The Liverpool Observatory at Waterloo Dock

Part 1: Origins and controversy

Richard E. Schmidt
and Paul Dearden

The Liverpool Observatory was established in 1844 on the banks of the River Mersey for the purpose of providing accurate time and weather to the public, and rating of chronometers for the maritime community. Funding for the Observatory as a public utility came solely from the Liverpool Town Council. From its inception, the Observatory came under unrelenting criticism for its scale and location on the Waterloo Dock. But under the direction of the astronomer and chronometer expert John Hartnup the Liverpool Observatory soon became synonymous with astronomical excellence. This esteem culminated with the 1855 transatlantic chronometric expedition organized by William Cranch Bond at the Harvard Observatory at Cambridge, Massachusetts. The united efforts of Hartnup and Bond succeeded in establishing the geodetic reference of longitude for the entire North American continent, a standard that prevailed into the era of the transatlantic cable. In this two-part series we shall follow the bumpy road to that triumph.

1. Liverpool on the Mersey

The city of Liverpool was given its royal charter by King John of England in 1207.[1] It was a small settlement that was destined to become one of the most important ports in the British Empire (Figure 1). There were several reasons for its rapid growth, particularly in the 18th and 19th centuries. The city of Chester, which had been the main deep-water port in north-west England for many centuries, was no longer usable because the River Dee had silted up, effectively shifting the emphasis to Liverpool. Also, the persistent threats from the French navy made ports on the south coast less popular with seamen and traders, and drove them farther north.

The ever-increasing networks of canals, coupled with the development of the Liverpool and Manchester railway in the 1830s, provided Liverpool with excellent links for the transportation of goods and people. In the year 1709, 708 vessels visited the port, but by 1800 this had risen to 4,746. By 1851, this figure had increased hugely, to 21,071.[2]

2. Early advocacy for a Liverpool Observatory

As early as 1822 a writer to the Liverpool *Saturday's Advertiser* advocated the addition of an observatory to the planned new baths at St George's pier: 'The observatory would not cost much to the establishment, as a principal will be necessary to conduct it, and many scientific men might be found competent and willing to undertake its general superintendence.'[3]

The Liverpool Royal Institution for the Promotion of Literature, Science and the Arts was established in 1814 by a group of like-minded Liverpool merchants and professional men, among them Thomas Stewart Traill (1781–1862), a Scottish physician and scientist who practised medicine in Liverpool. At their annual meeting in 1824 February the members resolved unanimously, on Traill's proposal, 'that an astronomical observatory be erected by this institution'.[4] But eight years later funds for that plan were still insufficient, and the observatory never materialized.[5] However, Traill was to raise the matter again some years later, this time with more success (see Section 3.1).

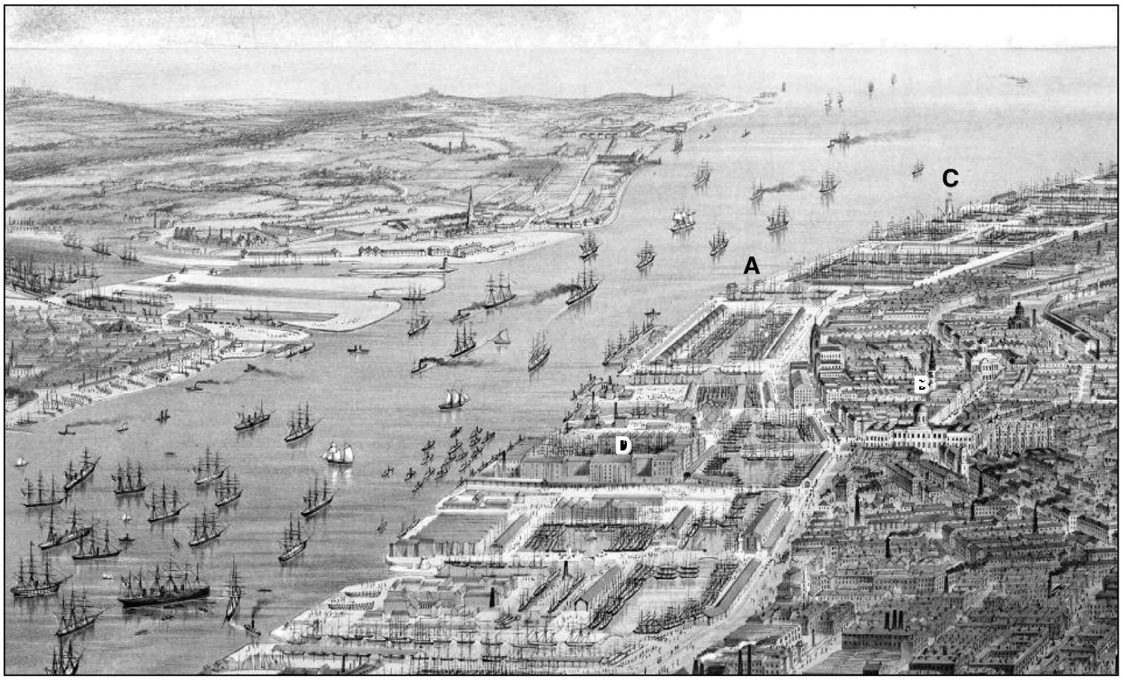


Fig. 1: Liverpool and the River Mersey in 1859 with part of Birkenhead at left and the Liverpool docks in the foreground, drawn by the Liverpool printmaker and publisher John Raphael Isaac (1809–70). The Liverpool Observatory is at A, by Waterloo Dock, while the domed building at B is the Custom House that was originally considered as a site for the observatory. C is the Victoria Tower, a clock and bell tower controlled by the Observatory. D is the Albert Dock, now a major tourist attraction. (Library of Congress Geography and Map Division)

In 1826 a writer under the pen-name Mercator advocated for a local observatory in the *Liverpool Mercury* newspaper, citing the improved safety that properly rated chronometers would bring to navigation:

> I would further advise that a transit instrument, and an astronomical clock be set up for the purpose, in some convenient part of the town, and entirely unconnected with the chronometer dealers; for, however respectable this body of men may be, and I think them highly so, yet it is but natural they should evince a predilection for their own instruments… Besides, is it not disgraceful, that Liverpool, which is rapidly approximating to the first port in the kingdom, should, in this respect, fall short of several places of minor importance? [6]

In 1830 May the *Liverpool Mercury* published a 'Proposal for a public establishment in Liverpool for exhibiting telescopes and microscopes of very superior description':

> What we would propose is, that a excellent telescopes [*sic*], of very great magnifying powers, should be procured by public or private subscription, and placed in the keeping of some individual… This telescopes [*sic*] should be stationed in some convenient situation, and exhibited at a moderate charge to the public, who would thus have access to optical instruments superior to those which an individual can afford to purchase. Few people would grudge sixpence for a peep on a fine day through a telescope which magnified 400 times… Such a telescope would be a great acquisition to the town.[7]

In 1830 June the *Liverpool Mercury* published a follow-up letter from Mercator suggesting that a more utilitarian use for astronomical instruments should be considered, particularly timekeeping for navigation.[8] Along with this letter the *Mercury* once again endorsed the establishment of an observatory for the regulation of chronometers: 'We have frequently urged the necessity of an observatory in Liverpool under the superintendence of a person possessing competent ability to discharge the important task of regulating ships' chronometers.'

2.1. *Letters to the Town Council*

Between 1834 and 1838 several letters were sent to the Mayor and Town Council of Liverpool requesting that they consider the building of an astronomical observatory to service the port.[9] At the quarterly meeting of the Town Council of the Borough of Liverpool on 1836 May 4 a letter from a Lieutenant Jon. Jones RN was read, advising the Council of the potential benefits of the establishment of a nautical, rather than astronomical, observatory:

> Of the various improvements now in progress or in contemplation by the Corporation, there is not one in my opinion of such importance to the foreign commerce of the town as that of erecting an Observatory for the rating of ships chronometers,

> particularly since the India trade has been thrown open … why is there not one at Liverpool, the second port in the British Empire?[10]

In his letter Jones stressed the importance of being able to keep accurate time when at sea:

> Should an erroneous rate of one second per day only, be given with the chronometer, it would amount after two months voyage to an error of fifteen miles, which is equal to a third of the distance between the Irish and the Welsh coasts at the entrance to the Channel… My experience for more than a quarter of a century when in charge of His Majesty's ships with chronometers under my care makes me well aware of the anxiety which a captain experiences when sent to sea with a chronometer the rate of which he cannot calculate upon with certainty.[11]

The letter was referred to the Improvement Committee, who met on May 11. The committee agreed with Jones's arguments, but nevertheless decided that the subject should be postponed.[12]

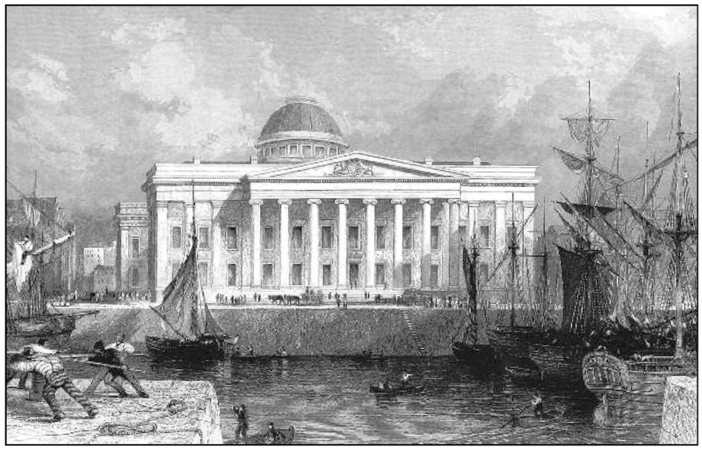


Fig. 2: The New Custom House at Liverpool Docks, opened in 1839, was considered as a possible home for the Liverpool Observatory. It was bomb-damaged during World War II and finally demolished in 1948. From 'Lancashire: its history, legends, and manufactures' by George N. Wright, 1843. (British Library)

2.2. *The influence of William Lassell*

Three months later, on 1836 August 3, a letter from the Liverpool astronomer William Lassell (1799–1880), one of the most accomplished astronomers and telescope builders of his time, was presented to the Town Council. Lassell strongly advocated for an observatory, both for navigational purposes and astronomical work, writing:

> It appears to me in this most extensive and increasing Sea-port, the ascertaining and publishing officially, true mean Liverpool Time, in such a manner as to afford to Mariners and others the means of determining with all attainable accuracy the errors of chronometers and other time-pieces, would of itself be an object of sufficient importance, and yet would involve comparatively, only a very trivial expense.[13]

He also proposed 'that a large ball should be suspended in some situation about the building, so conspicuous, that it could be observed from the whole of the shipping in the port, and that precisely as the sun passed the meridian, this ball should be dropped, whereby all the captains of vessels would be enabled correctly to regulate their chronometers'.[14]

Lassell estimated the cost of the instruments for the Observatory at £168, and provided a breakdown of costing for the Council: about £45 for a clock, £26 for an 8-inch sextant with stand, £6 for an artificial horizon and glass roof, £84 for a 3½-ft transit instrument on stone piers, and £7 for an achromatic telescope of 30 inches focal length to be used as a fixed transit instrument.[15]

Lassell's letter proved persuasive, for the Town Council resolved that his proposals be referred to a special committee. This committee was to consist of William Brown, alderman and chairman of the board of the Bank of Liverpool; Dr James Carson, doctor of medicine and inventor of 'an improved method of slaughtering animals for human food';[16] James Aikin, merchant; Samuel Hope, banker; and Robert Roskell, chronometer maker.

3. Early work of the Observatory Committee

The new Observatory Committee met for the first time on 1836 August 26. They resolved to make enquiries about the establishment of an observatory and report back to a future meeting of the Town Council.[17] Two months later the Observatory Committee had completed their investigations and produced their report, which was presented to the Town Council. The report stated that the Observatory Committee were 'unanimously of the opinion that the establishment of an Observatory is exceedingly desirable for the general convenience and maritime trade of the port'.[18]

They found that the costs of the fully equipped building would be around £1,200, with an annual expense of £250–£300, and awaited further instruction from the Town Council as to how to proceed.[19] Nearly a year was to pass before any further action was taken.

On 1837 January 4 Samuel Hope again spoke to the Council on the subject of an observatory, suggesting that 'it would be desirable that it should be erected near the margin of the river'.[20] But he questioned the idea of the observatory being both for navigational and astronomical purposes, recommending that it be confined to nautical purposes alone. Hope had learned from Liverpool's chronometer manufacturers that no chronometer left the port properly regulated – there was considerable difference between chronometers, and none were completely accurate.[21] He added that a barometer should also be installed to give notice of approaching bad weather.[22]

There was a mixed response to Hope's words. Several Council members were of the opinion that, if an observatory would be of such importance to merchants and ship owners, perhaps they ought to pay for it themselves. Also, it was questioned whether the Council had the authority to commit public funds to the project.[23]

Alderman Eyre Evans voiced a new concern, namely that 'the observatory must be most particularly kept out of the range of every thing metallic, – of any iron, and therefore it must not be on the edge of the river, with all the steamers, and their chimneys and boilers constantly coming within its range.' The bank of the river, he opined, was therefore not exactly the place for an observatory.[24]

In 1837 July, the *Liverpool Mercury* published a letter from someone signing themselves 'H.', presumably Samuel Hope, advocating installing the observatory in the dome of the new Custom House, then under construction (Figure 2).

> It occurred to me, a few days since, in passing by this fine building, that the dome which is now in progress does offer a fine opportunity for converting the top part into an observatory. With a very little arrangement it might be put into practice; it is only making two large and long windows in the curve of the dome, for the working of a transit instrument, open to the north and south, and erecting a large pole rising out of the very apex of the dome, with a large ball to fall in the same manner as the one at Greenwich, and show the exact meridian of the town, which might be seen by all captains passing down the river to sea, to check their chronometers before their departure. The situation could not possibly be better; it might be seen without the aid of a telescope, and would be a great addition to the beauty of the building, combining utility and ornament at the same time.[25]

However, the editors of the *Liverpool Mercury* raised some objections to the plan:

> In the first place, the situation is not sufficiently lofty for the purpose, and in consequence of the contiguous population the atmosphere would be obscured by coal-smoke, &c. … those who have the management of the establishment will never allow a person to have free access to the interior of the building at midnight ... which would be indispensable to the master of an observatory.[26]

3.1. *The British Association becomes involved*

In 1837 September the British Association for the Advancement of Science met in Liverpool. In an address to the Association the local physician Thomas Traill (Figure 3) took the opportunity to return to a matter which he and the Liverpool Royal Institution had attempted to accomplish some years before: 'Might I venture here to allude to a recommendation which I hope the Association will not fail to leave in Liverpool, for the promotion of a scientific object of immense consequence to this port – the establishment of an Observatory in or near Liverpool?' [27]

Fig. 3: Thomas Stewart Traill (1781–1862), a Liverpool doctor, was a prime mover in promoting and planning the Liverpool Observatory. (Wellcome Collection)

This time action was forthcoming. The British Association appointed a committee consisting of Thomas Romney Robinson of Armagh Observatory, Francis Baily, President of the Royal Astronomical Society, and Traill himself, 'to apply to the proper authorities for the establishment of an astronomical observatory at Liverpool'.[28]

At the meeting of the Town Council on 1837 September 20 a letter was read from Robinson, Baily, and Traill, on behalf of the British Association, urging the establishment of a nautical observatory at Liverpool 'devoted to the objects of naval astronomy'.[29] Regarding its location, they noted that 'A site in this great city would not be desirable, from the annoyance caused by smoke, and the agitation from carriages. The Cheshire side would be more suitable, and not less accessible to sailors.'[30] Traill conveyed an offer from Robinson to go to Liverpool for a week to assist in choosing a site.[31]

3.2. *More deliberations*

The Town Council decided that these letters should be referred to a select committee, which would consist of William Brown, alderman and founder of Brown, Shipley, & Co., Liverpool and London merchants; Dr James Carson; William Wallace Currie, first Lord Mayor of Liverpool; William Lassell, astronomer and Liverpool brewer; Samuel Hope, banker; John Platt, Town Councillor for South Toxteth; and Thomas Blackburn, Councillor for Lime Street. This new Observatory Committee met on 1837 September 28 and read both letters. The Committee decided to approach the Dock Committee, who met on the same day and agreed to receive the group on October 5.

On 1837 October 16 the Dock Committee appointed their own sub-committee to confer with the Observatory Committee, but it was also decided that it was not in their power to contribute any funds towards an observatory under the Municipal and Dock Acts. The group advised the Council that in the event of any new Bill being read in Parliament, that opportunity should be taken to insert the necessary text to amend the Acts, and allow the funds to be released for the commencement of the observatory project. The opportunity came in March the following year, with a Bill in Parliament for the improvement of the Liverpool Borough Court and some other local matters.

Support for the observatory continued to grow. In 1838 November the Council received a letter from the Liverpool Literary and Philosophical Society.[32] The Society saw the need for an observatory in Liverpool 'similar to that at Greenwich', and recommended housing it in the new Custom House, as had previously been suggested.[33]

The following month, the letter was read at a meeting of the Observatory Committee. The Committee concluded:

> The establishment of an Observatory under the management of the Town Council or the Dock Committee or both, is highly desirable, and would greatly conduce to the advantage of the shipping frequenting this port … it is most desirable for the present to limit the establishment to the accomplishment of practical Maritime purposes connected with the Interests of Commerce … That Mr. Hartley, Mr. Lassell and Captain Denham be requested to favour the committee with their Opinion as to the best site for an Observatory.[34]

The 'Mr Hartley' referred to was Jesse Hartley (1780–1860), a civil engineer who was Surveyor to the Liverpool Dock Trustees (Figure 4), while Henry Mangles Denham (1800–87) was a Royal Navy hydrographer who had previously surveyed the port of Liverpool.

Hartley asked for a meeting with the Observatory Committee where they could lay out plans of the North Docks and look for a suitable site for the observatory. At this meeting Denham revived the idea of a Custom House/Observatory: 'If we were only desirous of a site for observation and transmitting of the results by signal or journeymen chronometers then our site might be on the Cheshire side of the river with some local recommendations, but as the Shipmasters business lies on the Liverpool side … *It appears to me that the three essentials quoted are offered at the Custom House*.'[35]

Fearing the disturbing effects of people traffic in the Custom House, the Observatory Committee decided to approach Richard Adie (1810–81), a local scientific instrument maker, to test the area for suitability, in particular the main cross-wall on which the transit telescope and other instruments would be mounted.[36] Adie concluded: 'I should consider it a very unfavourable place for fixing a fine clock, the vibration of the wall during the hours of business being certain to derange the regular motions of a pendulum.'[37]

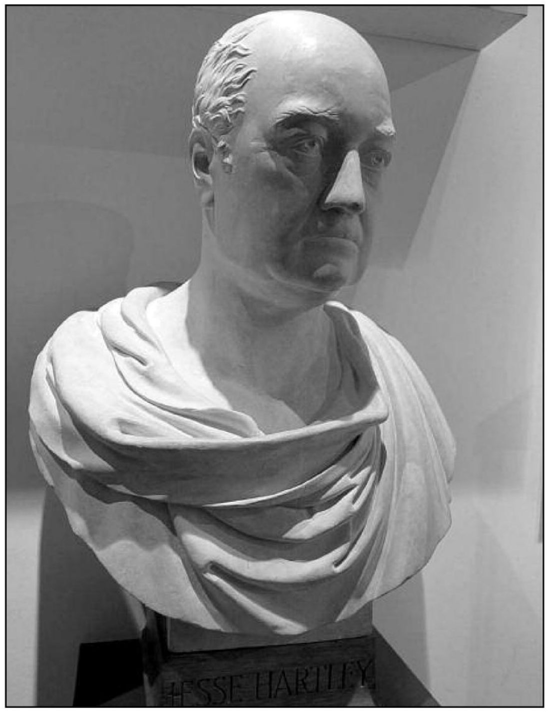


Fig. 4: Jesse Hartley (1780–1860), Liverpool's dock engineer from 1824 to 1860, selected the site for the Liverpool Observatory on the waterfront next to Waterloo Dock and designed the building for it. This bust of him is on display in the Museum of Liverpool. (Grace's Guide to British Industrial History)

Abandoning the Custom House location, the Observatory Committee decided that 'Mr. William Lassell Jnr be requested to confer with Mr. Hartley as for the best site on the margin of the Docks for the erection of an Observatory, as the letter of Mr. Adie appears to demonstrate the ineligibility of the situation at the top of the Custom house.'[38]

3.3. *Finalizing the site*

On 1839 March 4 Hartley proposed a site for the observatory on a pier between the Prince's and Waterloo Docks (Figure 5).[39] The following month the Observatory Committee presented its report to the Liverpool Town Council, advising them of the desirability of a maritime observatory, and recommending the site proposed by Hartley. The Committee also submitted financial estimates for the entire project, which they quoted as being considerably less than £2000. In the months that followed, the Town Council referred the report to the finance committee, and directed the Town Clerk to confer with the Dock Committee on the subject.

A meeting of the Committee of Finance on 1839 October 26 resolved ‘That it be recommended to the Council to adopt the report of the Observatory Committee of the 30th April last recommending the erection and support of a Building devoted to that object and to give the necessary directions for carrying the same into effect.’ [40]

4. The Observatory takes shape

On 1839 December 2 the Observatory Committee directed the Surveyor (presumably meaning Hartley) to produce plans for the observatory together with an estimate for the work. Ten months later, on 1840 September 22, the Surveyor produced suitable plans, together with an estimate for the work of £1200.[41] The addition of a navigation school attached to the Observatory was raised at a meeting on 1841 March 17, and the Observatory Committee approached the Dock Committee to request additional ground for the school.[42]

In October the Observatory Committee decided to ask the Surveyor to submit plans for erecting a dwelling house for the astronomer, as well as the navigation school, on the land agreed by the Dock Committee.[43] The requested plans were submitted to the Observatory Committee on 1842 January 28, with an estimate of £1900. It was decided that the chairman of the committee should: ‘submit the plans to Sir John Hershell [*sic*] and Professor Airey [*sic*] and other scientific gentlemen for their advice in carrying out the intention of the Committee to the greatest advantage.’[44]

The following month the chairman detailed his visit to the observatory of Sir James South at Kensington. In addition, he laid before the committee a letter from Thomas Traill, with plans of Thomas Brisbane’s observatory at Makerstown, and also a letter from Lassell with a plan of his observatory near Liverpool. The Committee decided that the chairman should contact the Astronomer Royal George Airy and Thomas Romney Robinson of Armagh to request their presence in Liverpool to assist in planning and erecting the observatory, and that the Surveyor, on visiting London, should obtain all the information he could on the subject.[45]

On 1842 July 28 it was reported that the chairman had been in touch with Airy and Robinson to arrange for them to visit Liverpool and inspect the observatory site during the British Association meeting in Manchester, but this had been prevented by ‘a journey to the continent’. However, William Dawes and Francis Baily were able to visit, and confirmed the ‘superior advantages’ of the site for the purpose required.[46]

On the advice of Airy, Lassell, and Dawes the Surveyor made alterations to his plans and resubmitted them. The revised plans included second-floor chronometer and transit rooms and the addition of the nautical school. With ‘stone fronts to the two principal elevations’, the building was estimated to cost £2050.[47] (A payment by the Corporation for Liverpool for the ‘new observatory’ of £1418 9s 6½d was made during the fiscal year that ended 1844 August 31, and another of £542 10s was made in the following fiscal year.)[48]

Airy recommended the firm of Troughton and Simms in the Strand, London who had made instruments for the Royal Greenwich Observatory, including the transit instrument of 10 feet focal length and 5 inches aperture (1816), and one of the 6-ft mural circles (1812).[49] In a meeting on 1843 May 2, the chairman of the Observatory Committee reported that ‘a transit instrument five feet long as recommended by Mr. Airey [*sic*], Mr. Sheepshanks and Mr. Lassell had been ordered.’ [50] Richard Sheepshanks (1794–1855) was Secretary of the Royal Astronomical Society, and a great supporter of the Liverpool Observatory; soon he would be involved in an extended feud with John Taylor over

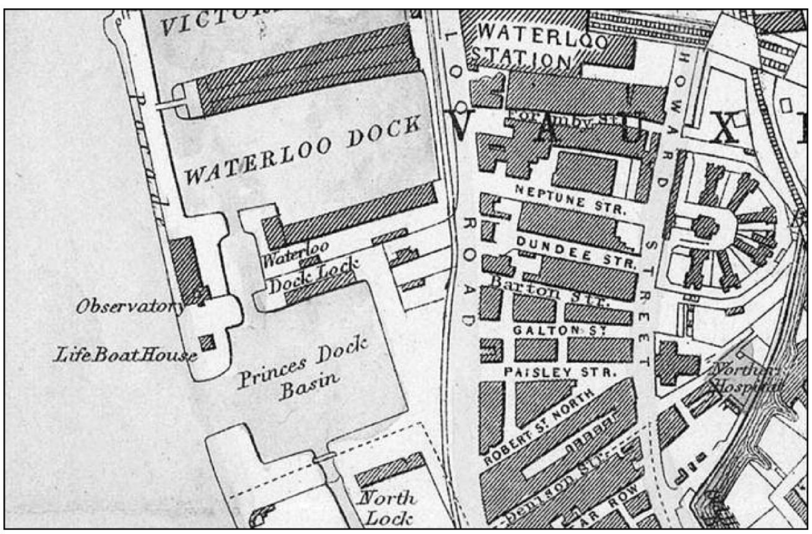


Fig. 5: Location of the Liverpool Observatory on the river wall next to Waterloo Dock. The Mersey is to the left. Waterloo Station, seen at the top of this illustration, was a railway goods station opened in 1849 to serve the docks. The station was closed in 1963 and demolished in the early 1970s. From Atlas Supplement to the Weekly Dispatch, London, 1860 December 16. For a present-day view of the area see Figure 13. (Library of Congress)

the suitability of the Waterloo Dock site (see Section 6).

Construction of the observatory by John Tomkinson, a renowned local builder, was underway in 1843 April.[51] Still to be determined was who would be hired to run it. Airy, Lassell, and Sheepshanks recommended John Hartnup, Sub-Secretary of the Royal Astronomical Society.[52]

5. John Chapman Hartnup, Sr

John Chapman Hartnup (1806–85), son of a gentleman farmer, was born at Hurst Green, Sussex. His early astronomical work was carried out at the private observatory of Lord Wrottesley, where he assisted in the production of the *Wrottesley Catalogue of Stars*, earning its namesake the Gold Medal of the Royal Astronomical Society – although most of the observations and reductions were actually made by Hartnup (Figure 6).[53] In 1836 he was hired by Airy as computer to reduce the Greenwich planetary and lunar observations made between 1750 and 1830. Two years later he accepted the position Assistant Secretary to the Royal Astronomical Society.[54] He was obviously interested in navigation: in 1843, he determined the latitude and longitude of the offices of the Royal Astronomical Society using a sextant and pocket chronometer.[55]

Hartnup was clearly held in high esteem by his peers. In 1843 August, three months after he was initially recommended to the Observatory Committee, Hartnup's appointment was endorsed by Lord Wrottesley, Francis Baily, William Henry Smyth, Lt. Henry Raper RN, and William Lassell. Sheepshanks advised that £200 per year would be a suitable salary for the post, and the Committee agreed that Hartnup should be approached.[56]

Airy reported to the 1843 August meeting of the Observatory Committee that he had located for sale in London a Swiss flint glass 'capable of making an object glass of about seven and three quarters inches', and

Fig. 6: John Chapman Hartnup (1806–85), the first director of Liverpool Observatory, was largely responsible for establishing its reputation. (Proudman Oceanographic Laboratory)

requested its purchase for the construction of the equatorial. In 1843 October, Airy offered his assistance in the planning of a time signal ball, to be located in a highly visible position on the roof of the Observatory and dropped daily to indicate the time (Figure 8).[57]

By 1843 November the observatory buildings were nearly complete, with the exception of the dome to house the equatorial telescope as the dimensions of the instrument were not yet known. At this time Airy was advising Simms on its construction.[58] In 1843 December Hartnup attended an Observatory Committee meeting for the first time, and officially began his duties on December 20.

Hartnup had already received the transit instrument and the two clocks (sidereal and mean-time), and was directed

> to make the necessary enquiries for obtaining a barometer and thermometer of the most improved construction … to obtain information as to the best method of constructing the (signal) Ball, and the necessary fittings of the same, so as to secure the immediate fall of the ball on the most simple and certain principle … [and] … to proceed with the fixing of the transit instrument and the clocks and to give the necessary instructions for providing an observing chair.[59]

By the following February Hartnup reported that the installation of the transit telescope and clocks were complete, and that he was 'now prepared to give the time with the greatest possible degree of accuracy.'[60]At the Observatory Committee meeting on 1844 March 6 Councillor Aikin proudly proclaimed that they had 'not only the best transit instrument, but the best observer in the kingdom'.[61]

6. Enter John Taylor, warrior poet

Politics and personality played a major part in the opinions of most of the major players surrounding the new Liverpool Observatory. In truth battle lines had solidified more than a decade before, with Airy, Sheepshanks, William Stratford of the Nautical Almanac Office, and James Glaisher of Cambridge Observatory supporting the Town Council plan, and Sir James South and his protégé John Taylor opposing.

John Taylor (d. 1857) was a cotton broker, poet, amateur astronomer, and early advocate for a Liverpool Observatory.[62] His 1828 design for a 'cometarium', a device for displaying the apparent orbital paths of comets, was constructed by Richard Adie in 1833 and presented to James South.[63] Taylor's seminal work was an 1839 translation and annotation of Ovid's *Fasti*, on the Roman calendar, with astronomical tables calculated for Rome in AD 13.[64]

As early as 1833 November Taylor proposed to the Commissioners of the Municipal Inquiry a plan for an observatory and seamen's school. He submitted

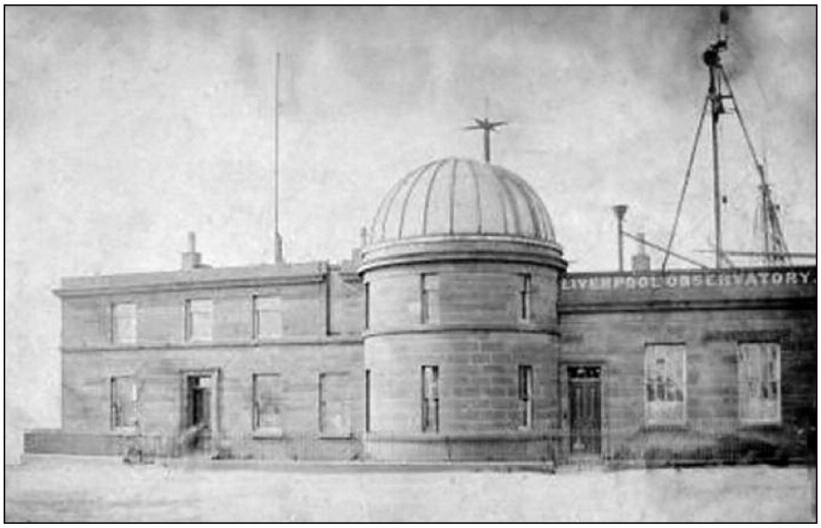
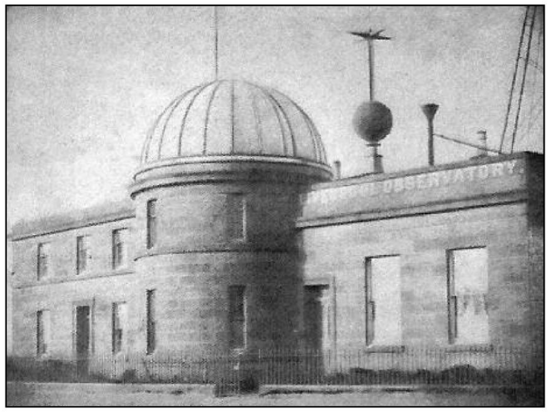


Fig. 7 (left): Liverpool Observatory seen from the southeast. The four cardinal points are indicated at the top of the time-ball mast, behind the dome of the equatorial. A signal flagpole is to the left of the dome. To the right are the rain gauge funnel and an Osler anemometer.

Fig. 8 (below): On this view of Liverpool Observatory the entire time ball mast is seen to the right of the dome. Its mast was too short to be widely visible from the River Mersey, leading Hartnup to lobby for a second, more visible time-ball site. (Provenance for these photographs is unknown)



these to the Board of Admiralty in 1844 'and received their approval and promise of support'.[65] Taylor was adamant that Liverpool should have a 'noble' observatory on the scale of Greenwich and Cambridge. As such he was strongly opposed to the 'nautical' establishment proposed by the Town Council, and it did not help matters that he had not been appointed to the Observatory Committee. Taylor loved nothing more than a newspaper fight, and was a long-time friend of the *Liverpool Mercury*'s founder Egerton Smith. Taylor's ready access to its pages would soon bedevil the Liverpool Town Council.[66]

6.1. *John Taylor attacks the Observatory*

The opening salvo from Taylor against the Liverpool Observatory came on 1844 March 12. In a lengthy letter to the *Liverpool Mercury* he attacked 'the establishment of the Observatory erected, and now fitting up on the north-west corner of Waterloo Dock Basin':

> I have uniformly, and as far as has lain in my power, strenuously opposed the erection of an Observatory on a small scale in magnitude and in equipment … and, in particular I have objected the situation which has been chosen for it. The scale I consider to be far below that which the exigency of the case requires; and the situation unfit for an Observatory on any scale. It is damp, and will spoil the instruments; it is inaccessible with personal comfort, or even safety, after nightfall. It is miserably cramped for want of room. It has only about 15° range of true horizon, and that to the North by West, where no star above the fourth magnitude is ever seen to set; and where no star was or ever will be seen to rise. From N. by W. to S. S. E. the horizon is cut off, as well as many degrees of altitude, by the warehouses, and by the high land of Everton hill, and, in fact, the whole of that whole portion of the vault of heaven is rendered unserviceable by the glare and smoke of the town. From south to south-west there is an imperfect horizon, subject to almost constant fog, arising from the trough of the river Mersey, especially in the night and morning. To be seen at all, a star must commonly have ten or twelve degrees of meridian altitude. The rest of the range, from south-west to north by west, where the Fort and Lighthouse stand, is more or less impeded, and even spoiled, by the high Cheshire and Welsh hills. Besides this the foundation of the Observatory is close to the sea wall on a red sandstone rock, subject to cracks, and which must be subject to vibration from the beating of the waves in the furious tempests from the north-west … to say nothing of the shaking of the building by occasional cannonadings from the Fort, batteries, and shipping, nor of the perpetual nuisance of the smoke from the steamboats. These and other causes render the situation chosen peculiarly unfit … A worse situation could hardly have been fixed upon. I, therefore, consider the sum laid out in the building to be totally thrown away.[67]

Taylor concluded with an attack on the time ball, that no one could trust to regulate a chronometer, 'although it may serve to give the hour for dinner … but no man fit to command a ship, or to navigate by a chronometer, would ever think of trusting the safety of his vessel to so very uncertain an indication'.

6.2. *Liverpool Town Council responds*

On Wednesday 1844 April 3 the Town Council met and the Observatory Committee discussed Taylor's missive. The *Liverpool Mercury* reported:

> [Council Chairman James Aikin] was not desirous to get into any newspaper controversy, but it did so happen that a letter from a respectable individual had made its appearance in a public paper, and, in consequence of that letter, he (Mr. Aikin) had received letters from various members of the Astronomical Society, and from the Astronomer Royal at Greenwich, in reply to those animadversions… He would not indulge the writer of the observations in question with an opportunity of getting into a controversy with the Astronomer Royal, of which he was evidently desirous, but he would state that the committee had one very great advantage over that individual, *a thorough consciousness of their own ignorance* as to the best mode of setting about the establishment of an observatory. They had consequently availed themselves of the best advice which Europe could furnish, which had been freely given, particularly by the Astronomer Royal, to whom they were greatly indebted.[68]

Aikin particularly noted that the Council had taken no action without the 'sanction and direction' of the Astronomer Royal, and that when the public were assured of this 'they would see that the establishment was in good hands, and that their money was not likely to be thrown away'.[69] He then described the complaints of dampness, the glare of the town, the cannonading and the dashing of the waves as existing only 'in the imagination of an individual'.

Aikin then read a letter of 1844 March 22 from Hartnup, who expressed his pleasure at his situation:

> With regard to the site, I can say from experience, having already made a great many observations, that the situation is particularly favourable. The horizon is so free from obstruction, and so little inconvenience is experienced from fog, that celestial objects may generally be seen much nearer the horizon than it is desirable to observe. Transits have occasionally been taken to the south of the zenith, where the meridian line crosses the Mersey, of stars having a meridian altitude not exceeding two degrees and a half…
>
> I have already announced that I believe I can ascertain time with the greatest possible degree of accuracy… With respect to the signal ball … any person competent to get his time and longitude may satisfy himself of the dependence which may be placed in it. I have myself tested the accuracy of the drop of the ball at Greenwich more than one hundred times, and am prepared to prove that the probable error does not exceed [an error in longitude equivalent to] one-tenth of the width of the Mersey opposite the observatory.[70]

Responding in the same issue of the *Liverpool Mercury*, Taylor denied that he wished to get into a controversy with the Astronomer Royal, adding 'Mr. Aikin says that he (for he is I believe the acting committee) "has the advantage of a thorough knowledge of his own ignorance." I am afraid that, in this particular, he flatters himself, and that his consciousness of his own utter ignorance is not yet complete.'[71]

With a week to formulate a further more thoughtful response, Taylor wrote in the *Liverpool Mercury* asking whether anyone thought the Observatory's location on the Waterloo Dock Basin was satisfactory, and 'whether an observatory was ever before placed on the face of the earth in such a position'.[72]

Taylor then went on to describe the unfavourable aspects of the river wall site, exposed to tempests, sea spray, crowded docks, smoke, and illumination of the 'large densely-built town, three miles long by two miles broad', subjected to smoke from steam-boats, cannon discharges, and if all this be true, 'the situation is bad, and the money of the town has been thrown away'. As to the advice from 'London' in favour of the site

> Then those persons should lose no time in removing the Greenwich Observatory from that preposterous hill, and set it where it ought to be, on the brink of the Thames, in Deptford, or in Rotherhithe at the mouth of the Thames Tunnel, or by the Stairs of the Tower of London, where there is plenty of fog, smoke, gaslights, and cannonading; for those are the places of which the situations correspond with the north-west corner of the pierhead of the Liverpool Waterloo Dock Basin.[73]

Taylor closed with 'enough has been said. The Observatory is constructed', and that there was reason to believe that Hartnup would make every effort to overcome the site's deficiencies. And Taylor kept the peace, for about one year.

7. Chronometer makers' concerns

The rating of ship's chronometers was long considered one of the principal utilities of the Observatory, but this too was not without controversy. In the 1844 March meeting of the Observatory Committee Councillor Aikin expressed his intention to consult Liverpool chronometer-maker Robert Roskell 'to adopt a plan the most effective for the public interest, and to interfere as little as possible with private interests'.[74] At the 1844 April meeting the Observatory Committee also discussed the complaints of a number of chronometer and watchmakers of Liverpool, who had written to the Committee protesting against the planned rating of chronometers as 'highly unjust and injurious', and 'positively ruinous to tradesmen'.[75] They asked the Council

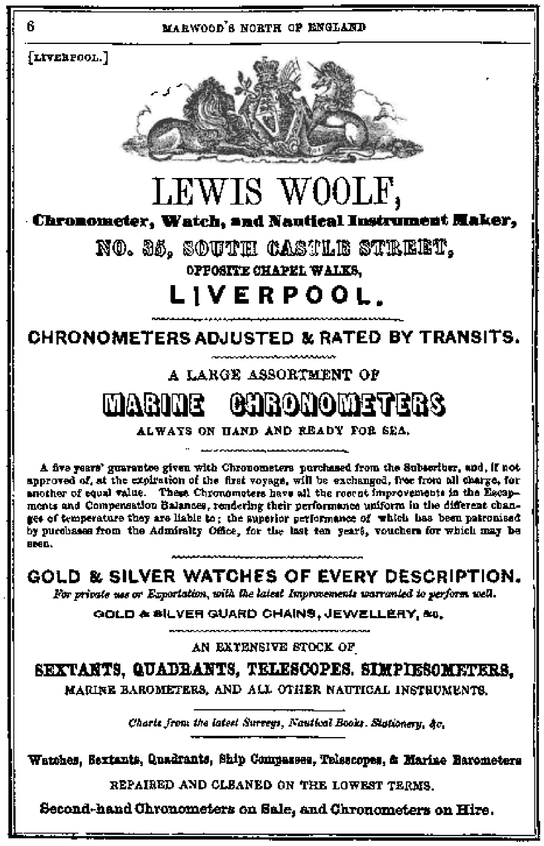


Fig. 9: Advertisement for chronometer maker Lewis Woolf, one of many such makers plying their trade in Liverpool at the time. From Marwood's North of England Maritime Directory, 1854.

to block the plan. The chronometer makers of Liverpool were a local trade whose numbers were large, with many to choose from (Figure 9).[76]

Until then, individual clock and watch-making businesses had been responsible for the rating of chronometers at the port. The Committee decided to meet with a deputation of local clock and watchmakers to discuss the matter. During the meeting, it became clear that there was a difference of opinion among the clock and watchmakers. Some believed that the Observatory would 'deprive them of a source of profit' while others thought that it would be 'of decided advantage to the trade as well as to the public.'[77] Subsequently, they asked that the Observatory should neither sell nor rate chronometers 'except for government', and that a 'moderate charge' be levied for the rating.[78] On 1844 June 5 the Observatory Committee approved a rating fee of 7s 6d per chronometer.[79]

In 1844 December the *Liverpool Times* and the *Liverpool Mail* reported that the Observatory was, 'as regards its most popular and important use, the determination of time', in full operation, and pointed out its 'immense value … as yet but imperfectly appreciated.'[80]

In 1845 January the following advertisement was read and approved by the Observatory Committee, and inserted in newspapers and printed in slips for distribution:

> Liverpool Observatory
>
> Masters of ships and the Public generally are informed that the Signal Ball on the top of the Observatory recently erected on Waterloo Dock Pier Head, is dropped daily at one o'clock Greenwich Mean Time, being twelve minutes and two tenths of a second before one o'clock at this Observatory. Chronometers are received and rated at the Observatory at the charge of seven shillings and six pence each. The system of rating adopted is precisely the same as that pursued at Greenwich by the Astronomer Royal. The respective owners will be furnished with the gain or loss of their chronometers for each day, and the temperature of the room in which the chronometers are placed, in addition to the error on Greenwich Mean Time and the mean daily rate.[81]

8. The longitude of the Liverpool Observatory

Knowledge of one's precise longitude is a key component in measuring time on the Greenwich standard meridian. For many years George Airy, the Astronomer Royal, had intended to measure the arc of longitude between Greenwich and Valentia Isle on the west coast of Ireland. These endpoints are more than twelve degrees of longitude apart, and lie nearly along a parallel of latitude. Measurement of such an arc would provide information on the shape of the Earth, for example its oblateness, as used in Ordnance Survey calculations. Fortunately for Hartnup, the Liverpool Observatory was an ideal intermediate point along this arc.

Accordingly, in 1844 December, Airy organized a chronometric expedition to be carried out from Greenwich to Liverpool, then to a temporary site chosen at Kingstown harbour, near Dublin on the east coast of Ireland, and finally to Valentia Isle. Assisting Airy in this endeavour were Robert Main, the First Assistant at Greenwich; John Hartnup; Richard Sheepshanks; Lieut. James W. Gosset of the Royal Engineers; and John Russell Hind, the latter destined to become a future discoverer of minor planets and superintendent of HM Nautical Almanac Office.[82]

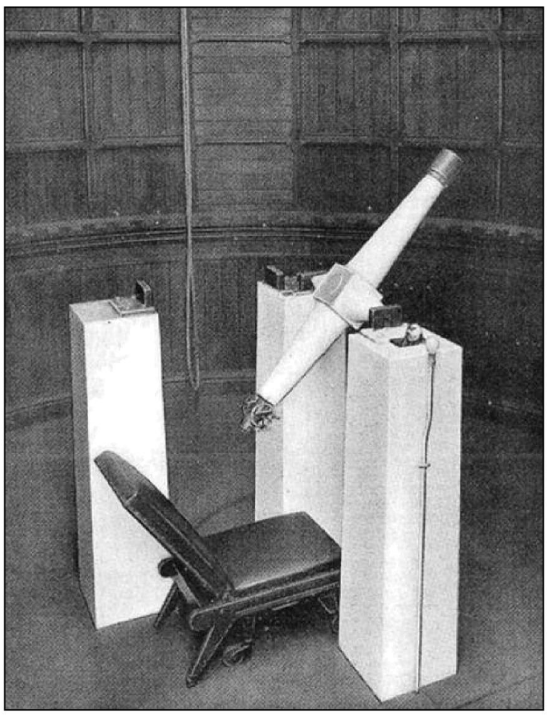
The measurement of this longitude arc consisted of a number of delicate steps. Time must be accurately determined at Greenwich, from transit observations of standard stars. Each expedition clock's displayed time must be compared with true Greenwich time, and the individual errors on the meridian of Greenwich recorded. The chronometers are then transported as quickly and smoothly as possible to each of the next stations, and compared with a local transit instrument clock, giving the errors on that local meridian. If the rate of each clock is also known, the errors of each clock on Greenwich are also known, and the difference of these two errors is the longitude difference between the two stations.

Thirty pocket chronometers were chosen by Airy in the belief that pocket watches were, by their design, less susceptible to disturbance by motion in the plane of the balance wheel than marine (box) chronometers. These were packed into specially made boxes, each chronometer in a spring-mounted padded compartment. These boxes were screwed down into 'every railway-carriage, steam-boat or mail-coach' used along the arc. As described in *The Practical Mechanic*, the arrangements were as follows:

> The first assistant of the Royal Observatory, Mr. Main, compared each watch by coincidences [of half-second beats] with the Greenwich transit-clock; the cases were then put into a box and transported in an easy carriage, in the care of one of the assistants of the Royal Observatory, avoiding the pavement as much as possible, to the Euston Square Station, when the cases were transferred by him to the box already attached to the imperial of the mail. On the arrival of the mail at Liverpool, Mr. Hartnup was in waiting with a box and carriage; with which he transferred the cases to a box already fixed on board the steamer belonging to the City of Dublin Steam Packet Company. Mr. Sheepshanks, who had undertaken to make the transit observations and to compare the chronometers at Kingstown, was in readiness to take the chronometers when the steamer arrived; and it was his business to wind up the chronometers, compare them, and return them by steamer that evening. Mr. Hartnup again conveyed the cases at Liverpool, and they were received at Euston Square and taken back to Greenwich by one of the assistants, where they were compared by Mr. Main.[83]

A similar set of ten runs were made between Kingstown and Valentia by express horse-drawn carriage arranged with the local operator Charles Bianconi.[84] After crossing on the Valentia ferry, the chronometers were hand-carried for four miles up a 900-ft (275-m) hill where Lieut. Gosset had constructed an observatory. Thus, the arcs measured were Greenwich–Liverpool, Liverpool–Kingstown, Greenwich–Kingstown, and Kingstown–Valentia. By comparison with Ordnance Survey triangulation along the latitude 51° 41′, the length of one arc second in longitude was found to be 101.6499 feet (30.9829 m). For Hartnup, the prize was finding the longitude of Liverpool with respect to Greenwich: 12m 0s.05 of time west.[85] In 1865 the position of the Observatory was advertised as latitude 53° 24′ 48″ N, longitude 3° 0′ 1″ W.[86]

Fig. 10: The Troughton and Simms 4-inch (100-mm) transit instrument of Liverpool Observatory. Here it is seen in the early 20th century in its dome at Bidston, in Birkenhead, where the observatory moved in 1866 following the expansion of Waterloo Dock. Note the unusual third pier which enabled its use as a prime vertical instrument for precise measurement of declination.



9. The Liverpool Transit Instrument

The transit telescope at the Liverpool Observatory was of 4 inches (100 mm) aperture and 5 feet (1.52 m) focal length, and was manufactured by London instrument makers Troughton and Simms (Figure 10). There were seven vertical and two horizontal fixed wires and one vertical wire moved by a micrometer screw.[87] Hartnup reported that the instrument had been installed in early 1844, and that he was: 'now prepared to give the time with the greatest possible accuracy'.[88]

In his reports to the Observatory Committee, Hartnup explained that observations of stars on the meridian rather than of the Sun were used in determining time, the errors of the solar tables being large compared to those of the stars.[89] The brighter stars could even be observed during daylight: 'For all objects, bright enough to be seen in daylight on the meridian, there are no instruments so good as meridian instruments for determining their positions.'[90]

10. The Liverpool Equatorial Telescope

The equatorial telescope was not completed until 1848 August, four years after the Observatory first came into service. Airy had identified two object glasses in 1845 November which on examination had proved to be unsuitable. At Airy's suggestion the Observatory bought

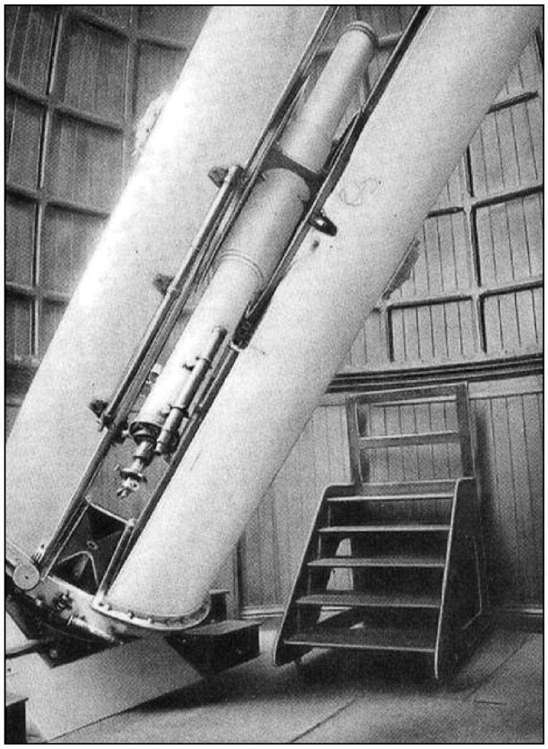


Fig. 11: The 8½-inch (216-mm) equatorial of the Liverpool Observatory in the west dome at Bidston in the early 20th century. The massive mount by Maudslay and Field dwarfs the telescope tube. To the left of the tube is the declination-reading periscope. The two half-cylinders comprising the polar axis provided such rigidity to the instrument that Hartnup referred to it as his 'extra-meridian transit instrument'.

an 8½-inch (216-mm) lens with a focal length of 12 ft (3.66 m) from Merz of Munich, who Airy regarded as making the best object glasses in the world.[91] The large parts of the mounting were made by the prominent mechanical firm Maudslay and Field of Lambeth, south London, builders of the marine engines for Isambard Kingdom Brunel's SS *Great Western*, the first purpose-built transatlantic steamer.[92]

The equatorial was designed by Airy after the general plan of the Northumberland Equatorial at Cambridge, with a clock-driven hour circle of 4 feet (1.2 m) diameter that could be clamped to the telescope at will (Figure 11). It was divided on Simms's 'self-acting circular dividing engine', as used on the new Greenwich altitude and azimuth instrument. Hartnup believed it to be so accurate that, with its dual-reading microscopes, angular distances of some degrees could be measured with a precision equal to or better than the accuracy of star catalogues.[93]

A remarkable feature of the equatorial was the motive power for the clock drive, using a water mill regulated by Siemens's chronometric governor.[94] Maudslay and Fields constructed a massive 'Barker's Mill' (Segner wheel) with Siemens's governor adjusting the water intake pressure and a complex mechanical arrangement maintaining a constant gear rotation for the clock drive.[95]

The polar axis of the Liverpool equatorial was described as massive and stiff, made of wrought-iron plate. The whole telescope weighted about 8400 lb (3810 kg).[96] The more delicate parts of the instrument, graduated circles, eyepieces, and a filar and split-image micrometer were made by Troughton and Simms, to Airy's specifications. Hartnup considered it to be the finest equatorial telescope in the world.[97] He called the equatorial his 'extra-meridian transit instrument':

> When … objects are too faint to be seen on the meridian in daylight, as is the case with comets and the small planets recently discovered, they must be observed out of the meridian, and we are obliged to have recourse to the Equatorial. One serious objection to the ordinary equatorial is a want of firmness in its construction … With a view to lessen this defect, as far as possible, the Astronomer Royal has, in the construction of the instrument, availed himself of means never before, so far as I know, had recourse to in the mounting of an equatorial … the result is, that an Equatorial has been produced, which I believe it to be no exaggeration to say, is not to be equaled in the world for strength and firmness.[98]

In 1849 August Hartnup wrote:

> I am told, and believe, that for the immediate and exact determination of [the position of] any object in the heavens, which cannot be observed when on the meridian (passing, for instance, in daylight), the Liverpool Equatorial is the finest instrument in existence … I have had great pride in exhibiting this matchless instrument to several competent judges, and very recently to the Earl of Rosse, who gave it his unqualified admiration.[99]

11. Hartnup's observations at Liverpool

In the twenty years beginning in 1846 Hartnup published more than seventy papers on astronomical observations made with the Liverpool Observatory's transit and equatorial telescopes. His earliest contributions were made in the aftermath of the excitement over the discovery of Neptune.[100] In 1848 October and November Hartnup made 18 observations of the position of Neptune with the equatorial, and of a background star near the planet.[101] During the 1848 November 8 transit of Mercury he was able to observe one contact with the equatorial: 'The instance is noted at which the sun's light was first seen to surround the planet entirely'.[102]

The fine telescopic comet 1849 I ('Petersen's second comet') provided for Hartnup an interesting demonstration of the astrometric precision of the equatorial. He obtained 34 precise positions with the equatorial in 1848–49 December and January, including 10 observations on January 15 between 06h 00m and 07h 22m GMT. Referring to Hartnup's observations and to the *Nautical Almanac* for 1849, we can compute that at the time of Hartnup's final observation the comet was at an altitude of only 2°.3 at azimuth 227°, and Hartnup noted it was 'so low that the Greenwich Refraction Tables do not apply'. Hartnup is referring to Bessel's Refraction Tables, Table V of Appendix I to *Greenwich Observations for the year 1836*, which do not go below zenith distance 85°.[103]

Equally remarkably, Hartnup noted that on three nights the declinations were deduced from the readings of the declination circle alone; on other days the differences of declination from comparison stars were measured with a micrometer. Hartnup published the comet positions to 0s.01 of right ascension and 0″.1 of north polar distance 'to enable astronomers to judge of the probable accuracy of the determinations of the Liverpool Observatory, which is now completely furnished and in full activity'.[104]

In 1849 Hartnup reported his observations of eclipses of two of Jupiter's satellites. While waiting for the emersion of the fourth satellite, he observed the contact and separation of the second and third satellites. 'One passed so nearly over the other, that at one time the elongation was only just perceptible,' he reported in the *Monthly Notices* of the RAS.[105] Such observations were highly relevant to the Observatory's prime purpose, because comparing the local timing of eclipses of Jupiter's satellites with the calculated time at Greenwich was in those days a ready means of finding longitude.

Also in 1849 Hartnup reported twelve observations of positions of Neptune made with the equatorial, six of Metis, nineteen of Goujon's comet (1849 II), seventeen positions of Flora, two of Hebe, eight of Hygeia, thirteen of Iris, and four each of Pallas and Ceres.[106] For the observations of Pallas and Ceres the equatorial was firmly clamped in the meridian, and used as a transit-circle.[107] The rings of Saturn turned edgewise to the Earth in 1849 January, facilitating visual measurements of the planet's diameter. Hartnup continued to make measurements of Saturn's diameter throughout the year with his parallel-wire and double-image micrometers on the 8½-inch equatorial.[108]

12. 'Malebolge', or the Liverpool Observatory

The annual report of the Council of the Royal Astronomical Society for 1845 drew its attention to the recently established Liverpool Observatory:

> The principal and most interesting object of this establishment is, *that of giving true time to the great port of Liverpool*… The observatory is admirably situated for this purpose, on the brink of the Mersey, at the entrance to the Waterloo Dock; the horizon is good, and infinitely better than could have been hoped for in the heart of a busy manufacturing town. A ball similar to that at Greenwich is let fall every day, except Sunday, precisely at one P.M. Greenwich time, and the whole arrangement is so complete, and the longitude so well known, that the dropping of the balls at the two observatories may be considered to be simultaneous… Mr. Hartnup's aid was most efficient in the measurement of the Valentia arc of longitude, and we trust that is only the first of many services to be rendered to science by this zealous and intelligent observer.[109]

This report presented Liverpool Observatory in a most favourable light. That conflicted with the previously expressed opinion of John Taylor (Section 6.1) who, on 1845 April 1, launched a new series of attacks in letters to the editors of the *Liverpool Mercury*. He was particularly incensed by the statement that the observatory was 'admirably situated', with a good horizon, and 'infinitely better than could have been hoped for'. Taylor reiterated his litany of complaints about the site: 'Such a situation for an observatory may be thought a good one by the Royal Astronomical Society of London, whose great learning may enable them to see things with eyes of peculiar perspicacity; but to other men the place will probably still appear a *condemned hole*.'[110]

Taylor warned that 'fog and sea spray, with the fumigation of passing steam-boats, would corrode metal and glass, tarnish specula, and cause vegetation to shoot between the achromatic plates [lenses]' and that 'tremor from the winds, wave, rolling of carts, discharging and loading of cargoes, and the shock of cannonadings, to say nothing of the crumbling of the foundation … would render a re-adjustment of the instruments constantly needed.'

12.1. *Richard Sheepshanks springs to the defence*

On April 8, Richard Sheepshanks (Figure 12) penned a lengthy letter to the *Mercury*, which did not print it, but sent a copy to Taylor. It appeared instead in the *Liverpool Times* on 1845 April 22:

> The main purpose of the Liverpool Observatory, and the proper business of the observer, is to get, keep, and communicate true Greenwich time to the great port of Liverpool. Will your correspondent say distinctly, that Greenwich time has not been well got, well kept, and faithfully communicated? And, if he does say so, will he produce some proof of his assertion? … I hereby cordially invite T. to a co-examination with me into the effects of the "crumbling foundation", the "shock of cannonadings," &c. &c. I hope to be in Liverpool in a few weeks, and shall be ready, with T.'s assistance, to ascertain whether the "readjustment of the instruments" had been "constantly needed" … There are, luckily, no specula to be corroded; and if "vegetation should shoot between the achromatic plates of the object glass," which is not impossible, but unlikely, the lenses must be separated and wiped … I cannot help hoping that T. himself will, on con-

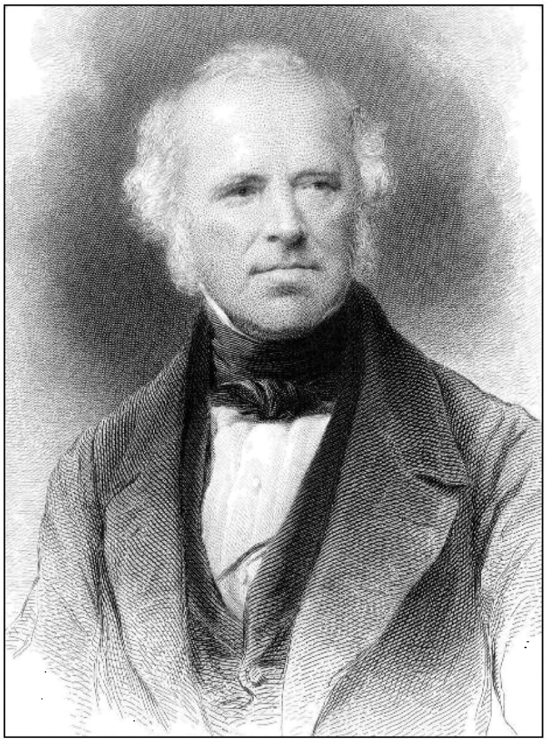


Fig. 12: Richard Sheepshanks (1794–1855), Secretary of the Royal Astronomical Society, publicly defended the Liverpool Observatory against unfounded criticism, describing it as 'a great step towards promoting the security of navigation and an honour to the great port of Liverpool'. (University of Cambridge, Institute of Astronomy Library)

> sideration, allow that his zeal has outrun his discretion upon this hobby; and I am confident that, after he has joined me in a careful examination of the real state of the Observatory … he will also agree with me in thinking it a great step towards promoting the security of navigation and an honour to the great port of Liverpool.[111]

Taylor's response appeared in the *Liverpool Mercury* on April 25, headlined with a reference to Dante's eighth circle of Hell, Malebolge, and containing a poetic slam at Sheepshanks:

> MALEBOLGE, THE LIVERPOOL OBSERVATORY
> I doubt m', frien', you think ye're nae sheep-shank,
> Since you have got a *Secretary's* rank!
> But gin ye've read one half as much as me—
> Though faith that day, I doubt, ye'll never see—
> There'll be, if that date come, I'll wud a boddle,
> Some fewer whigmeicaries in your noddle.
> BURNS, (cum licentia poetae.)[112]

Taylor then discussed his view that the 'main purpose' of the Liverpool Observatory should not be limited to its present functions, but ought to exist on a much greater scale with a larger staff of officers. He claimed that to discern whether Greenwich time is 'well got, well kept, and faithfully communicated, or not' would require another observatory in Liverpool, and that the ball is 'not widely visible, except from the river, where few ships lie'. He then devolved into a lengthy discussion over the definition of the horizon, and the meaning of meridian marks in transit observations: 'I should like to know where the south meridian mark for the *Malebolge* transit instrument is? Perhaps Mr. Sheepshanks thinks that a dancing buoy, floating in the stream, will be good enough for Malebolge; and I think so too.'

Taylor concluded with his efforts to obtain support from the Board of Admiralty and the Parliament for 'the establishment of a noble astronomical observatory, with schools attached to it, for teaching mathematics, astronomy, and navigation, and with examiners qualified to grant diplomas to the masters and mates of mercantile vessels'. Taylor later defended making fun of Sheepshank's name, claiming it was 'pretty well, if not fully warranted by his unnecessary and ridiculous display of honorary titles.'[113]

Sheepshanks was unable twice to insert his reply of April 26 in the *Liverpool Mercury*. Instead, the *Liverpool Times* carried his response:

> The topics of Mr. Taylor's letter shall be treated of in order, and I will begin with the principal one, my very ugly and remarkable name. This has furnished amusement to other wits besides Mr. Taylor, and I occasionally hear a tittle from a raw footman when he announces me. Happily, my equanimity is not seriously affected, and I console myself with reflecting that it is better to have the *hitch* in my cognomen than in my cranium. If I had my choice, I would greatly have preferred the euphonious name in which Mr. Taylor rejoices, but I am dull enough not to see what effect a change of names would have had on the stability of the Liverpool Observatory…
> Mr. Taylor admits that he cannot say whether "Greenwich time is well got, well kept, and faithfully communicated, or not." I say that it can be so, for I have repeatedly observed and got my Liverpool time, at the Liverpool Observatory, and we have now a good longitude, partly, I hope, by my aid. I *know* that Mr. Hartnup is a more capable observer than I am, and I *believe* that he has anxiously and honestly performed his duty. What Mr. T. says about "another observatory," &c. is fudge…
> In most observatories the meridian error is deduced from observations… By combining observations, made in reversed positions of the transit, the errors of meridian and collimation can be deduced with accuracy, by any person able to solve simple equations with two unknown quantities… There are two good ways of getting the same thing, and I prefer the stars to a mark…
> If I, a stranger, had compared the magnificent estuary of the Mersey to the inner depths of Dante's hell, I should have expected to be called a

> very uncivil and impertinent person, if not worse… I am satisfied by finding that Mr. Hartnup, who has enjoyed and observed in the pure and serene air of Blackheath, Greenwich, and London, can see and observe stars, and that right well, in the Liverpool Malebolge.[114]

12.2. *The war of words intensifies*

Far from ending the battle of letters to the editors between Taylor and Sheepshanks, they were in fact just getting started. Taylor replied in a letter to the *Liverpool Mercury* of 60 lines, challenging Sheepshanks to 'eat his own words' on a number of his statements of fact.[115] Sheepshanks published a rejoinder on May 6, in the *Liverpool Times*, characterized by Taylor on the same date, and published three days later in the *Liverpool Mercury*, as 'Another letter from the Rev. Mr. Sheepshanks, 164 lines long by eleven words broad … an awful length, streaming like *tail cometin*, or the beard of Sir Hudibras.'[116] Taylor insisted that terrestrial meridian marks must be established north and south of a transit instrument, and that the Waterloo Dock location ('Malebolge') did not allow for such meridian marks.

Frustrated at having his letters rebuffed by the *Liverpool Mercury*, Sheepshanks circulated a pamphlet entitled 'Correspondence respecting the Liverpool Observatory, between Mr. John Taylor and the Rev. R. Sheepshanks'.[117] Of this pamphlet the editors of the *Mechanics Magazine* cuttingly remarked:

> Mr. Sheepshanks appears to be of that combustible constitution, that the smallest spark of irony sets him in a blaze; and any man who wishes to see what a man in a passion can do and say, or how he can do and say it, has only to wade through these one hundred and thirty closely printed octavo pages… That Mr. Taylor's character as a practical astronomer is completely annihilated, there can be no doubt; but we are at a loss to divine the real motive for all this apparently personal hate, or to judge of the interests which were so evidently involved in accomplishing his destruction.[118]

Sheepshanks explained his reason for devoting time to countering Taylor:

> I shall be reproached by my friends for wasting my time on so insignificant an object; but I do not allow that a man's intellect is any fair measure of his capacity for doing harm. If Mr. Taylor can pass for a man of science, even in the second class of a provincial town, it is not easy to estimate the possible mischief he may cause; and I know of no way to prevent this, except by shewing that he is *ridiculously* ignorant.[119]

Sheepshanks sent a copy of the pamphlet to Taylor care of the *Liverpool Mercury*, and on the front page of that newspaper's *Weekly Supplement* on 1845 October 3 appeared a letter by Taylor entitled 'The Rev. Richard Sheepshanks, M. A., Fellow of trinity College, Cambridge; Member of the Board of Visitors of the Royal Observatory; Foreign Secretary of the Royal Astronomical Society; F.R.S., F.G.S., F.C., P.S., &c.; Author of the Articles on Practical Astronomy in the Penny Cyclopedia,' (that being the contents of Sheepshank's calling card).[120] Taylor said of the pamphlet, 'It is a compound of malignant slander, imbecile rage, and miserable folly, undeserving of any serious reply.' He then filled most of a column of print rehashing his argument with Sheepshanks of ten years prior regarding Sir John Herschel, William Stratford, and the opinions of Laplace and Poisson on the application of the method of least squares to the solution of elliptical cometary orbits.

On 1845 October 11 the editors of *The Athenaeum* magazine in London published a piece entitled 'Correspondence respecting the Liverpool Observatory between Mr. ------ ------- and the Rev. R. Sheepshanks':

> We have omitted the name of one of the disputants [i.e. Taylor]. Our reason for this act of mercy is not that we think the punishment he has received too severe, but that we can serve our present purpose in noticing the discussion without increasing his unhappy notoriety … the mischief is, that he was not mindful of the proverb *ne sutor ultra crepidam*, [a shoemaker should not judge beyond the shoe]… So matters stood when the town council of Liverpool determined upon erecting an observatory to give time to the port, and to rate chronometers for their seamen. They followed a plan which, if they always do the like, explains the prosperity of their noble pile of docks and warehouses. They found out who could give the best advice, went and got it, and then followed it. Now, whether it was that [Taylor] was uneasy in his mind at not being consulted or that some most particularly malicious imp of Satan had nothing to do … we do not know--- but this is certain, that he raised his voice against the passage of the Astronomical Society's annual Report, which mentioned the execution of the plan in terms of praise. This passage, so it happened, had been contributed to the Report by the Rev. R. Sheepshanks, decidedly one of the best of our practical astronomers, and who had … acquired a full acquaintance with the capabilities of the Liverpool Observatory… We agree with Mr. Sheepshanks, and we think the working world of science owes him deep thanks… Those who have a right to judge are fewer and further between. The consequence is, that many scientific pretenders have *nothing but pretension*. As far as modern astronomy is concerned, Mr. ------ is in this class, second to none.[121]

In another front-page article the following January headed 'The Liverpool Observatory, and Mr. Sheepshanks', the editor of the Weekly Supplement to the *Liverpool Mercury* comments with heavy satire on Sheepshank's pamphlet, which 'kills everybody who reads it, for inquire as you will, not a living soul has

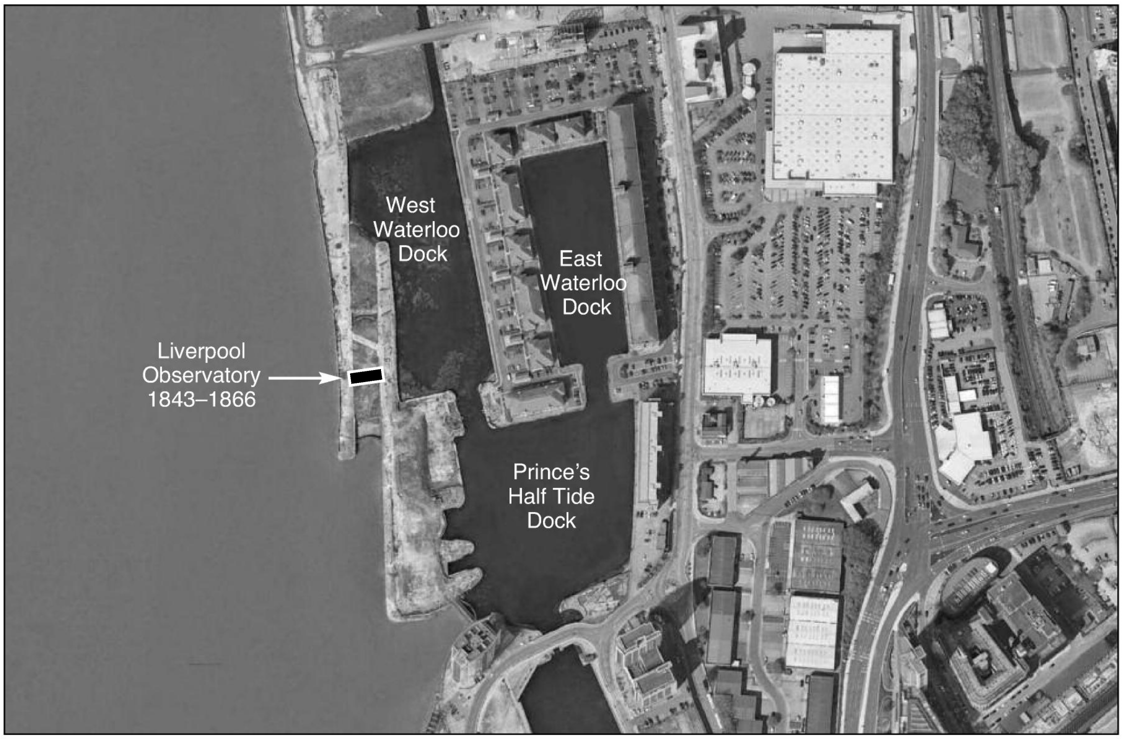


Fig. 13: Site of the Liverpool Observatory (1843–66) on the banks of the River Mersey as it appeared in 2019. North is to the top in this aerial view. Liverpool Observatory lay on the west quay of Waterloo Dock, just north of the entrance to Prince's Half Tide Dock (see Figure 5). In 1866 the Observatory moved to Bidston Hill in Birkenhead to make way for the redevelopment of Waterloo Dock, which was subdivided into West and East sections, as seen today. At the same time Prince's Half Tide Dock to the south was enlarged. The site of the former observatory is now occupied by a large lock that was built after World War II to allow direct access to West Waterloo Dock from the river. Waterloo Dock closed to shipping in 1988 and this lock was then filled in. (Google Maps)

seen it… And all this about the wise or unwise placing of the observatory'. The *Mercury* editors concluded:

> We think, with Mr. Taylor, that the Observatory is most injudiciously placed. Mr. Sheepshanks is quite welcome to the contrary opinion; and, indeed, it is highly probable, judging of his taste, both in localities and in language, that, had the placing of the Royal Observatory itself been left to him, it would not have formed a conspicuous object at Flamstead-house [*sic*], but [would] have been peeping from amidst a forest of masts just below London-bridge, in the congenial vicinity of Billingsgate.[122]

The editors found support for Taylor by including a letter from an old enemy of Sheepshanks: Sir James South. 'I very much regret having again to soil my pen in writing the name of the Rev. Richard Sheepshanks,' he wrote with distaste.[123]

South had been the defendant in a notorious trial in 1833. Troughton and Simms sued South for non-payment of the equatorial mounting they constructed for his 12-inch refractor. The arbitration extended over five years.[124] Sheepshanks and Airy had acted as witnesses for the plaintiffs to support Troughton's case that the instrument was serviceable. The court found for the plaintiffs. South lost over £8,000 and was so enraged that he cut the mounting up and sold the bits in a scrap auction, posting bills blaming Airy and Sheepshanks.

The resulting newspaper battle in 1838 between South and Sheepshanks was widely reported: 'South bites at Sheepshanks, and, by way of poor thanks, Sheepshanks makes of South a South-down' [South-down: a breed of Sussex sheep].[125] During the five years of arbitration, in an exchange of letters with Airy on another matter, South became enraged to the point of intimating his readiness to duel with Airy: 'You may require to my friend Captain Francis Beaufort, R. N., to whom I have confided the preservation of my character as a man, and my honour as a gentleman.'[126]

Taylor maintained his opposition to the Liverpool Observatory to his last days. The American astronomer Maria Mitchell took tea with him on 1857 August 3 and wrote later:

> He is an old man … but full of life, and talks by the hour on heathen mythology. He was the principal agent in the establishment of the Liverpool Observatory, but disclaims the honor, because it was established on so small a scale, compared with his gigantic plan… He struck me as being a man of taste, but of no great profundity.[127]

13. Greenwich Time is adopted in Liverpool

The advocacy for uniform time across Britain had long been a particular concern for the Liverpool councillors. It is difficult today to imagine what 19th-century time-keeping entailed. While all matters astronomical and nautical had adopted Greenwich or 'London time', in ordinary business and commerce every village and town kept its own peculiar time based on its own longitude, differing in varying amounts from every other place. When travel was difficult and infrequent, lack of uniformity in time was a tolerable inconvenience. But that could not last. By the 1840s demand for standardized time came from three space-condensing enterprises: the postal service, regional railroads, and the electric telegraph.

In a 1842 May lecture to the Birmingham Philosophical Institution, the meteorologist and chronologist Abraham Follett Osler (1808–1903) spoke on the early efforts of William Hyde Wollaston (1766–1828) in promoting standard time for the postal service. Wollaston was a member of the Royal Society and the Board of Longitude and a wealthy chemist. He proposed that the daily mail coaches bring chronometers from London to set the clocks in every post office to London time.

> He had no doubt that, ere long, all the town clocks, and eventually all the clocks and watches of private persons, would fall into the same course of regulation; so that only one expression of time would prevail over the country, and every clock and watch indicate by its hands the same hour and minute at the same absolute time.[128]

In 1844 Dundee clockmaker Alexander Cameron proposed that uniform time be adopted about the kingdom, but implemented along with local mean time: 'Let there be two minute hands attached to the clock on the same axis … the one hand to point to show Greenwich mean time, and the other so fixed to it as to show the mean time of the place where the standard clock is situated' [129] (Figure 14).

When the House of Commons met on 1845 March 13 William MacKinnon, MP for Lymington in Hampshire, suggested that 'the same time, either that of Greenwich or London, ought to be fixed for all railways in the United Kingdom and Ireland'.[130] That same year the Institute of Civil Engineers proposed that all railway station clocks 'should be made to show not only London or Greenwich mean time – by which the trains work – but the actual mean time at each place' using 'an extra (gilt) minute hand to show London time.' [131]

13.1. *Influence of the railways*

The London and North Western Railway Company (LNWR) was formed in 1846 from a union of various companies. Its northern secretary was Henry Booth (1788–1869), the son of a Liverpool corn merchant. In 1847 January Booth published a 20-page open letter to

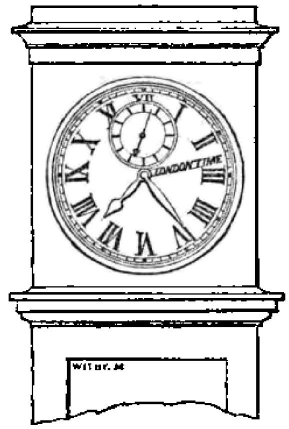


Fig. 14: Proposed design for a public clock with two minute hands, one showing local time and the other showing London (Greenwich) time. (The Civil Engineer and Architect's Journal, 1845)

the Chairman to the Railway Commissioners, Edward Strutt MP, entitled 'Uniformity of Time, considered especially in reference to Railway Transit and the Operations of the Electric Telegraph'.[132] Booth detailed a number of 'ludicrous' problems of commerce and practical life caused by the lack of uniformity of time, and recommended that all clocks in the land be adjusted to Greenwich time during the night preceding the start of the new year 1848.

On June 24 Booth wrote to Liverpool's mayor, George H. Lawrence, to inform him that on the first of September the Trent Valley Railway would open, and on that date all trains for Liverpool, Manchester, London, and all towns between would be regulated in 'London or Greenwich time', and requesting that the town authorities would sanction setting Liverpool's public clocks to the same.[133]

Six weeks passed before Booth's letter was read at the Town Council meeting of 1847 August 4. Councillor Aikin remarked that the issue had been mooted several years ago and 'it had been stated that considerable inconvenience would result from it'.[134] Mayor Lawrence observed that if the railroads introduced it Liverpool would experience 'considerable difficulties' as the difference between local mean and Greenwich time was 'about fourteen minutes'. This required 'serious attention', so the matter was referred to the Observatory Committee. On October 6 Aikin announced that 'the Observatory Committee would use their influence to have Greenwich time universally adopted in Liverpool'.[135]

In the last week of 1847 November, both Henry Booth, for the LNWR, and William Shuttleworth, Liverpool's Town Clerk, published announcements in the papers that 'the principal Railways Companies throughout the kingdom' had adopted Greenwich Time, and that 'the Mayor and Common Council of Liverpool and the Churchwardens of the Parish' had ordered town clocks also to adopt Greenwich time, to which 'the attention of Proprietors of Hotels and Managers of Newsrooms and other Public Institutions is respectfully called'.[136]

13.2. *Financial concerns*

In one regard, namely the rating of chronometers, the finances of the Observatory were falling short of expectations. At the 1849 March 11 meeting of the Town Council James Aikin regretted to say that

> the observatory was not so well supported by the English captains as it was by the American: for, in fact, whilst almost all the American captains sent their chronometers to be regularly rated, not a tithe [tenth] of the English captains did so. He (Mr. A.) said the observatory was not at present a paying concern: it was not self-sustaining; but he hoped the time was not far distant when it would.[137]

For the Observatory to become self-supporting it would have had to rate 800 chronometers per year at 7s 6d each. Chronometers were subjected to 30 days of temperature variations over a range covering typical winter to tropical heat environments, so in a typical year (1853) only 256 chronometers were tested (one-third were from Liverpool makers).[138] And, at various times in its history, the Observatory's fee was rescinded. By 1868 chronometers were tested without charge, and when a rating fee of only five shillings was reinstated for several months, 'there had been only 17 chronometers tested, the amount received for the testing being £4 5s. This sum was so small that it was thought advisable to test them gratuitously'.[139]

14. The Harvard–Liverpool chronometric expeditions

In 1849 March Alexander Dallas Bache (1806–67), Superintendent of the U.S. Coast Survey, was scanning the afternoon mail in his office on New Jersey Avenue in Washington, D.C. This was an era of rapid expansion of the Coast Survey's North American geodetic campaign. Local astronomical observations compared across telegraphic lines measured relative longitude differences with probable errors of a few hundredths of a second of time. Bache was determined to tie the American longitude grid to that of Great Britain.

Thus far, attempts to determine transatlantic longitudes using observations of Moon culminations, eclipses and occultations, and the transportation of chronometers, yielded a range of values that varied by several seconds of time. Bache needed an 'American Greenwich'. He soon found it at the Harvard College Observatory, where the director was William Cranch Bond (1789–1859). For a few years Bond had been given access to the chronometer records of the Cunard steamers that plied the Boston–Liverpool line. He soon realized that deducing transatlantic longitude by chronometers required much more control over every aspect of the individual clocks.

What caught Bache's attention on that afternoon in 1849 was a letter from Bond on a subject of mutual interest. Bond wrote:

> My patience having been totally exhausted in fruitless efforts to induce the person having charge of rating the steamers chronometers at Liverpool to interest himself in the subject of the determination of our differences of Longitude, I wrote to Mr. J. Hartnup, Director of the new Observatory at Liverpool, stating my difficulties and proposing an alliance with him for the purpose of ascertaining the difference of Longitude between Greenwich and Cambridge by means of chronometers transported in the Liverpool steamers. Mr. Hartnup entered heartily into the plan … I have no doubt you will feel, as I do, grateful for the ready zeal with which Mr. Hartnup has entered into the very spirit of the thing. We shall find in him an able coadjutor.[140]

Following a quarter century of debate and advocacy for an observatory at Liverpool, and propelled to completion with the energy of Airy and Sheepshanks, an institution modest yet noted had emerged on the banks of the River Mersey. Under the capable stewardship of Hartnup, advances in maritime navigational support and public time service would ensue.

In Part 2 of this paper to appear in the next issue of *The Antiquarian Astronomer* we will continue with the story of the remarkable Harvard–Liverpool Chronometric Expeditions, plus Hartnup's innovative chronometer testing and electric clock time distribution.

Acknowledgements

The authors gratefully acknowledge the assistance and contributions of Dr Mike Houlden and Dr Peter Rowlands, University of Liverpool; Gerard Gilligan, Liverpool Astronomical Society; Mark Hurn, University of Cambridge; Alan Bowden, John Griffiths, Nathan Pendlebury, and Wendy Simkiss, National Museums Liverpool; Dr Sian Prosser, Royal Astronomical Society; the staff of the Records Office, Liverpool Central Library; and Roger Hutchins, Society for the History of Astronomy. Paul Dearden is especially indebted to the late Martin Suggett, National Museums Liverpool, who inspired him to take an interest in this area of research.

References and notes

1. Muir, Ramsay, *A History of Municipal Government in Liverpool*, Part 1 (University Press of Liverpool, 1906), p. 7.
2. Webster, Thomas, *Minutes of Evidence and of*

Proceedings on the Liverpool and Birkenhead Dock Bills in the Sessions of 1848, 1850, 1851, & 1852 (John Weale, 1853).

3. 'The new baths, to the Editor of the Liverpool Saturday's Advertiser', *Liverpool Mercury*, 1822 November 8, p. 152.
4. 'Public Meetings', *Liverpool Mercury*, 1824 February 20, p.269.
5. 'Proposed Observatory', *Liverpool Mercury*, 1832 December 28.
6. 'Chronometers and insurance', *Liverpool Mercury*, 1826 August 4.
7. 'Proposal for a public establishment in Liverpool for exhibiting telescopes and microscopes of very superior description', *Liverpool Mercury*, 1830 May 7, p. 150.
8. 'Observatory for the regulation of chronometers', *Liverpool Mercury*, 1830 June 4, p. 179.
9. Liverpool Observatory, 'Statement as to the Observatory, submitted by the Astronomer and Solicitor … Marine Committee of the 12th of June 1876', Report of the Astronomer to the Marine Committee, Mersey Docks and Harbour Board, 1876.
10. Lt. Jones RN., Letter to the Town Council of Liverpool, 1836 May 4.
11. Ibid.
12. 'Council Proceedings', *Gore's Liverpool Advertiser*, 1836 June 2, unpag.
13. Lassell, William, Letter to the Mayor and Town Council of Liverpool, 1836 August 3.
14. 'Council Proceedings', *Gore's Liverpool Advertiser*, 1836 August 4, unpag.
15. Ibid.
16. *The Mechanics' Magazine, Museum, Register, Journal, and Gazette*, 30 (1839), p. 270.
17. Minutes of the Liverpool Common Council, Observatory Committee, Ref. No. 352/MIN/OBS/1/1, Liverpool Central Library Record Office [hereafter LCLRO], 1836 August 26.
18. LCLRO, 1836 October 24.
19. Liverpool Town Council Observatory Committee minutes book, LCLRO, p. 9.
20. 'Council Proceedings', *Gore's Liverpool Advertiser*, 1837 January 5, unpag.
21. Ibid.
22. 'Town Council Proceedings, Wednesday January 4th 1837', *Liverpool Mercury*, 1837 January 6, p. 7.
23. Ibid.
24. 'Town Council Proceedings', *Liverpool Mercury*, 1837 January 6, pp. 725. 'Dome of the new custom house', *Liverpool Mercury*, 1837 July 28, p. 239.
26. Ibid.
27. *Report of the Seventh Meeting of the British Association for the Advancement of Science, Held at Liverpool in September, 1837*, 6 (1838), p. xxx.
28. Ibid., p. xvii.
29. Robinson, J. R., Baily, F., and Traill, T. S., Letter to the Worshipful the Mayor, the Aldermen and Common Council of the Port of Liverpool, 1837 September 14.
30. 'Common Council Proceedings', *Liverpool Mercury*, 1837 September 22.
31. Traill, Thomas Stewart, Letter to the Worshipful the Mayor of Liverpool, 1837 September 15.
32. Minutes of the Meeting of the Town Council of the Borough of Liverpool, Ref. No. 352/MIN/COU II, LCLRO, 1838 November 21.
33. Ibid., 1838 December 18.
34. Ibid.
35. LCLRO, 1839 January 22.
36. Entry for Adie, Richard, *Gore's Liverpool Directories*, 1839–65.
37. LCLRO, 1839 February 12.
38. Ibid.
39. LCLRO, 1839 March 4.
40. Minutes of the Liverpool Common Council, Ref. No. 352/MIN/FIN/1, LCLRO, 1839 October 26.
41. LCLRO, 1840 September 22.
42. LCLRO, 1841 March 17.
43. LCLRO, 1841 October 15.
44. LCLRO, 1842 January 28.
45. LCLRO, 1842 February 24.
46. LCLRO, 1842 July 28.
47. Ibid.
48. *Liverpool Mail*, 1844 November 2, p. 3; *Liverpool Mercury*, 24 October 24, p. 8.
49. *Astronomical Observations made at the Royal Observatory at Greenwich, in the year 1833* (J. Murray, 1834), iii–iv.
50. LCLRO, 1843 May 2.
51. *Gore's Liverpool General Advertiser*, 1843 March 30, p. 4.
52. Ibid.
53. Dolan, Graham, 'People: John Chapman Hartnup' http://www.royalobservatorygreenwich.org/articles.php?article=1216
54. John Hartnup obituary, *MNRAS*, 46 (1886), p. 188.
55. Hartnup, J., 'Results of Observations made with a Sextant and Pocket Chronometer, for determining the Latitude and Longitude of the Apartments of the Society', *MNRAS*, 6 (1843), p. 16.
56. LCLRO, 1843 August 26.
57. LCLRO, 1843 October 25.
58. LCLRO, 1843 November 18.
59. LCLRO, 1843 December 7.
60. LCLRO, 1844 February 29.
61. 'Observatory Committee', *Liverpool Mercury*, 1844 March 8.
62. Ellison, T., *The Cotton Trade of Great Britain* (Effingham Wilson, 1886), p. 191.
63. The *Liverpool Mercury*, 1845 September 5, p. 1, excerpts Taylor's description of the cometarium from the *Raccolta Scientifica*, 1845 August 15. A design critique by Sheepshanks appears in

Sheepshanks, R., *Supplement to the correspondence respecting the Liverpool Observatory* (1845), p. 18. See also Beech, Martin, 'The Cometarium by John Taylor', *Bulletin of the Scientific Instrument Society*, No. 88 (2006), p. 2; Beech, Martin, *The wayward comet: a descriptive history of cometary orbits, Kepler's problem, and the cometarium*, (Universal-Publishers, 2016), p. 54. Taylor's cometarium is now in the collection of the History of Science Museum, University of Oxford, inventory number 84080.

64. Taylor, J., *Poems and Translations, Including the First Four Books of Ovid's Fasti; to which are added the Ancient Roman Calendar, with Solar and Sidereal Tables, Calculated for the Thirteenth Year of the Christian Era, and Giving the Positions of Two Hundred and Five Principal Stars then Visible at Rome* (William Forshaw, 1839).
65. 'The Liverpool Observatory', *Liverpool Mercury*, 1844 March 15.
66. 'The Late Mr. John Taylor', *Liverpool Mercury*, 1857 December 14, p. 8.
67. 'The Liverpool Observatory', *Liverpool Mercury*, 1844 March 15.
68. 'Town Council Proceedings', *Liverpool Mercury*, 1844 April 5, p. 115.
69. Ibid.
70. Ibid.
71. 'The Observatory', *Liverpool Mercury*, 1844 April 5, p. 115.
72. 'The Liverpool Observatory', *Liverpool Mercury*, 1844 April 12, p. 118.
73. Ibid.
74. 'Observatory Committee', *Liverpool Mercury*, 1844 March 8.
75. 'The Observatory', *Liverpool Mercury*, 1844 April 5.
76. They included W. Armstrong, Chas. Bake, Barber & Bastin, Thos. Bassett, Thos. Blundell, Samuel Bros., James Brownbill, John Bruce, John M. Butt, Alexander Cairns, Cameron Graham & Parkes, John R. Cameron, John Campbell, Benj. Chadwick, Daniels, G. & T. Davison, W. DeSilva, Alexander Dobbie, Thos. Doodson, Ewins & Griffith, Henry Frodsham, Wm. Gerrard, G. H & C. Gowland, John Graham, C. J. Gray, Ja. Hatton, Henry Hiatt, Rich. Hornby, John Inman, Wm. Jewitt, Gray & Keen, John Ladyman, H. R. Lemon, Lister Williams & Son, Litherland Davies, Leon Marks, J. & E. McGregor, S. D. McKellan, Moncas, Ltd., Musker & Co., Norris & Campbell, Wm. Norton, Owen Owens, John Parkes & Sons, Chas. J. Parkinson, Penlington & Hutton, John Pickford, Charles Piers, J. Preston & Son, Samuel Quilliam, J. W. Ray, Chas. Read, James Reed, Reid & Son, Thos. Roberts, Robert Roskell, Wm. Roskell, Chris. Rowson, Peter Rowson, Thomas Russell, Alfred Russell, Russells Ltd, J. Scott, Joseph Sewill, William Shepherd, Simpson & Roberts, J. T. Simpson, John Skellorn, Sutherland Davies, W. Ushaw, Alexander Walke, Robert Walsh, James Whyte, T. B. Wile, William Wood, Lewis Woolf, John Worden, Karl Zimmerman. Names compiled from Liverpool business directories, e.g., *Marwood's North of England Maritime Directory*, and *The Commercial Directory and Shipper's Guide*, R. E. Fulton.
77. LCLRO, 1844 April 22.
78. LCLRO, 1844 May 30.
79. 'Town Council Proceedings', *Liverpool Mercury*, 1844 June 7, p. 191.
80. 'The Liverpool Observatory', *Liverpool Mail*, 1844 December 21, p. 2.
81. LCLRO, 1845 January 20; advertisements also appeared in the *Liverpool Mail*, 1845 January 25, *Liverpool General Advertiser*, 1845 January 30, and *Liverpool Mercury*, 1845 January 31.
82. 'An account of the measurement of an arc of longitude between Greenwich and the Island of Valentia', *The Practical Mechanic*, 1846 August, p. 276.
83. Ibid.
84. Valentine, Aofi, 'Charles Bianconi and the Ryanair of the 19th century', *Irish Times*, 2015 July 4, https://www.irishtimes.com/news/world/europe/charles-bianconi-and-the-ryanair-of-the-19th-century-1.2272492
85. Findlay, A. G., *Memoir descriptive and explanatory of the Northern Atlantic Ocean, 14th Edition* (R. H. Laurie, 1879), p. 15, Note 3.
86. 'Meteorological Results', *Liverpool Mercury*, 1855 October 5.
87. Hartnup, J., 'Report on the Liverpool Observatory addressed by the astronomer to the Observatory Committee of the Town Council', 1849 February 2, p. 4; and Hartnup, J., letter to Bond, W. C., (1851).
88. LCLRO, 1844 February 29.
89. Hartnup, J., 'Report on the Liverpool Observatory addressed by the astronomer to the Observatory Committee of the Town Council', 1850 September 16, p. 7.
90. Hartnup (1849), op. cit. (ref. 87), p. 4.
91. LCLRO, 1845 November 27.
92. Bagust, Harold, *The Greater Genius?* (Ian Allan Publishing, 2006).
93. Hartnup, J, 'A short notice of the Equatoreal of the Liverpool Observatory', *MNRAS*, 9 (1848), 34–5.
94. Ibid.
95. 'Report of the Council to the twenty-ninth annual meeting of the Royal Astronomical Society', *MNRAS*, 9 (1849), 76–7. For a detailed description of the Siemens chronometric governor see Airy's report on the 12.8-inch Merz Great Equatorial, Appendix III of *Greenwich Astronomical Observations in the year 1866* (HMSO, 1868).
96. Hartnup (1848), op. cit. (ref. 93).
97. LCLRO, 1848 August 18.
98. Hartnup (1849), op. cit. (ref. 87), pp. 5–6.
99. 'The Liverpool Observatory', *The Liverpool Mail*, 1849 October 20.
100. 'Observations of Le Verrier's Planet', *MNRAS*, 7 (1846), pp. 155, 157.
101. 'Neptune', *MNRAS*, 9 (1848), p. 23; 'Neptune', *MNRAS*, 9 (1849), p. 43.

102. 'Notice of Transit of Mercury', *MNRAS*, 9 (1848), p. 23.

103. Airy, G. B., *Astronomical Observations made at the Royal Observatory at Greenwich, Vol. 21* (1836), pp. DI–DXXIII.

104. Ibid.

105. 'Eclipses of Jupiter's satellites', *MNRAS*, 9 (1849), p. 105. Hartnup's paper has an apparent typographical error, as his reported time of emersion of Callisto is early by three hours.

106. 'Neptune', *MNRAS*, 9 (1849), p. 43; *MNRAS*, 10 (1849), p. 26.

107. 'Ceres', *MNRAS*, 9 (1849), p. 221.

108. 'Diameters of Saturn', *MNRAS*, 10 (1849), p. 7.

109. 'Report of the Council of the Society to the Twenty-fifth Annual General Meeting', *MNRAS*, 6 (1845), 185–6.

110. 'To the editors of the Liverpool Mercury', *Liverpool Mercury*, 1845 April 1.

111. Sheepshanks, R., *Correspondence respecting the Liverpool Observatory between Mr. John Taylor and the Rev. R. Sheepshanks* (privately printed, 1845).

112. 'Malebolge, the Liverpool Observatory', *Liverpool Mercury*, 1845 April 25, p. 142.

113. 'The Rev. Richard Sheepshanks, M.A.', *Liverpool Mercury*, 1845 October 10, p. 15.

114. Sheepshanks, op. cit. (ref. 111), p. 31.

115. 'The Liverpool Observatory alias Malebolge and the Rev. Mr. Sheepshanks', *Liverpool Mercury*, 1845 April 29, p. 150.

116. 'Liverpool Observatory alias Malebolge and the Rev. Mr. Sheepshanks', *Liverpool Mercury*, 1845 May 9, p. 158.

117. Sheepshanks, op. cit. (ref. 111).

118. 'The Liverpool Observatory', *The Mechanics Magazine*, 1846 January 24, No. 1172, p. 7.

119. Sheepshanks, op. cit. (ref. 111), p. x.

120. 'The Rev. Richard Sheepshanks, M. A.', *Weekly Supplement to the Liverpool Mercury*, 1845 October 3, p. 1.

121. 'Correspondence respecting the Liverpool Observatory between Mr. ------ ------- and the Rev. R. Sheepshanks', *The Athenaeum*, 1845 October 11, p. 985.

122. 'The Liverpool Observatory, and Mr. Sheepshanks', *Weekly Supplement to the Liverpool Mercury*, 1846 January 16.

123. Ibid.

124. De Morgan, S. E., *Memoir of Augustus De Morgan* (Longmans, Green, 1882), p. 61.

125. 'On the Astronomical Disputation between Sir James South and the Rev. Mr. Sheepshanks', *Dublin Evening Mail*, 1838 November 14; *Naval & Military Gazette*, 1838 November 10.

126. De Morgan, op. cit. (ref. 124), p. 64.

127. Kendall, P. M., *Maria Mitchell, Life, Letters, and Journals* (Lee and Shephard, 1896), p. 86.

128. 'Suggestion for obtaining uniformity of clock time throughout Great Britain', *Yorkshire Gazette*, 1842 May 7.

129. Cameron, Alexander [A. C., pseud.], *The Fife Herald, and Kinross, Strathearn, and Clackmannan Advertiser*, 1844 December 5, p. 167.

130. 'Imperial Parliament', *Morning Chronicle*, 1845 March 14.

131. 'Railway time', *Leicester Chronicle*, 1845 June 28.

132. Booth, Henry, *Uniformity of Time, considered especially in reference to Railway Transit and the Operations of the Electric Telegraph* (John Weale, London, and Thomas Baines, Liverpool, 1847).

133. 'Greenwich time in Liverpool', *Liverpool Mercury*, 1847 August 6.

134. 'Town Council Proceedings', *Liverpool Mercury*, 1847 August 6.

135. 'Town Council Proceedings', *Liverpool Mail*, 1847 October 9.

136. *Liverpool Mail*, 1847 November 27; *Gore's Liverpool General Advertiser*, 1847 December 2.

137. 'Town Council Proceedings', *Liverpool Mail*, 1847 March 17.

138. 'Report on the Liverpool Observatory Addressed by the Astronomer to the Observatory Committee to the Town Council, August 24, 1853', *Liverpool Mercury*, 1853 September 6.

139. *Liverpool Mercury*, 1868 November 20.

140. Bond, W. C., letter to A. D. Bache, 1849 March 12, Correspondence and notes, 1849–1856. Records of the Harvard College Observatory Chronometric Expedition, UAV 630.349, Harvard University Archives.

The authors

Richard E. Schmidt retired in 2012 as an astronomer at the U.S. Naval Observatory in Washington, D.C., where as a part-time contractor he is currently training as an observer on the 26-inch Clark refractor. He operates his own rooftop observatory, specializing in photometry of minor planets and short-period variable stars. Richard is a past lecturer in astronomy for the Smithsonian Institution. His paper 'The Tuttles of Harvard College Observatory, 1850–1862' was published in Issue 6 of *The Antiquarian Astronomer* (2012).

Paul Dearden is an astronomer and teacher of mathematics based in Liverpool. He received his MSc in the history of science and technology from the University of Liverpool in 2004. His thesis title was 'The Development and Work of the Liverpool Observatory at Waterloo Dock, 1836–1866'. Paul is a Continuing Education Lecturer in astronomy at the University of Liverpool, and teaches mathematics in secondary schools across Merseyside.