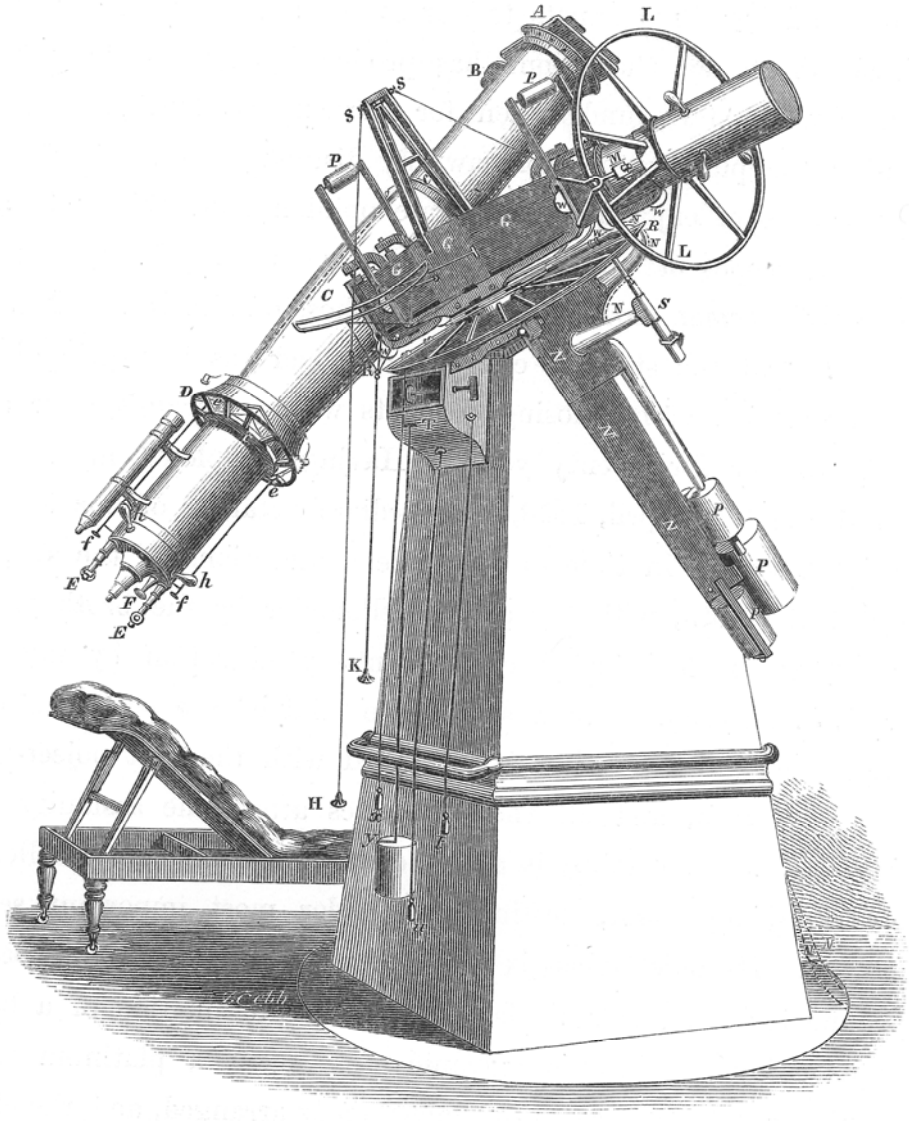
The Antiquarian Astronomer

Journal of the Society for the History of Astronomy



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The cover illustration

The Oxford heliometer

Continuing the anniversary theme of previous covers of *The Antiquarian Astronomer*, this issue shows an engraving of the Oxford heliometer[1]. Ordered from the instrument maker A & G Repsold, Hamburg, Germany, in 1841, the heliometer began work 160 years ago, in 1848. It was the only large example of this type of instrument installed at an observatory in Britain.

The heliometer (more correctly a divided-objective-lens micrometer) was conceived by Ole Römer (1644-1710), and improved by the optician, John Dollond (1706-1761). His design used an objective lens bisected across the diameter, each part having the same focal length, and served by one eyepiece. Mounted in a frame, each semi-lens could be moved along its diameter using a fine screw-thread. The displacement between the two images gives a very precise measure of the angular separation of the stars under observation, or the apparent diameter of the Sun or planet. Significant work using a heliometer was not achieved until a 6-inch instrument was delivered to the Königsberg Observatory in 1829. Designed by Joseph Fraunhofer (1787-1826), this heliometer was used by Friedrich Bessel (1784-1846) to measure the parallax of the star 61 Cygni - the first accurate measure of the distance to the stars.

Against this background of German success in using the heliometer, the trustees of the Radcliffe Observatory, Oxford, England, opted to acquire an example with a 7½-inch diameter objective lens. The commission was part of the re-equipping of the observatory under its new director, Manuel J. Johnson (1805-1859) appointed in 1839, whose aim was to broaden the observing programme from being solely concerned with meridian astronomy. This new area of research, which had no immediate utility, was not normally undertaken by state- or university-funded observatories in Britain. Financed by the Radcliffe Trust, the Radcliffe Observatory could afford the substantial £1,500 price for the heliometer, and a further £800 for the building and dome. The bisected objective lens and other optical elements were supplied by Georg Merz (1793-1867), a Munich optician and successor to Fraunhofer. The mounting and mechanical parts were provided A & G Repsold. Founded by Johann Georg Repsold (1771-1830), the company was run at this time by his sons Adolf (1806-1871) and Georg (1804-1867), the former coming to England to supervise personally the erection of the instrument. The final cost for importing this new piece of German technology was £3,500; such a large expense attracted much publicity and expectation.

However, despite its great technical design and fine engineering, the Oxford heliometer never achieved its full potential. It was soon realised that to operate it successfully needed at least two people. Although Johnson was able to appoint a second assistant to alleviate the problem, the observatory's other duty - reducing earlier meridian observations - compromised observations with the heliometer. In addition, the objective lens frequently required adjustment, a task that was beyond the skills of even such talented observing assistants as Norman Pogson (1829-1891), and it had to be undertaken by Repsold craftsmen sent from Germany. Johnson's successors, Robert Main (1808-1878) and Edward Stone (1831-1897) persevered with the heliometer; planetary and some stellar parallax measurements being made up to 1885. In 1907 it was displaced by the 10-inch aperture Thomas Cook refractor donated by J. G. Barclay in 1887 [2]. Until 1907 the refractor had been housed in a wooden shed.

After being dismantled in the late 19th century, the heliometer was stored until 1930 when, prompted by the relocation of the Radcliffe Observatory from Oxford to South Africa, it was donated to the London Science Museum. It was displayed in London from the 1960s until 1987, when it was removed to a museum store in west London, where it can be now be seen by appointment.

1. The illustration is from: Captain W. H. Smyth, R.N., K.S.F., D.C.L., F.R.S. &c. *Ædes Hartwellianae*, *or Notices of the Manor and Mansion of Hartwell.* London: Printed for private circulation by John Bowyer Nicols and Son, Parliament Street. MDCCCLI. Page 246. Much of the astronomical content of this book, including the heliometer illustration, appears in Smyth's later book: Vice-Admiral W.H. Smyth, K.S.F., D.C.L., F.R.S., F.R.A.S. etc. *The Cycle of Celestial Objects Continued at the Hartwell Observatory to 1859. With a notice of recent discoveries, including details from the* 'Ædes Hartwellianae'. London: Printed for private circulation by John Bowyer Nicols and Sons, Parliament Street. M.D.CCC.LX. This book is commonly known by the only words present on its spine - *Speculum Hartwellianum*. It is frequently confused with the 1851 publication.

2. C. E. Barclay. 'Joseph Gurney Barclay and the 1860 10-inch Cooke Refractor'. *The Antiquarian Astronomer*. Issue 3. December 2007. 11-18.

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Two Guernseymen and Two Eclipses

David Le Conte

Past President, La Société Guernesiaise

Warren De La Rue was undoubtedly the most accomplished Guernsey-born astronomer, while Paul Jacob Naftel was an equally accomplished Guernsey-born artist. Apart from their island births and contemporary 19th century lives, it appears unlikely that they had much in common. But both made scientifically valuable observations of total solar eclipses, coincidentally both in Spain, just ten years apart. This paper records these achievements of both men, and some details of the expeditions in which each participated. It is based in part on lectures given by the author to the Society for the History of Astronomy in 2003, and to La Société Guernesiaise (the Guernsey local studies society) and the Royal Astronomical Society in 2005.

The reputation of Warren De La Rue (1815–1889) (Figure 1) as a Victorian businessman-scientist is based on his work in early astronomical photography, especially of the Sun, in electricity and chemistry, and in printing processes. His crowning astronomical achievement was his photographic observations of a total solar eclipse in 1860, which demonstrated conclusively the solar origin of prominences. This was the first example of photography being successfully applied to resolve a question in astronomy.

Figure 1

Warren De La Rue (1815–1889), *circa* 1870

By courtesy of the Royal Astronomical Society.

Paul Jacob Naftel (1817–1891) (Figure 2) was a successful British landscape artist, whose paintings are still highly valued. This paper records his depiction of the solar corona and the appearance of the terrestrial atmosphere, in a painting of the total solar eclipse of 1870 executed for the Royal Astronomical Society (R.A.S.). While people in Guernsey today are familiar with Naftel's work, which regularly appears in local auction sales, Warren De La Rue is virtually unknown in Guernsey, even though the family firm – the De La Rue Press – is recognised by, for example, Guernsey banknotes and the name of a public house in the island's capital, St Peter Port.

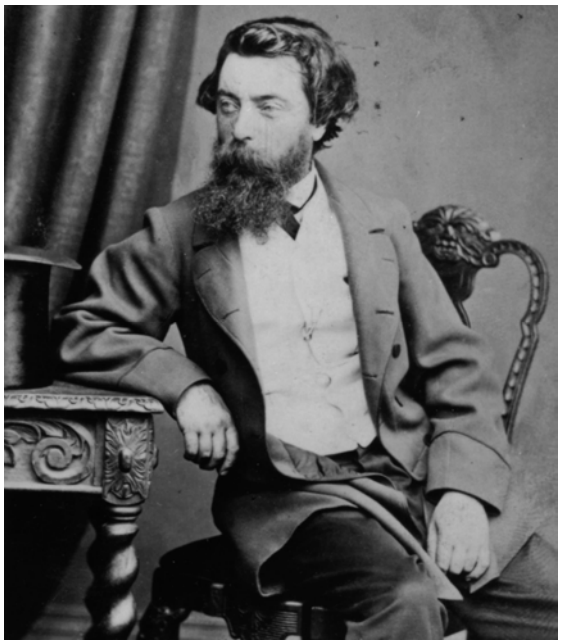

Figure 2

Paul Jacob Naftel (1817–1891), *circa* 1865

By courtesy of the National Portrait Gallery, London.

Figure 3

The De La Rue photoheliograph

By courtesy of the Science Museum, London.

Warren De La Rue

Warren De La Rue was born in St Peter Port, Guernsey on the 18 January 1815, the eldest son of Thomas De La Rue, who was later to found De La Rue Press, still a multi-national printing firm. The family left Guernsey in 1816, and settled in London. Early in his life Warren showed an aptitude for science and technical innovation, publishing papers in chemistry and electricity, building a superb 13-inch reflector, and inventing an envelope-making machine that created much interest at the Great Exhibition of 1851.

It was at the Great Exhibition that his interest in astronomical photography was first aroused, by sight of a daguerreotype of the Moon, taken with the 15-inch equatorial refractor at Harvard College Observatory. This led to a lifelong pursuit of photography of the Moon, planets, and especially the Sun, using the wet collodion process.

Heinrich Schwabe's records of sunspot numbers from 1826 to 1842 had provided, for the first time, evidence of the sunspot cycle. In the 1850s Richard Carrington, who knew De La Rue well, made meticulous measurements of sunspot positions, throwing light on the nature of the Sun's surface rotation. So there was much interest and research into these new findings in solar physics. In the mid-1850s Sir John Herschel proposed that there would be merit in developing a telescope designed specifically to take daily photographs of the Sun, in order to study the sunspot cycle and other surface features.[1] The British Association for the Advancement of Science asked De La Rue to undertake this task, which he took on avidly, inventing the 'photoheliograph', the first telescope designed for this purpose, indeed probably the first photographic telescope designed for a specific astronomical purpose (Figure 3).

The photoheliograph was a refracting instrument of 3.4 inches aperture, stopped down to 2 inches, and with a focal length of 50 inches, the Sun's image being enlarged to a diameter of 4 inches. The picture was taken by setting fire to a thread holding a sliding plate with a rectangular aperture, which had a spring attached to the other side; this caused the aperture to flash rapidly across the photographic plate. The exposure speed, which was a fraction of a second, could be adjusted by changing the aperture of the sliding plate, and its rate of motion.[2] The instrument was installed at the Kew Observatory, run by the British Association, in 1858, and it was this telescope which was to be the prime instrument used for his observations of the total eclipse of the Sun in 1860.

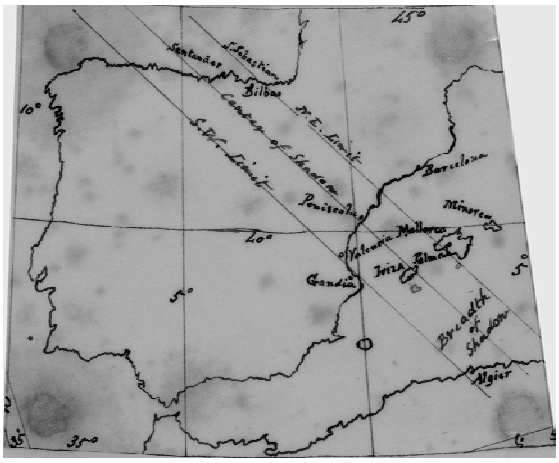

Figure 4

George Biddell Airy's map of the path of totality of the solar eclipse of 18 July 1860

From a letter from Airy to Lord John Russell, Secretary of State for the Foreign Department, dated 22 February 1860.

Royal Greenwich Observatory Archives R.G.O.6/123 leaf 4.

The 1860 eclipse - Preparations

During the eclipse of 1836, Francis Baily (1774–1844) had observed what became known as 'Baily's beads'. But an even more surprising phenomenon, observed during an eclipse in 1842, was the appearance of red, flame-like 'protuberances' or prominences around the limb of the Moon. Theories were expressed that they were associated with the Moon itself, or were caused by the Earth's atmosphere, or emanated from the Sun. Similar debate centred on the nature of the solar corona, seen only during a total eclipse. By 1851, when the next major total eclipse was to take place in Spain, photography was a feasible tool, and Sir John Herschel suggested to the Astronomer Royal, George Biddell Airy (1801–1892), that an attempt be made to photograph the protuberances. The proposal was passed to William Henry Fox Talbot (1800–1877), inventor of the calotype process and a close friend of Herschel, but no photography of the 1851 eclipse was carried out by British astronomers.

However, De La Rue frequently travelled abroad on the business of the De La Rue Company, and often took the opportunity to visit astronomical institutions. In 1858, he visited the Königsberg Observatory in East Prussia and was shown a Daguerreotype (made with a small refracting telescope mounted on their Fraunhofer heliometer) of the total eclipse of 1851, in which the prominences had been photographed, albeit poorly. During the same trip, in Russia, he was made aware of the forthcoming eclipse to take place on 18 July 1860, and resolved to attempt high-resolution photography to determine the nature of the prominences.[3]

At that time there was considerable confusion and disagreement about the nature of the many phenomena associated with solar eclipses. It was exacerbated by the fact that different observers recorded differently what they saw, making scientific deductions extremely difficult. Airy had recognised the advantages of applying photography to resolving perplexing phenomena, and sought to have the eclipse of 1860 photographed. No better instrument existed for this purpose than De La Rue's photoheliograph. Airy proposed that an expedition be mounted to the eclipse in Spain, and that the instrument be transported to an observing site in the path of totality (Figure 4).

However, De La Rue had some reservations about the ability of his instrument to photograph the prominences, because of their reported faintness and redness, his photographic plates not being very sensitive to red light. It was reported that the prominences were about as bright as the Moon, but tests on photographing the Moon with the photoheliograph failed to produce an image.[4] Nevertheless, Airy decided to proceed with his plans.

In addition to the telescope, itself a massive instrument, it was necessary to convey to Spain an entire photographic darkroom, as the wet collodion plates had to be developed on the spot. Transport to Spain and logistical arrangements within Spain were clearly major organisational matters. Through a direct approach to the First Lord of the Admiralty, Airy secured a large Royal Navy steam-and-sail troopship, *H.M.S. Himalaya*, and consequently, the expedition became known as the *Himalaya Expedition*.[5] This iron-built ship, of about 4,500 tons displacement, was the largest steamship afloat when launched in May 1853. She was converted in 1854 for use as a troopship in the Crimean War. Local assistance in Spain was arranged through the very helpful services of Charles Vignoles, Engineer-in-Chief, Bilbao and Tudela Railway.

Not only was there the organisation involved in transporting all the equipment, but time also had to be allowed for setting up and testing. Airy proposed to leave on the 9 July, but De La Rue wrote to him (in May 1860) saying:

> " I beg leave to state that for the purposes of photography it is very desirable for as much time as possible to be allowed previous to the eclipse. Not only is the apparatus heavy and large, requiring some days to put together and adjust in position, but the collodion must be mixed and allowed to settle and then experimented with for some time to ensure good results. I would therefore suggest that the departure of the expedition ought not to be delayed beyond the 6th of July from the port of embarcation." [6]

The journey out

In the event, the *Himalaya* sailed from Plymouth on the morning of 7 July 1860, the party having been subjected to some confusion at Plymouth station "… attributable to the puzzling array of scientific packages brought down by the astronomers." [7] This was hardly surprising. De La Rue had initially listed a fairly modest set of equipment, but when he learned that the *Himalaya* was to be used, he decided to increase the equipment list substantially. The photoheliograph, auxiliary photographic apparatus, 3-inch Dallmeyer refractor, chronometers, meteorological and surveying instruments, and other equipment were to be housed in:

> "… a complete photographic observatory, … part to contain the heliograph with a removable roof, and part divided off and fitted up as a photographic room, with a cistern, to be filled from the outside, a sink, and with tanks and shelves to hold the apparatus and photographs."

In addition there was a set of engineers' and carpenters' tools, as well as 139 lb of distilled water, a stove, and emergency provisions. The whole comprised 30 packages and weighed nearly two tons.[8]

To ensure that all worked well he took no less than four assistants, including the mechanical assistant at Kew (Mr Beckley) and his private photographic assistant (Mr Reynolds). Over 50 people, including the Astronomer Royal and his wife, Otto Struve of the Pulkowa Observatory in Russia, a number of English astronomers, and a deputation of Norwegian astronomers, sailed, most going to other destinations in Spain to watch the eclipse.[9]

The journey appears to have been pleasant enough. Some of the astronomers who had brought sextants participated in celestial observations to determine latitude and longitude. One of the passengers wrote:

> " Some were congratulating themselves on the impossibility that, with such an astounding amount of science on board, the ship could go wrong: others profanely quoted the adage about 'too many cooks', while I fear the good-natured captain [Captain Seccombe, R.N.] and his master merely set us all down as land lubbers, and quietly ignored our nautical science altogether." [10]

During the voyage Airy gathered everyone on deck to assign locations and tasks, according to each person's skills. The *Himalaya* arrived at Bilbao on the 9 July. The next day Airy again called a meeting, at the Railway Office, to make the final arrangements. De La Rue's chosen site was Rivabellosa (42°43′ N, 0°11′42" W, altitude over 1500 feet), 2 miles from Miranda, and 70 miles from Bilbao, "… only accessible through a pass difficult for the transmission of heavy baggage." His apparatus was sent ahead, and the party followed on the 10 July, arriving the next day, "… after a journey very trying to our chronometers." [11] The instruments took longer, arriving that evening. De La Rue selected as his observing site a thrashing floor, 60 feet in diameter, level, hard and dry, with a supply of water readily to hand. The owner, who had intended using it the next day, as the harvest had commenced, gladly lent it without remuneration.

The solar eclipse of 18 July 1860

De La Rue and his assistants set to work erecting the observatory and darkroom (Figure 5). The roof and walls of the latter were covered with a canvas with a gap of three feet, which was kept wet in order to lower the temperature in the darkroom by evaporation. They obtained a photograph of the Sun on the 14 July. Sunday 15 July was "… a splendid day", succeeded "… by one of the grandest and most awful thunder-storms I have ever witnessed." Monday and Tuesday were cloudy, with only the slightest glimpses of the Sun - occasions that "… had to be diligently made use of for the adjustment of the instruments and the procurement of observations." [12] There was no opportunity for rehearsal of the eclipse photography programme.[13]

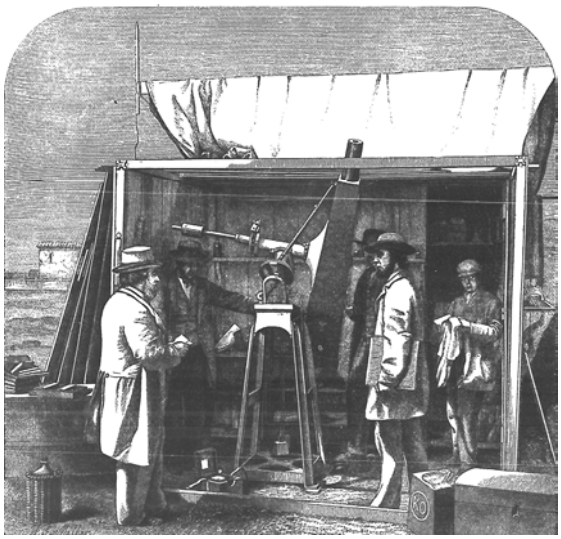

Figure 5

The photoheliograph at the eclipse site

Warren De La Rue is the foreground figure on the left.
This image is from the *Philosophical Transactions of the Royal Society of London*. 1862, Volume 152. Page 363.

De La Rue recorded that the morning of eclipse day, Wednesday 18 July, arrived:

> "… and appeared hopelessly cloudy. The sky was watched with the most intense anxiety by us all; and I am free to confess that my nerves were in the most feverish state of agitation."

However, at mid-day there was some clearing, and soon after the clouds "… disappeared all at once; and we had a magnificent sky." Other members of the expedition were scattered in the region. Through his telescope De La Rue observed two of them a few miles west, enjoying similarly good weather, but others were less fortunate, some being completely clouded out.[14]

About 200 people from the village had assembled round the observatory, seeming to think that the eclipse could only be seen from there. Five mounted guards kept them away from the operation, but their talking made it difficult for De La Rue to hear the beats of the chronometer. Some were persuaded to go to a higher place, where they could see it better, and the rest were asked to keep quiet, which they readily complied with.

All therefore appeared well at the De La Rue site, until about 20 minutes before the start of the eclipse, when "… an occurrence took place which very nearly brought all our labours to a calamitous termination." De La Rue had smoked a piece of glass with a wax lucifer-match, so that a locally-hired servant, Juan, who had proved most helpful, could watch the eclipse. Juan then did the same with more pieces of glass for the bystanders. Unfortunately, the demand "… soon increased so much that he was scarcely able to keep pace with it, and at length became so excited that he threw away the matches in all directions without extinguishing them, and some, falling in the standing corn, set it on fire." Fortunately, they were able to extinguish the fire before it got out of control, using the neighbouring water supply.[15]

The partial phase of the eclipse commenced at 1.48 p.m. De La Rue had prepared 48 plates and three plate holders, so that photographs could be taken rapidly in succession. He took them every few minutes during the partial phase, including the occultation of a sunspot; and two during the three minutes of totality. As is inevitably the case with such enterprises, not everything went smoothly. Twice he forgot to uncover the plate, one plate was ruined because the full aperture was used, the wind affected another, and in the rush of totality the precise times of some exposures were not noted. There must also have been anxiety when clouds briefly interrupted observations.

Photographic and telescopic observations

Despite these difficulties, De La Rue was successful with his programme of photographs – those taken during totality being of historical importance (Figure 6). Preparations in the few minutes before totality must have been quite frantic, as the telescope had to be changed to full aperture, the fast shutter apparatus disconnected, and three specially sensitised plates readied. Although he had been doubtful that prominences would be recorded, the very first plate of totality, taken with an exposure of one minute and immediately developed, showed them clearly, being much brighter than expected.

> "Although my own observations during the totality gave me greater hopes of success, it was with a thrill of pleasure that, in answer to my questions, I learnt from Mr Reynolds that the picture was coming out under the influence of the developing fluid." [16]

Knowledge of this fact, while totality was still in

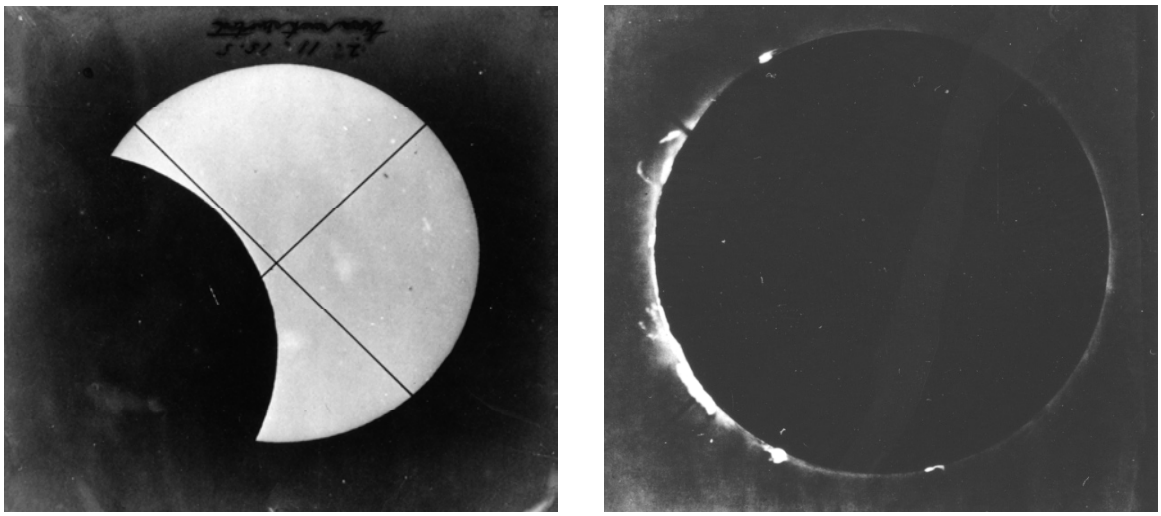

Figure 6

Photographs by Warren De La Rue of partial and total eclipse 18 July 1860

By courtesy of the Royal Astronomical Society.
Left Panel: RAS ADD MS 146 Page 16r.
Right panel: RAS ADD MS 146 Page 6r, image (ii) [No. 25] "Original untouched photograph".

progress, gave De La Rue the confidence that the plates would be useful, even with shorter exposures, and he later regretted that he had not arranged to take more pictures during totality.

Although the photography was the first priority for the expedition, De La Rue also undertook visual observations in case the photographs were not successful. The 3-inch Dallmeyer telescope was fitted with inscribed micrometer lines (what we would now term a graticule), in order to measure and record the precise positions of features that appeared during the eclipse. He had prepared two diagrams representing the lines' appearance, at a scale which sufficed to include a circle, representing the Moon, four-inches in diameter. This was the same size as the images on the photographic plates, so the drawings and photographs could later be compared. On the diagrams he had painted 15 "… streaks of various tints ...", so that he could judge the colour of the prominences.

The telescope's eyepiece had been fitted with an ingenious system of De La Rue's devising, so that the eclipse, in its various stages, could be observed without damage to the eyes. As no account of it had been published, and as it had proved its value during the eclipse observations, he described it in full (Figure 7).[17] It was a modification of 'Hodgson's solar eyepiece'. It consisted of a reflecting surface, half of which was silvered and the other half plain glass, with a graduated filter held in place by a spring. During the partial phases of the eclipse the solar image was reflected from the plain glass, the filter being positioned to produce a safe image at the eye. At totality the filter was removed and the reflector slid so that the solar image was reflected to the eye by the silvered half. This action could be carried out rapidly.

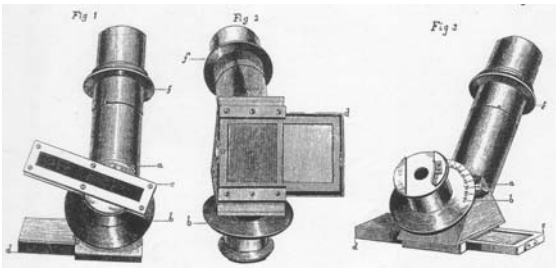

Figure 7

Details of De La Rue's solar eyepiece

This image is taken from De La Rue's report to the Royal Society (see Reference 3, Page 351).

By courtesy of the Royal Society.

The first of his two drawings (Figure 8) was started half a minute after the beginning of totality, and took one minute to complete. He then took a brief break to observe the scene with the naked eye for half a minute, then measured the position of one of the prominences, re-centred the Moon in the telescope, and started the second drawing. De La Rue gave a detailed account of his telescopic observations, especially of the prominences, which, after all, were the *raison d'être* of the expedition.[19] He clearly observed the Moon's motion uncovering them, so demonstrating that they were attached to the Sun. The photographs confirmed this.

He also looked for Baily's beads, but did not observe them. He expressed no surprise at this:

> "… for I had always believed that they arose, in all probability, from atmospheric disturbance of an image formed by a telescope wanting in perfect definition. The Dallmeyer I used was so perfect that I did not think I should see anything of the kind." [20]

It was later reported that some observers did see them, while others, despite clear skies, did not.[21]

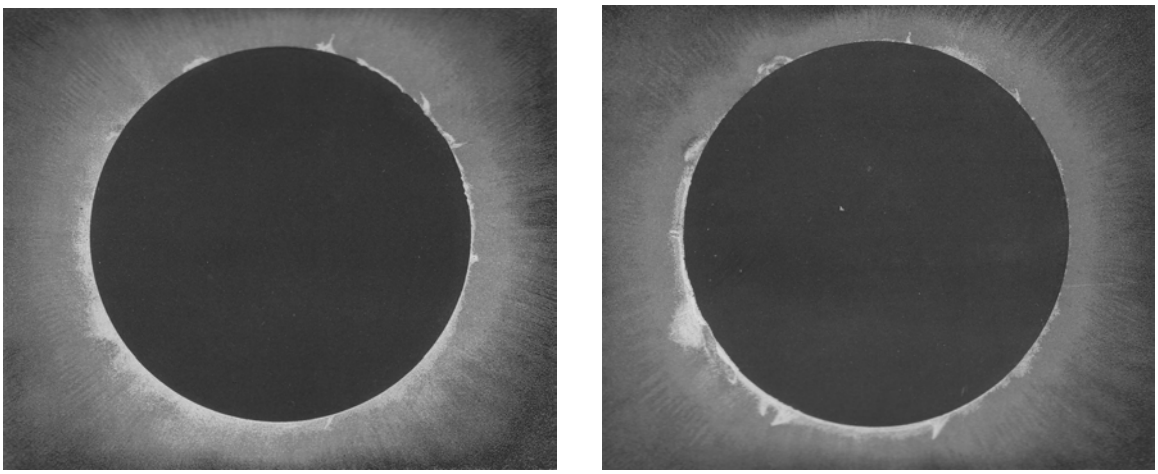

Figure 8

Drawings by Warren De La Rue of the total solar eclipse of 18 July 1860

These drawings are copied from Amédée Guillemin, *The Heavens: An Illustrated Handbook of Popular Astronomy*, Edited by J. Norman Lockyer. 3rd Edition. London: Richard Bentley, 1868. Facing page 171.[18]

Visual observations

The detail in De La Rue's drawings, executed in such a short period of time, is matched by his descriptive detail, especially of even briefer visual observations of totality. As the total eclipse approached, De La Rue remarked upon the changing colour of the sky, "… which had been gradually losing its azure blue and assuming an indigo tint.", noted a bronze hue illuminating the surrounding landscape, the blackness and sharpness of shadows as the Sun became a thin crescent, contrasted with the vivid intensity of the lighted areas "… strongly recalling to mind the effects produced by the illumination of electric light". He also observed, several minutes before totality "… the whole contour of the brown-looking lunar disk".[22]

He allowed himself a mere 20 seconds away from the telescope, between the drawings, to gaze on the spectacle of totality. His description of the scene is highly evocative:

> "… when I had once turned my eyes on the moon encircled by the glorious corona, then on the novel and grand spectacle presented by the surrounding landscape, and had taken a hurried look at the wonderful appearance of the heavens, so unlike anything I had ever before witnessed, I was so completely enthralled that I had to exercise the utmost self-control to tear myself away from a scene at once so impressive and magnificent, and it was with a feeling of regret that I turned aside to resume my self-imposed duties. I well remember that I wished I had not encumbered myself with apparatus, and I mentally registered a vow, that, if a future opportunity ever presented itself for my observing a total eclipse, I would give up all idea of making astronomical observations, and devote myself to that full enjoyment of the spectacle which can only be obtained by the mere gazer."

He saw the planets Jupiter and Venus, which were just a few degrees from the Sun. He goes on:

> " The effect of totality upon the bystanders was most remarkable. Until the beginning of totality, the murmur of the conversation of many tongues had filled the air; but then in a moment every voice was hushed, and the stillness was so sudden as to be perfectly startling; then the ear caught the sound of the village bells, which had been tolling unheeded during the eclipse, and this circumstance added much to the solemn grandeur of the occasion." [23]

This was in marked contrast to the effect upon the "… native spectators ..." at a neighbouring site where "… as soon as the Sun quite disappeared, they set up a great shout of applause!" [24]

The expedition members, including the Astronomer Royal, were photographed, at De La Rue's site, De La Rue himself incongruously lying on the ground (Figure 9). The photograph was reproduced in engraved form in his report, with De La Rue more properly standing next to Airy.[25]

Figure 9

The eclipse expedition party, with local people, at De La Rue's observing site

De La Rue is the figure lying in the centre. The Astronomer Royal, Airy, is standing with the telescope. In the background can be seen the portable photographic darkroom, covered with wetted sailcloth to keep it cool in the heat of Spain.

By courtesy of the Royal Astronomical Society. (R.A.S. ADD MS 146 f 5r).

Initial results

De La Rue was clearly delighted with the photographs. He hurriedly penned a note to Airy, who had set up his observing site at the village of Pobes, saying:

> " My dear Sir
>
> I have the pleasure to say that my success is complete - The light of the red flames was very intense and if I had known it I could have obtained an instantaneous picture - The red flames belong to the Sun & in my opinion the corona is a consequence of their light.
>
> I have two photographs of the red flames imperfect only from the going of the clock.
>
> I consider my success complete in all respects - but I did not note the time of totality.
>
> Yours Very Sincerely
>
> Warren De La Rue" [26]

The next day *The Times* published a telegram from "… one of the party who left England to observe the complete obscuration of the sun":

> " The success was complete. We have two photographs of the red flames, which prove they belong to the sun, and many photographs of other phases." [27]

This initial exuberance was followed by a long letter describing the observations, published in *The Times* of 9 August 1860, and reprinted in the *Photographic Journal* of 15 August.[28] De La Rue's pride in his accomplishment shines through these communications. However, although considerable detail was given, including the photographic method and detailed descriptions of the prominences, he did not provide a summary of his conclusions. That was to await his lengthier report to the Royal Society.

The return voyage was delayed by a few days, because of a "Fiesta de Toros". The expedition embarked on the *Himalaya* on the 26 July. The voyage was enlivened by the fact that it was the Astronomer Royal's birthday on the 27 July, and the vessel arrived at Portsmouth at 4.00 p.m. on Saturday, the 28 July.[29]

Report to The Royal Society

The detailed analysis of the photographs, and the preparation of the major report on them, took a long time, and much correspondence between Airy and De La Rue, not least on the subject of the cost of reprinting the photographs.[30] The report finally appeared in the *Philosophical Transactions* in1862. It runs to no less than 84 pages, plus 18 plates and colour reproductions of De La Rue's scales to determine the colour of the prominences.

De La Rue went to painstaking lengths in the measurement of the photographs. He had a measuring instrument constructed by Troughton and Simms [31], and declared that:

> "… every spare moment has been devoted to the final accomplishment of this work; and, taking into account the interruptions I am subject to, I feel convinced that it could not have been done in less time, although I candidly confess that the delay in sending in this Report must appear scarcely warranted." [32]

The Report goes into considerable detail on the determination of longitude and latitude of the observing site, the comparisons between the various chronometers, his observational techniques, the evaluation of any contraction in the collodion during drying, the description and measurement of the prominences, and the considerable calculations involved.

In this his approach to scientific recording was exemplary. He clearly recognised the importance of his findings, and the effort he expended on them is evidence that he foresaw that this was perhaps his greatest opportunity to establish his place firmly in the history of scientific accomplishment.

Although he went to great lengths to determine the times of first and last contact, and the total duration of the eclipse, interestingly he omitted to record the times or duration of totality. This was, apparently, not accidental. Indeed, he says:

> " I had given instructions that no attempt was to be made to note the precise epoch of total obscuration; for each operator had too much to occupy his attention to admit of any work being done which was not absolutely essential to the photographic operations." [33]

His refusal to be side-tracked into making observations not central to his main purpose, and his concentration on obtaining telescopic and photographic observations of the prominences, paid off. As he says in his report:

> " The main object of the observations of the total eclipse of 1860 was to ascertain whether the luminous prominences are objective phenomena belonging to the sun, or whether they are merely subsidiary phenomena, produced by some action of the moon's edge on light emanating originally from the sun." [34]

He reasoned that if they belonged to the Sun then, as the Moon moved across the Sun's disc they would continually change their positions with respect to the centre of the Moon's disc. He therefore took great care in measuring the positions of the prominences shown in the totality photographs.

Also, if the prominences are purely solar phenomena, then photographs of them taken from different locations should accord. He obtained copies of photographs of the eclipse taken by a team led by Father Angelo Secchi at Desierto de las Pal-

mas, which was south of the central line of totality (De La Rue was north of it). He enlarged them to the same size as his own (9 inches diameter), and, although they were not of such good quality, he compared the distances between pairs of prominences. It was not until November 1882, however, during a visit to Rome to see Father Secchi (who had visited De La Rue's observatory four years earlier[35]), that he was able to examine directly a high-quality photograph and carry out detailed comparisons.[36] In a 1864 appendix to his 1862 report he stated that, after allowing for parallax, they:

> "… accord in their most minute details. The photographs must, from the difference of position of the two stations, have been made at an absolute interval of about seven minutes; and this fact, while it strongly supports the conclusion that the protruberances belong to the sun, at the same time shows that there is no change in their form during an interval much greater than the whole duration of an eclipse." [37]

De La Rue's later work

With his position as a serious and accomplished scientist firmly established, Warren De La Rue continued to play a significant part in Victorian business and astronomy, in England and in international circles. He continued researches on electrical discharges and silver chloride batteries. There is evidence that his long history of solar observation caused him some eye problems. Indeed, for some years he gave up solar observation, but expressed surprise and delight when he regained perfect vision in later years.[38]

After the eclipse the photoheliograph was returned to the King's Observatory at Kew, and was used under De La Rue's direction for an entire sunspot cycle of 11 years, producing what was at that time the longest detailed photographic record of solar activity. De La Rue continued his observations with his 13-inch reflector, which by now had become a celebrated instrument, and which he modified for solar photography by replacing the solid tube with a skeleton one.[39] In 1873 he discontinued observations, and presented his telescope to Oxford University, which used it to develop the University Observatory into one appropriate for a major university.

His post-eclipse years were marked by successful management of the De La Rue Press, of which he was Chairman until 1880. He was President of the Royal Astronomical Society (1864-6), and twice President of the Chemical Society (1867-9 and 1879-80). For his work on the eclipse and his contributions to astronomical photography he was awarded the Gold Medal by the Royal Astronomical Society (1862) and the Royal Medal by the Royal Society (1864). He was awarded an honorary D.C.L. by Oxford University in 1870.

The solar corona and Paul Jacob Naftel

While Warren De La Rue's observations had resolved the controversy as to whether the prominences emanated from the Sun or the Moon, interest amongst astronomers in the years following the eclipse of 1860 turned to the nature of the solar corona and an explanation of the appearance of the Earth's atmosphere during an eclipse.

De La Rue himself had observed that the light of the atmosphere was similar to twilight, that he was able to distinguish the colours of nearby objects:

> "… but those in the distance appeared to be illuminated by the most unearthly hues. Immediately surrounding the corona, the sky had an indigo tint, which extended to within about thirty or twenty-five degrees of the horizon, while lower down it appeared to me to be modified by a tinge of sepia. It became red as it approached the horizon, close to which, and just above the mountains, it was of a brilliant orange. The mountains appeared, by contrast, of an intensely dark yet brilliant blue." [40]

De La Rue's account is a good example of the many anecdotal accounts of these phenomena. But there had been no systematic study of them, and there was, therefore, no agreement as to their nature. This is where his fellow Guernseyman Paul Jacob Naftel came to play a rôle.

Naftel came from a family of Guernsey clockmakers. The clock faces were painted with decorations, often scenes of rural life. So it is probable that the family were minor artists. Indeed, Paul's father had a shop in St Peter Port, which sold, not only clocks and watches, but also artists' materials. Paul soon found an aptitude for art, was appointed drawing master at the local public school, gave private lessons, and added a studio onto the side of his house.[41] His many watercolours of Guernsey and Sark are of high quality, and were, and still are, much sought after by collectors. In the collections of the R.A.S. there exists a painting by Naftel of the solar eclipse of 1870, observed from Spain. [42] In 1999 an almost identical painting by him came into my possession. This stimulated me to carry out some research into the origins of these paintings and the circumstances of the expedition which Naftel was on.

How did a successful Guernsey painter come to be present at a total solar eclipse in Spain in December 1870? That was a seminal year in Naftel's life. His father died in July, and by the end of the year he had moved to London. He was 53

years old, and had long been a member of the Old Watercolour Society. He was already exhibiting regularly in London, where he had good friends, and where his work was clearly well regarded. Indeed, Alfred, Lord Tennyson appears to have owned one of his paintings.

Planning had been underway for some time for official expeditions to observe the total solar eclipse in Spain and North Africa, which was to take place on 22 December 1870. Three of the expeditions were to travel together, to Cadiz, Gibraltar and Oran, and it was on the Cadiz expedition, led by the experienced eclipse researcher Father Stephen Perry S.J., that Naftel was invited to participate as an artist. 'It seems to have been reasonably common practice to invite artists to accompany eclipse expeditions to use their illustrative skills to record the general *ambience;* for example the painter Joseph Bonomi went on the expedition to Spain for the event of 18 July 1860, his notebook being preserved in the R.A.S. Archives. [43]

I have not been able to determine the circumstances of Naftel's invitation to join the eclipse expedition. A clue may, however, be found in the *Monthly Notices of the Royal Astronomical Society* earlier in the year, when Richard A. Proctor (1837–1888) proposed that special attention be paid to the visual appearance of the forthcoming eclipse, in order to resolve the nature of the solar corona.

There was also interest in observations of the colours of the sky near the horizon, and some debate as to whether these colours of red and orange, for example, so vividly described by De La Rue, were of terrestrial origin, or whether they were caused by the solar chromosphere.

> " Are observers to be found [Proctor said] who, supposing the circumstances of the coming eclipse to be favourable, will be ready to forego the opportunity of witnessing one of the grandest of all natural phenomena, of watching the gathering shadows, of beholding the wonderful transport of the face of nature, the weird and unearthly aspect of all things around them and the strange beauty of the solar corona of glory, in order that they may devote all their observing energies during two short minutes to important, but severally uninteresting, phenomena? We know that, so far as the period of totality is concerned, such a sacrifice has already been made by De Le Rue and Tennant, by Secchi, Janssen, Herschel, Young, and a number of other lovers of science, but no observer has yet foregone the whole spectacle of a total eclipse for the sake of the dull, dry details of scientific observation." [44]

Who could be better to carry out these visual observations than a non-scientist – a landscape painter skilled in observing atmospheric colour and terrestrial illumination?

I have found no evidence of communication between De La Rue and Naftel, even though they were exact contemporaries, both Guernsey-born, both lived in London, and both observed solar eclipses in Spain, albeit ten years apart. I feel sure, however, that they must have known of each other's existence. Indeed, it is possible that De La Rue might have recommended Naftel to the R.A.S.

There are several interesting coincidences connecting the two expeditions. The 3-inch refractor used by De La Rue was used in Oran in 1870, and travelled out on the same ship as Naftel. Father Perry, who led the 1870 expedition, had travelled with De La Rue to Spain ten years earlier. In fact, in a photograph taken on board the *Himalaya* he was standing next to De La Rue. A tenuous link is provided by letters from De La Rue to Professor Charles A. Young (1834–1908) of Princeton, inviting him to dinner in January 1871, just a month after the eclipse, thanking him for two pamphlets, and expressing his and his family's "… very great pleasure in making your acquaintance which we hope will be renewed on your next visit to England." [45] Young had headed a large American contingent, observing the eclipse from the same location as that chosen by Naftel, and carried out historically important spectroscopic observations of the chromosphere, observing the reversing layer or "flash spectrum" in detail. His eclipse report states that "… several English gentlemen joined us in general observations and in making sketches and drawings of the corona." [46]

The expedition parties embarked in *H.M.S. Urgent* (Figure 10), leaving Portsmouth in early December. The winter journey was not as pleasant as the summer one of the *Himalaya* ten years earlier. The voyage out was anything but smooth.

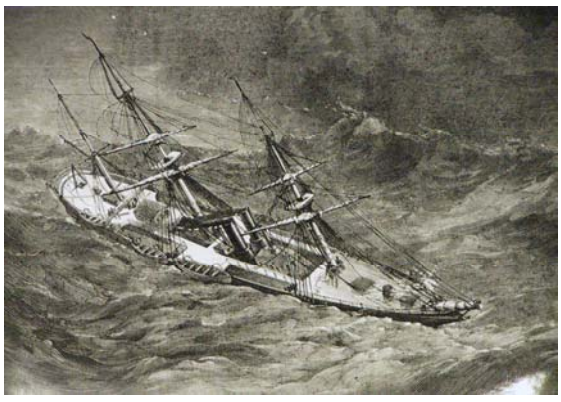

Figure 10

***H.M.S. Urgent* in heavy seas**

From a drawing in a manuscript notebook kept by Captain William Noble during the solar eclipse expedition to Oran, led by Dr William Huggins. (R.A.S. ADD MS 145)

By courtesy of the Royal Astronomical Society.

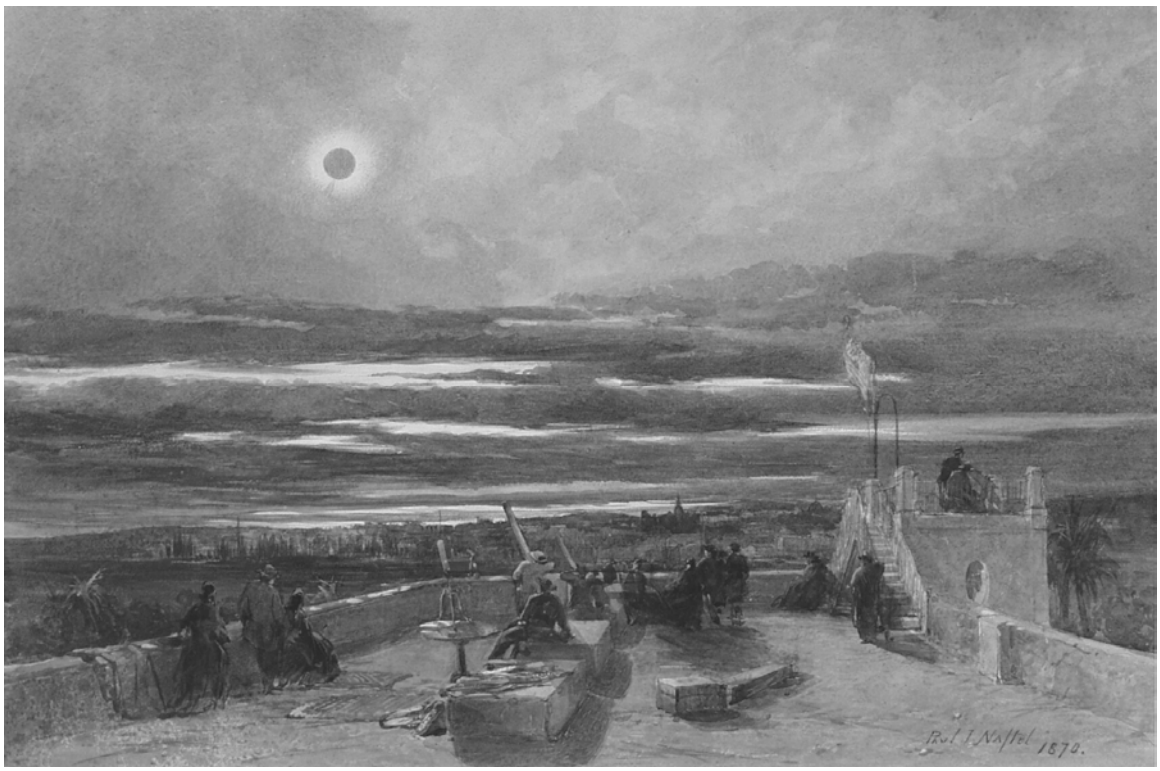

Figure 11

Painting by Naftel's of the total solar eclipse of 22 December 1870

Old Glory can be seen flying the right way up!

Author's collection.

They ran into very bad weather, crockery was smashed, and the sternpost was lost. They held a sweep-stake about the hour at which the vessel would drop anchor at Cadiz, but when they got there they discovered that they were not at Cadiz after all, so they had to spend an extra night on board, arriving on the 13 December, the sweep-stake of £3 15s being won by Captain Parsons.[47]

Up to the day of the eclipse the weather was not good, with general cloud cover. Perry decided to spread his party out across southern Spain, in the hope that some would be able to see the eclipse. Naftel was visiting an artist friend, Mr Gordon, in Jerez, and Perry agreed that he should stay there, just outside the town, on the centre line, where an expedition led by Lord Lindsay, who had travelled out separately, was based. Perry's report states:

> " At Jerez Mr Abbey was to observe with a two prism spectroscope belonging to Prof. Young; Mr Penrose to sketch the corona as seen through a telescope; & Mr Naftel to take an eye sketch of the corona, noting as well any changes of colours that might steal over the landscape during the progress of the eclipse." [48]

Naftel joined some of the American party on the roof of a villa, having uninterrupted views. Naftel's own account of the eclipse states:

"… we awaited the great event provided with every kind of material for recording the impending changes that might occur.

The morning of the 22nd was dull threatening rain. The Americans could only continue to hoist their flag half mast high, moreover upside down and all the party were as dull and miserable an aspect as the day. About half past ten the sky became brighter though no sunshine appeared & the Americans at last managed to right their flag and I proceeded to make the following observations without the aid of any instruments. From the first second of contact I watched with all the attention I could command for any change in the effect on the landscape & sky.

The sky might then be described as dull, not particularly dark and with small light clouds passing rapidly across, the general tone being inclined to violet grey. No change took place till within a few seconds of totality when the light very sensibly lessened. At the first moment of totality sudden darkness came on – dark purple clouds appeared on the horizon with streaks of bright orange between them. The distant town of Xeres from white became a dark rich hue and the lights & shadows on our housetop were such as would be produced by and about equal to a pale moon light, but of a much warmer tone - The Corona was radiating and not perfectly circular and varied as totality progressed never symmetrical and much too

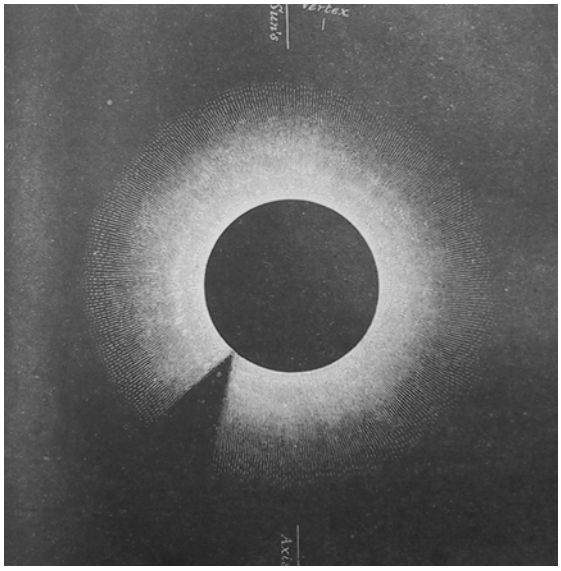

Figure 12

Drawing by Naftel of the eclipsed Sun

This image is reproduced from: A.C. Reynolds. 'Observations made during Total Solar Eclipses.' *Memoirs of the Royal Astronomical Society*. 1879, 41, 1-792 plus 17 Plates. Page 629.
By courtesy of the Royal Astronomical Society.

> vague to enable to describe by a line, excepting where a curved opening on the left hand lower limb of the moon occurred, as shown in the drawing.
>
> The colour of the Corona was warm white and I would perceive nothing approaching a defined edge to the bright light immediately around the moon - it simply became less light as the distance increased from the moon, though the contrast of the dark moon with the brightest part of the corona might induce a less practiced observer to call it a ring of light. **The drawing I send with this was painted immediately after, and is as true in colour & general effect as anything I ever did.** [emphasis added] [Figure 11]
>
> Totality ended by a sudden flash of light on the upper right hand limb of the moon - the dark purple clouds were no longer to be seen, the golden streaks disappeared, and I felt I had seen all that I should ever see of the Eclipse . . .". [49]

Despite the professed accuracy of the scene, the painting demonstrates that Naftel exaggerated the size of the eclipsed Sun, as do many such depictions. He made a separate, enlarged drawing of the eclipsed Sun, emphasising the V-shaped coronal gap visible in his painting (Figure 12). Although he remarked at the non-symmetry of the corona, its evident symmetrical appearance is typical of a Sun at solar maximum. Indeed, solar activity was high at the time of the eclipse, just as it was in 1860.

This eclipse was the subject of intense international interest, and expeditions were mounted from far and wide. The veteran French eclipse chaser and spectroscopist, Janssen, went to such lengths to observe it as to escape, in a balloon, from a Paris besieged by the Prussians, with vital parts of a reflecting telescope specially designed to observe the corona. He made it to Oran, where, in Agnes Clerke's account, he found himself "… *shut behind a cloud curtain more impervious than the Prussian lines*." [50] Norman Lockyer, the founder of the science journal *Nature* and discoverer of the element helium, was shipwrecked on his way to Syracuse in *H.M.S. Psyche*; he spoke in defence of her Officers at the subsequent court martial. However, he did eventually reach Sicily, where he briefly saw the eclipse. Other observers in Sicily were more fortunate: Mr Brothers made many observations, and conditions were good enough for the elusive shadow bands to be observed clearly.

Naftel went on to paint a number of landscapes in Spain and Italy, but those of the 1870 eclipse are his only ones having an astronomical theme. Although I have not located an explicit commission for the R.A.S. painting (Figure 13), it seems clear that it was expected as a result of his participation in the expedition, and that he took advantage of it to sell copies. In a letter of 14 February 1871 to the Secretary of the Society, which included his descriptions of the eclipse, he said:

> "I am afraid they are of little value unaccompanied by the drawing alluded to. My excuse for not sending the drawing is that I have two commissions for it, and had not yet had time to repeat the original but if you require it for an especial evening I shall be most happy to lend it for the occasion." [51]

Detailed observations such as Naftel's and others revealed that the corona is the Sun's outer atmosphere, and the appearance of the sky during a solar eclipse is due to terrestrial atmospheric effects, rather than the solar chromosphere.

Figure 13

Painting by Naftel of the eclipsed Sun

This painting belongs to the Royal Astronomical Society. In all but detail it is the same as the painting belonging to the author.
By courtesy of the Royal Astronomical Society.

There have been many examples throughout recorded history of the arts contributing to science, and *vice-versa*. As a Guernseyman I am pleased that two of my 19th century compatriots made scientific contributions to our understanding of the Sun: one, a Victorian amateur astronomer of considerable merit, by observing photographically the nature of the solar prominences during the eclipse of 1860; the other, a Victorian professional artist, of equal merit in his field, contributing through his artistic skills to the scientific understanding of the nature of the solar corona.

I strongly believe that Warren De La Rue's contributions to astronomy, chemistry, electricity, physics, printing, and particularly to the development of astronomical photography, are deserving of much further merit than they have heretofore been granted. My researches into his life therefore continue, and an in-depth account is planned for a future issue of *The Antiquarian Astronomer*.

Acknowledgements

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