ‘Harry’, inherited the business at the age of 16. The largest achromat that Harry made was an 8-inch f/16 objective; he did not have the skills to complete the Vassar 12-inch lens.

171. C. S. Farrar was recruited by Matthew Vassar from Elmira Female College, New York, (1855) where he taught (1856–63) on a salary of $900. Farrar was keen on astronomy but his plans for a college observatory and telescope were rejected by the Elmira trustees. His wife died in 1863 and a Vassar salary of $2,000 secured his transfer to Poughkeepsie with two of his daughters. It is probable that most decisions about VFC observatory were taken by three men (Vassar, Jewett, and Farrah) with Rutherfurd providing the link with Henry Fitz. Farrar taught at VFC until 1874.

172. Mitchell, M., (1863), op. cit. (ref. 154).

173. Letter MM to Joseph Henry, 1863 August 26.

174. Albers (2001), 148–51, letter from MM to RB, 1864 March 18.

175. William James Young (1800–70) was a mathematical instrument-maker in Philadelphia (1825–67). He built his own dividing engine to graduate circles (first in the US) and by the 1850s was producing 65 instruments per year with a skilled team of 10 engineers. Young had previously made the 3.2-inch f/15 meridian circle ($800, 1846) for Sharon Female Seminary.

176. Comet C/1864 N1 was found by Tempel at Marseille on July 5 and was closest to Earth four weeks later, enabling both Donati and Huggins to obtain the first spectrum of a comet. MM never extended her interest in star colours into visual spectroscopy.

177. Booker (2007), p. 269. Spica is one of four bright stars near the ecliptic that the Moon can occult, the others being Antares, Regulus, and Aldebaran

178. GPB died from tuberculosis; this ended the Mitchells’ close links with HCO.

179. Haley, P. A., ‘Astro-research 7’, SHA *Bulletin* no. 33 (2020), 44–46.

180. Haley, P. A., ‘Williamina Fleming and the Harvard College Observatory’, *The Antiquarian Astronomer*, 11 (2017), 2–32.

**The author**

Paul A. Haley was born in 1956 and has lived in Herefordshire with his wife Ann since 1991. He spent eight years delivering astronomical heritage projects across Europe and is a regular contributor to both the SHA *Bulletin* and *The Antiquarian Astronomer*. Current research is focused on the development of astronomical observatories globally since 1800. Future work will include the design and production of stained-glass panels to commemorate different aspects of the history of astronomy with a special focus on women astronomers. His other interests include Pyrenean Mountain Dogs, mountaineering, and the history of the Isle of Skye.

## Erratum Issue 14 (2020)

In the printed version of *The Antiquarian Astronomer* Issue 14 (2020 June) the caption for Figure 13 on page 59 should read ‘attached to a stone support’. This error was corrected for the online version.

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