The 8¼-inch Clark refractor of the Temple Observatory, Rugby

R. A. Marriott

During the 1850s W. R. Dawes purchased five object glasses from the American opticians Alvan Clark & Sons. The only one to have been in continuous use since then was the last of them, in a complete 8¼-inch refractor.

The founding of Alvan Clark & Sons

In 1844 George Bassett Clark, a young student from Cambridgeport, Massachussetts, decided to cast and figure a small telescope mirror, an account of which he had found during his studies for a career in civil engineering. His father, Alvan Clark, a well-established portrait painter, decided to help, and eventually made several mirrors himself. In 1846 he began grinding and figuring lenses, a venture in which he was later to be joined by George and by his younger son Alvan Graham. In the course of time their name was to become synonymous with the world's largest and finest refractors.[1]

When the Clarks began their business in the early 1850s[2] the largest refractors in the USA were a 5-inch Dollond at Yale University, a 6-inch Lerebours at Wesleyan University, Middletown, Connecticut and an 11-inch Merz und Mahler at Cincinatti Observatory. In 1847 a 15-inch Merz was installed at Harvard College Observatory, and hearing of its exceptional performance Clark obtained Bond's permission to look through it.[3] By then he knew enough to be able to locate the errors of figure at first sight, 'yet these errors were very small, just enough to leave me in full possession of all the hope and courage needed to give me a start, especially when informed that this object-glass alone cost $12,000.'[4] With this incentive, and with an awareness of his country's need of a first-rate optician, Clark thereafter applied himself to making lenses, eventually completing several which he knew by his tests were at least as good as those made in Europe. But although he managed to sell a few the venture was commercially unsuccessful, the quality and importance of his work attained limited recognition, and he had little choice but to look to Europe for further patronage.

A valued customer

In 1851 Clark wrote to William Rutter Dawes at Wateringbury, near Maidstone, about the close double stars he had observed with his own 4¾- and 5¼-inch lenses. This choice of contact was probably not made at random, as by then Dawes already had an international reputation, especially in the field of double star measurement. In 1852 Clark reported his discovery of two new double stars,[5] and further correspondence served only to add to Dawes' insatiable enthusiasm. The following year Clark completed a 7½-inch f/15 OG, and at his request Dawes sent him some difficult tests. These were selected from Otto Struve's *Pulkova Catalogue*,[6] several of them having 'a central distance of little more than half a second, and some even less. Yet of all these I soon received from the ingenious maker (who has also proved himself an acute observer) perfectly correct diagrams; together with the places of one or two extremely difficult new double stars which he had discovered with this glass.'[7]

Although Clark had intended to keep the 7½-inch he consented to let Dawes try it against his 6⅓-inch Merz (acquired in 1847), and in March 1854 it arrived at Wateringbury with its tube, finder and eyepieces, to be tested by Dawes in his characteristically thorough manner. 'Though the crown glass has a considerable number of bubbles,' Dawes wrote, 'the performance of the telescope is not sensibly affected by that circumstance. In other respects the materials are good; and the figure is so excellent, and so uniform throughout the whole of the area, that its power is quite equal to anything which can be expected of the aperture; and, consequently, both in its illuminating and separating power, it is decidedly superior to my old favourite of 6⅓ inches aperture.'[8] Clark never saw it again, as he reluctantly sold it to Dawes for $950 – about £200, a considerable sum at that time.[9]

On acquiring the 7½-inch OG and tube, Dawes placed it on his Merz mounting and, two years later (1856), sold the OG to Frederick Brodie,[10] although he retained the tube and accessories. Brodie then fitted it into his own telescope, replacing a 6⅓-inch Merz OG, which he sold to Sir William Keith Murray, and, in 1859, sold the complete instrument to Charles Leeson Prince, who had a new tube and mount made by Cooke. Ten years later the OG passed to Wentworth Erck of Bray, near Dublin, who constructed his own tube, mount and observatory.[11] After Erck's death in 1890, the telescope was acquired by Sir Howard Grubb who, after advertising it,[12] sold it to William H. S. Monck, of Dublin. In 1912 Monck presented it to Queen's College (now Queen's University) Belfast,[13] since when it has disappeared.[14]

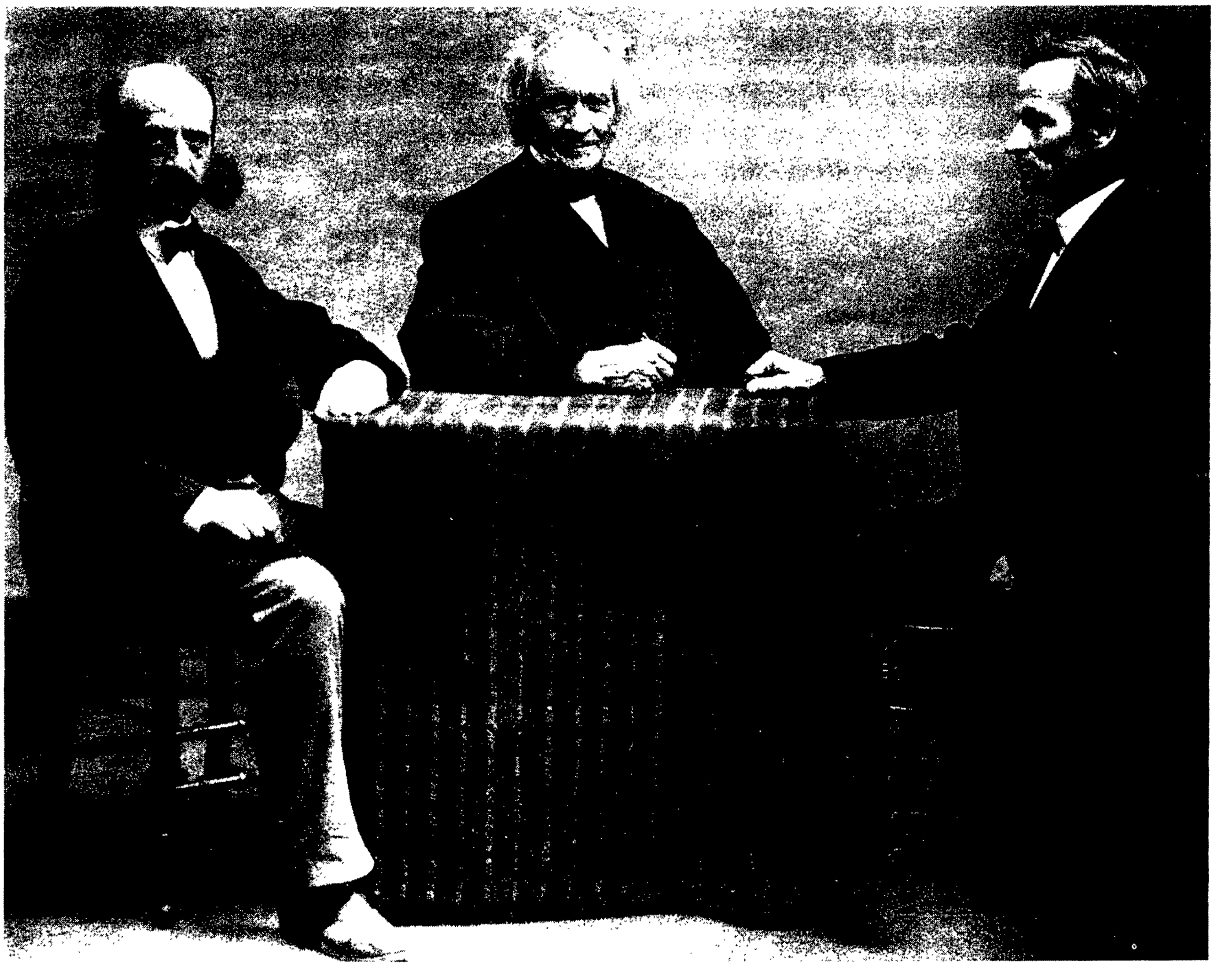

Figure 1. Alvan Graham Clark, Alvan Clark and George Bassett Clark. (Lick Observatory archives.)

Towards the end of 1855, Clark sent over an 8-inch OG, for which Dawes paid £200. It was 'a remarkably clear and sharp definer,' Dawes wrote, 'and has afforded me some of the finest views of Saturn I have ever enjoyed.'[15] However, its 120-inch focal length was inconveniently great for his dome and, in 1857, he sold it for the price he had paid for it to William Huggins. The following year Huggins had it mounted by Thomas Cooke, and during the 1860s used it for much of his pioneering spectroscopic work. In 1868 he sold the complete instrument to Charles J. Corbett of Thames Ditton, Surrey.

Around September 1857 Dawes asked Clark to supply a 7-inch OG with tube, although when it was delivered a few months later it proved to be a 7$\frac{1}{2}$-inch f/15. It was then attached to the Merz mounting in place of the 6$\frac{1}{3}$-inch Merz OG and tube – which were afterwards sold – and the following April was offered complete to George Knott, with whom Dawes had been corresponding for several months, and who was just beginning an astronomical career in which he was to become distinguished as an observer of double and variable stars. 'I can truly say that I never used any telescope with more uniform pleasure,' Dawes told him.[16] In May 1859 Knott bought the instrument for £400, and in the following March was also supplied with a mahogany observing chair[17] for £7 and a Dollond spherical crystal micrometer for 7 guineas (£7.35). These he used until his death in 1894. Some time later the OG passed to Stonyhurst College Observatory, to join a 5$\frac{1}{2}$-inch Clark OG acquired in 1886, but originally bought by Thomas W. Webb in 1859.

After the sale of the 8-inch OG to Huggins, Dawes placed an order for another of the same aperture but of shorter focus. Clark obtained the blanks from James Chance of Birmingham, and had to pay 30% duty at Boston; not only that, 'the glass was warranted first quality, and when I informed the deputy collector that a large portion of the amount in invoice was in consideration of the warranty and asked him if any allowance would be made in case it turned out worthless, he said "No, not a cent, if you buy the devil you may sell him again." The crown *did* turn out defective [he dropped and broke it], and I had to import another and pay 30% again.'[18] In the meantime he found another pair of suitable blanks in New York. From these he figured an 8-inch OG and, from the second pair of Chance blanks, an 8$\frac{1}{4}$-inch.

Figure 2. W. R. Dawes, photographed by William Huggins around 1865. (RAS archives.)

A visit, recognition, and the 8¼-inch

Despite the lack of personal contact there was obviously a great rapport between the two men. Indeed, Clark had painted a miniature portrait of Dawes based on a daguerrotype, and it was perhaps inevitable that he should accept an invitation to visit England. In May 1859 he arrived at Haddenham, near Aylesbury (to where Dawes had moved in 1856), bringing with him the 8- and 8¼-inch OGs, a tube large enough for either, and a mounting (Fig. 3) which Dawes had ordered after hearing of the efficiency of Clark's new clock drive on the Harvard equatorial. Dawes recorded the visit in his journal:[19]

'May 20. This day Alvan Clark arrived from Liverpool where he has been with Mr Lassell at Bradstones, since the 14th, after a remarkably smooth and agreeable passage from Boston, whence he sailed on the 4th. I met him at Aylesbury; and on my way I met the wagon bringing the new equatoreal, which arrived during my absence and was safely lodged in the coach house.

May 21. Engaged all day, with Alvan Clark's help, in taking down the Munich equatoreal mounting, and the 7¼ in. (more properly 7⅓ in.) which AC made for it. Got it almost all packed by evening.

May 24. AC and I began putting up the new equatl., the stone pier having been prepared for it yesterday and this morning.

May 25. Finished putting up the equatoreal; and put in the 8-inch OG. There is also an 8¼-inch, which is the one made out of Chance's glass and designed for me.

May 26. Turned the 8 inch onto the sun with my solar eyepiece,[20] and showed AC some spots. He said he had never seen the spots in such perfection before, having never before used the whole aperture of a large OG.'

The mounting, designed by Clark, was a cradle which obviated the need to reverse the instrument when passing the meridian, the action of the pendulum on the wheel-work, Dawes wrote, being 'rendered smooth and equable by an ingenious application of Bond's Spring-governor[21]; and so perfectly successful is this contrivance, that with the thread of the micrometer bisecting a star, and a power of 800 or 1000 on the telescope, no interruption or jerk from the escapement is perceivable,' the figure of the 8¼-inch being 'excellent to the circumference, and the dispersion but little over-corrected. Its performance fully supports the character of Mr Alvan Clark's object-glasses, and I believe it to be capable of everything which can be performed by such an aperture.'[22] It was of such fine definition that it 'effected the discovery of several excessively delicate double stars which had escaped the close scrutiny of the Struves with the Dorpat telescope of 9.6 inches aperture and the Poulkowa of 15 inches.'[23] Both OGs were thoroughly tested, and before leaving at the end of July Clark had discovered five new double stars with them.[24]

Dawes could not decide on which glass to purchase, and therefore had both, for which he paid $1600. He kept the 8¼-inch for himself, but was, as he told Knott,

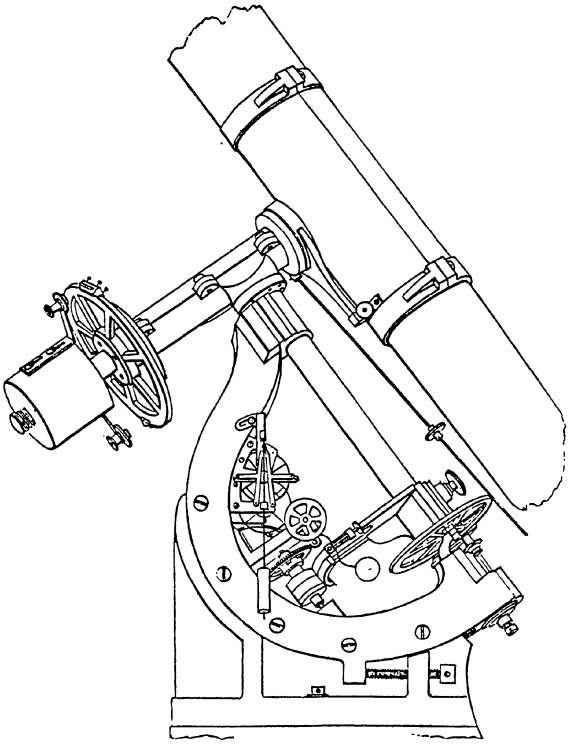

Figure 3. The first mount for the 8¼-inch, made in 1859.

Figure 4. G. M. Seabroke. BAA Presidential portrait, 1900.

'anxious to get the 8-inch into thoroughly good hands – such as would *work it*, and *not* place its splendid light 'under a bushel'. Do you know of any observer worthy of it? The cost is £180.'[25]

During Clark's visit Dawes accompanied him to London, 'specially to take care of him lest he should utterly lose himself in this interminable city, and to help him see what may be seen in a week.'[26] On June 4 they visited the Royal Observatory, Greenwich, and on June 10 attended the meeting of the Royal Astronomical Society, at which Clark exhibited and described his newly-invented double-eyepiece micrometer.[27] In those few days he was introduced to many eminent astronomers, including Sir John Herschel, Lord Rosse and G. B. Airy. With such influential contacts, and with Dawes' frequent reports of observations made with his instruments, Clark's reputation quickly spread throughout Europe and back to America, and on his return home he was inundated with orders. Thereafter he and his sons became firmly established in their business.[28] His indebtedness to Dawes is evident in a letter to J. M. Wilson, of Rugby, written some twelve years later: '[Dawes] was cordial and sympathizing beyond what I could have reasonably expected ... To within a few weeks of his death [on 1868 February 15] I had written him more letters than I have ever written to any other fellow mortal, all of which were answered, some at great length, in the most affectionate terms; beside, in 1862, after the settlement for the last work I sent him, the amount I had received from him in money was greater than I had ever received from any other individual in all my transactions with mankind. Such material aid, at the time, was of great importance to me, but his published opinion, relative to the ability and faithfulness with which I was executing my work, was, as time has proved, of the greater.'[29]

In 1860 Dawes sold the 8-inch OG, with the tube, mount and eyepieces, for £500, to 'a gentleman who wished to have a large telescope ... [It] is taken down and is now far away.'[30] This left him without a mount for the $8\frac{1}{4}$-inch and he therefore ordered another from Clark, who complied with his request 'to throw all the expense into the perfection of the working parts, all others being painted of a neat stone colour, the total expense being much diminished and the deterioration of the instrument in great measure prevented.'[31] It cost $1200, and was delivered a few months later. The resulting instrument was used chiefly for double star measures and planetary observations, and less than four years later was replaced with an 8-inch Cooke.[32]

In December 1863 Dawes advertised the complete $8\frac{1}{4}$-inch for sale[33] and, in the following June, received an enquiry from an old college friend of James Chance, the Rev. H. E. Lowe of Atherstone, who subsequently purchased the instrument and its accessories, including a Dollond filar micrometer. Lowe immediately replaced Clark's drive with a new drive by Thomas Cooke, but afterwards refitted Clark's drive, as 'perfect as one has been taught to consider Cooke's mountings to be, the Alvan Clarke [sic] clockwork was pronounced to take decided preference over that by which the York maker replaced it.'[34] But Lowe was only a casual observer, and in 1870 he decided to sell the telescope and all its accessories, together with a wooden observatory which he had built for it. His offer was taken up by George Mitchell Seabroke, of Rugby (Fig. 4).

The Temple Observatory

In 1863, Seabroke, then aged fifteen, entered Rugby School. He was particularly keen on science, and delighted in carrying out experiments, even connecting the handles of his study door to an electricity supply to discourage intruders. But astronomy held the greatest interest for him, and observations were carried out with his housemaster James M. Wilson, who taught mathematics and natural science. In 1866 Seabroke left school to become a solicitor, but his involvement with the school and with astronomy lasted for the rest of his life.

When Lowe decided to sell his equipment Seabroke introduced him to Wilson, who could not resist the opportunity of acquiring such an instrument. However, Wilson first sought the advice of G. B. Airy, who assured him that 'any telescope which was used and approved for any length of time by Mr Dawes was a very good one,' but that the makers' prices for a

Figure 5. The original Temple Observatory, with Lowe's wooden observatory, in 1871. The figure in the foreground is probably J. M. Wilson. (Temple Observatory archive.)

Figure 6. The new Temple Observatory, soon after completion in 1877. The engraved plate in Crossley, Gledhill and Wilson's *Handbook of Double Stars* was taken directly from this photograph. (Temple Observatory archive.)

Figure 7. The Temple Observatory today.

Figure 8. The 8¼-inch as it is today.

complete 8¼-inch were 'not very accordant. Merz seems to be about £900. Steinheil, rather smaller glass, £700, say £800 for German prices. Loomis speaks of one 8¼-inch made at New York by Fitz, £458 [and] of a 7¼-inch instrument by Alvan Clark, £375. We think that Cooke's price for a complete 8-inch equatoreal is £600.'[35] He also wrote to Clark, who informed him that his price for a complete 8¼-inch was $2500.[29] In the event, Wilson paid £420 for Lowe's telescope, its accessories, the observatory (Fig. 5) and a small collection of books, and a few months later also received a surprising piece of advice: 'Mr Dallmeyer advised an occasional lubrication of the surface of the object glass with some oily application, and considered the rubbing with the fingers after having run them well through the hair of one's own head for the getting its 'Natural Grease' upon it, the best perhaps of all measures.'[36]

The observatory and equipment arrived at Rugby on 1871 March 10, and were erected in Wilson's garden without delay; by April 8 the final adjustments had been made. On the pedestal was affixed a silver plaque, inscribed HOC PERSPICILLUM. IN USUM DAWESII AB ALVANO CLARK ELABORATUM. SCHOLAE RUGBEIENSI, QUO COELI MIRACULA EXPLORENT, SCIENTIAM AUGEANT, EXERCEANT INGENIA, IN DEI GLORIAM. FREDERICO TEMPLE AUCTORE DD J. M. WILSON, AD MDCCCLXXI. The observatory was named after Frederick Temple, headmaster of Rugby from 1858 to 1869 (and later Bishop of Exeter). In 1866 Temple had expressed a strong wish that the school should possess a first-rate telescope, but an attempt to raise funds to buy one had to be abandoned because of the tercentenary celebrations in 1867. The wish was granted on 1873 April 30, when Wilson formally presented the telescope and observatory to the Governing Body of Rugby School.

But the refractor did not stand alone. Other instruments had already been acquired and, by 1875, the equipment consisted of the 8¼-inch Clark, a 12⅛-inch f/6.5 With reflector with a tube, mount and drive constructed by Seabroke (which in 1947 was sold for £15 to buy paint), a 15-inch reflector, a heliostat, a 12-inch mirror and a 12-inch plane for a siderostat, a 3½-inch refractor, a 2½-inch f/12 transit instrument, several spectroscopes, a Dollond micrometer (Fig. 10), a sextant, a theodolite, and a mean and sidereal clock by Cooke and Sons.

Lowe's wooden observatory, however, was unsatisfactory. It was damp and draughty, and it warped. After a constant hope that a new site could be found, the Governing Body purchased a piece of land in 1876, and the new observatory and curator's house, designed by Wilson and Seabroke, were completed by October 1877 (Fig. 6). The total cost was £1234, the observatory itself costing £468. The old observatory was taken

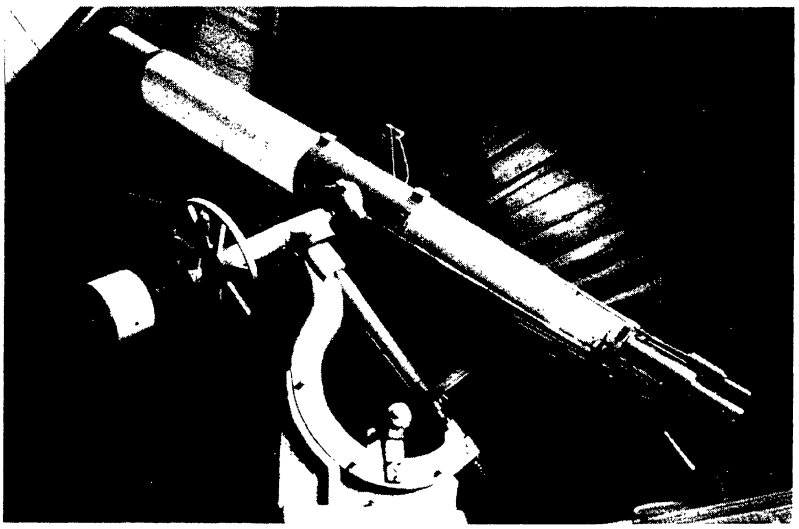

Figure 9. The 8¼-inch as it is today. The changes can be seen by comparing this photograph with Fig. 3

down during the last week of June, and everything was installed in the new observatory by October 26. The rules for its use, finalised on October 17, included the rather alarming edict that the sub-curator should be responsible for 'lighting fires in the Observatory when requisite.'

Achievements

During its first few years, Wilson and Seabroke elevated the Temple Observatory to a position which ranked with the world's foremost professional institutions, correspondence and observations being exchanged with such eminent figures as S. W. Burnham, Otto Struve, Ormond Stone and John Couch Adams. The With reflector and the heliostat were used to carry out an intense programme of visual and spectroscopic observations of the Sun – much of it in conjunction with J. Norman Lockyer[37] (who was born in Rugby) – and several papers were published in *Monthly Notices of the Royal Astronomical Society* and in *Proceedings of the Royal Society*, some of which were cited by George Ellery Hale in his B.S. thesis at M.I.T. in 1890. In 1876 regular solar observation was discontinued, chiefly because in 1874 Greenwich Observatory had begun daily solar photography.

The Clark was employed mainly for double star work, which began in 1871, the first catalogue of measures being published in 1875.[38] Wilson's impressions of the instrument seem understated: 'We have every reason to be content with its performance. On very fine nights, which are unhappily of rare occurrence, it divides down to half a second or thereabouts, and the clock-work is thoroughly satisfactory. It has not been out of order for a day since we had it.'[39] From 1873 measures were carried out in collaboration with Joseph Gledhill, using Edward Crossley's $9\frac{1}{2}$-inch Cooke refractor at Bermerside, Halifax. Gledhill also published his first catalogue in 1875,[40] part of the original plan for these combined observations being 'to throw the complete results into the form of an Observatory Handbook, giving the names, synonyms, RA and Dec. (1880), magnitudes, and colours of the stars; also a short history of each binary, with complete lists of Measures.'[41] This idea came to fruition only four years later with the publication of Crossley, Gledhill and Wilson's *A Handbook of Double Stars, with a Catalogue of Twelve Hundred Double Stars and Extensive Lists of Measures*,[42] the first work of its kind.

By this time Wilson had become a much-respected astronomer. In 1874 he was elected onto the Council of the Royal Astronomical Society, and in 1878 was asked to stand as successor to Robert Main as Radcliffe Observer at Oxford. He declined this post, however, as he was so happy at Rugby, but with the sudden death of his wife in July 1878 he felt he had to move away. He therefore took over as headmaster at Clifton School, and became ordained.

Seabroke carried on at Rugby, and by 1910 had published another seven catalogues of double star measures.[43] Most of these measures were taken by himself, the rest by a number of masters and boys trained in observation. Both the Clark and the With were also used for stellar spectroscopy, especially for determining the motions of stars in the line of sight, a field in which at that time very little was being done. In 1885 E. W. Maunder wrote that 'with the honourable exception of the Temple Observatory, the work has been for many years absolutely restricted to Greenwich Observatory',[44] although this statement was something of an exaggeration.

When the Temple Observatory was founded it was decided that one of its functions should be the education of members of the school. Wilson and Seabroke therefore had to take classes during the evenings, at which attendance averaged about three hundred a year; and as they also had to carry on their daytime professions their own observing time was considerably cut down, most suitable nights being restricted to the hours from around 10 p.m. to midnight. Consequently the Clark was also used a great deal for planetary, lunar[45] and cometary work – notably Coggia's comet of 1874[46] – besides general viewing during visits by people unconnected with the school.

Epilogue

After the completion of the new observatory Seabroke was appointed honorary curator. In 1870 he had been elected a Fellow of the Royal Astronomical Society, and from 1894 to 1902 served on its Council. In 1890 he became a founder member of the British Astronomical Association, served on its first Council, was Director of the Double Star Section from 1892 to 1914 and of the Saturn Section from 1899 to 1912, and served as President from 1900 to 1902. Besides his astronomical work Seabroke also had a number of important civic duties. He was instrumental in the building of the Rugby water supply and the foundation of the Rugby

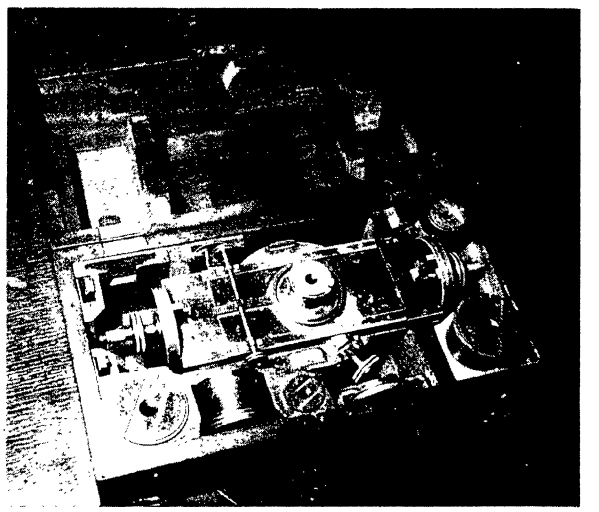

Figure 10. The Dollond micrometer, originally made for Dawes.

Volunteer Fire Brigade and the National Union of Fire Brigades. He was also an active member of the Rugby Volunteer Corps, on his retirement was made an Honorary Lieutenant-Colonel of the 2nd Royal Warwickshire Volunteer Company, and in early 1918 was appointed Deputy Lieutenant for the County of Warwickshire. He died on 1918 April 1, his 70th birthday. He had been determining instrument errors only the night before, and had thus kept company with the Clark for forty-seven years. Wilson eventually became Canon of Worcester, and died at an advanced age, respected both as astronomer and theologian, in 1934.

In later years the telescope was subject to a few modifications. A new clock drive installed in 1925 was replaced by an electric motor in 1964, and a new drawtube was also fitted; otherwise the instrument remains much the same as when it was made. It is still used, and can now lay claim to a scientific and educational record covering a period of more than 130 years.

Acknowledgements

Thanks are due to the following for permission to quote from manuscripts: J. D. S. McMenemy (past curator of the Temple Observatory), Peter Hingley (RAS librarian) and Alan J. Clark (Royal Society librarian).

Address: 24 Thirlestane Road, Far Cotton, Northampton NN4 9HD.

References and Notes

1 For a biographical account of the Clarks and a catalogue of their instruments, see Warner D. J., *Alvan Clark & Sons, Artists in Optics*, United States National Museum Bulletin 274, Washington, D.C., 1968.
2 There appears to be no record of the precise date. Alvan Graham Clark was still serving an apprenticeship when George Bassett Clark opened his shop in 1850, and Alvan Clark did not close down his portrait studio in Boston until 1860.
3 When the 15-inch was ready for use its work was held up for several weeks. It was paid for by public subscription, and the wealthy citizens of Boston were intent on seeing – and looking through – something which had cost them a great deal.
4 *Sidereal Messenger*, **8**, 113 (1889).
5 CMa 89 (A.C. 4) and 8 Sex (A.C. 5).
6 Published 1843; second, corrected edition 1850.
7 *Mon. Not. R. Astron. Soc.*, **15**, 79 (1855). One of these discoveries (A.C. 2) was the *comes* of 95 Ceti, then $\pm 0''.7$ separation. It was measured by Dawes the following year, but was not re-observed until 1878, when S. W. Burnham obtained negative results.
8 *Ibid.*, 80.
9 The relative value of this amount can be best appreciated by comparing it with contemporaneous property values. Dawes himself left an ideal record. In 1844 he ended his tenure as 'assistant' at George Bishop's observatory at South Villa, in the Regent's Park, London, and in January of that year sought the advice of Sir John Herschel in finding a country residence in the south-east, 'close to a village, and not too far from a town.' For himself, his wife and two servants he required 'a moderate-sized house ... three sitting rooms, containing each not less than about 250 square feet; five bedrooms, or four with a dressing-room or two; coach-house; 2-stall stable; good kitchen and convenient outhouses. This should be detached, with an acre or so of pleasure grounds and garden round it; and if a paddock of two or three acres contiguous, so much the better ... I should not wish to exceed £35 or £40 per annum, on lease of 7, 14 or 21 years, but should anything *very* desirable occur within £50, I would try to stretch so far.' (Letter dated 1844 January 13. Royal Society, Herschel papers HS 6.64). Within a few weeks he had moved to Camden Lodge, near Cranbrook, from whence he removed to Torquay in 1849 and Wateringbury in 1850.
10 See *Mon. Not. R. astron. Soc.*, **17**, 33 (1856), in which Brodie quotes a letter from Dawes describing the construction of Clark's tubes. Brodie, who lived in Eastbourne, was the uncle of the well-known amateur astronomer and author G. F. Chambers.
11 Described in *The Observatory*, **1**, 135 (1877).
12 The advertisement appeared as a separately printed slip tipped into the inside back cover of *J. Br. Astron. Assoc.*, **1** (5) (1891 February).
13 *The Observatory*, **35**, 349 (1912).
14 Dr Ian Elliott, of Dunsink Observatory, has made efforts to trace this instrument, but its whereabouts remains a mystery.
15 *Mem. R. Astron. Soc.*, **26**, 9 (1858).
16 Letter to Knott, 1859 February 26, in *The Observatory*, **33**, 347 (1910).
17 Dawes' observing chair is described in his penultimate paper in *Mon. Not. R. Astron. Soc.*, **28**, 9 (1867).
18 Ref. 4, 114.
19 RAS MSS Dawes 4.
20 For an account of this device see Marriott, R. A., *Dawes' Solar Eyepiece*, in *Bulletin of the Scientific Instrument Society*, **14**, 1 (1987).
21 Clark's application of Bond's spring governor is described and illustrated in Lockyer J. N., *Stargazing: Past and Present*, London, 1878, p. 319.
22 *Mon. Not. R. Astron. Soc.*, **20**, 60 (1859), in which the mount and the drive are described in detail.
23 Letter from Dawes to H. E. Lowe, 1864 June 20. Temple Observatory archive.
24 99 Her (A.C. 15), BAC 6959 (A.C. 17), 44 Cyg (A.C. 18), H I.48 (A.C. 19) and 75 Cyg B (A.C. 20).
25 Letter dated 1859 August 15, in *The Observatory*, **33**, 353 (1910).
26 Letter to Knott, 1859 June 9, *ibid.*, 349.
27 For a description of this micrometer see *Mon. Not. R. Astron. Soc.*, **19**, 324 (1859).
28 In 1860 F. A. P. Barnard ordered an 18½-inch refractor for the University of Mississippi, which because of the Civil War instead passed to the Dearborn Observatory of the old University of Chicago. Whilst testing this lens Alvan Graham Clark discovered the *comes* of Sirius.
29 Letter from Clark to Wilson, 1871 February 5. Temple Observatory archive.
30 Letter to Knott, 1860 November 19, in *The Observatory*, **33**, 386 (1910). The 'gentleman' may have been Nicholas Martindale who, before his marriage in 1863, had 'a very fine telescope by Alvan Clark' in his observatory in Liverpool. See obit. in *Mon. Not. R. Astron. Soc.*, **46**, 193 (1886).
31 Letter from Dawes to Lowe, 1864 June 20. Temple Observatory archive.
32 For the subsequent history of the 8-inch Cooke see McKim, R., and Marriott, R. A., *Dawes' Observations of Mars, 1864–65* in *J. Br. Astron. Assoc.*, **98** (6), 294 (1988).
33 *Mon. Not. R. Astron. Soc.*, **24**, 49 (1863).
34 Letter from Lowe to G. M. Seabroke, 1870 September 14. Temple Observatory archive.
35 Letter dated 1870 October 25. Temple Observatory archive.
36 Letter from Lowe to Wilson, 1871 July 14. Temple Observatory archive.
37 Lockyer was assisted by Seabroke in the writing of *Stargazing: Past and Present*. The description of Bond's spring governor (see ref. 21) is probably that of the 8½-inch.
38 *Mem. R. Astron. Soc.*, **42**, 59–100 (1875).
39 *Ibid.*, 60.
40 *Ibid.*, 101–127.
41 *Ibid.*, 101.
42 London, Macmillan, 1879.
43 *Mem. R. Astron. Soc.*, **43**, 105–128 (1877); **46**, 183–212 (1881); **48**, 195–224 (1884); **50**, 1–28 (1891); **51**, 267–276 (1895); **54**, 97–125 (1901); **59**, 291–301 (1910).
44 *The Observatory*, **8**, 170 (1885).
45 The Temple Observatory archive contains an early, if not the first, dry-plate photograph of the Moon, taken in 1872, a year after the introduction of dry gelatine silver-bromide plates.
46 *Mon. Not. R. Astron. Soc.*, **35**, 83 (1874).

Received 1990 May 24; accepted 1990 June 27