The life and legacy of G. H. With, 1827–1904

R. A. Marriott

The introduction of silver-on-glass mirrors in the mid-nineteenth century was an important advance in instrument design, providing greater opportunities for the amateur astronomer of modest means. One of the first exponents of the new technology was G. H. With.

Origins of silver-on-glass

From Newton's first reflecting telescope of 1668 until the mid-nineteenth century, telescope mirrors were made of speculum metal – an alloy of copper and tin. This was the best material available, but it tarnished after a relatively short time, the arsenic that was added to increase reflectivity further reduced the working life of the surface, and frequent repolishing was a necessity.[1]

Experiments in depositing metal films on speculum-metal mirrors and glass were attempted as early as the mid-eighteenth century, but for the following hundred years or so the process was used only for domestic or aesthetic purposes, culminating in examples of Victorian decorative extravagance such as those presented by Varnish & Mellish at the Great Exhibition of 1851. In 1855 the German chemist Justus von Liebig succeeded in refining the process to produce metallic surfaces fine enough for optical purposes, and yet did not apply his process to astronomical mirrors. This was a precedent set the following year by C. A. von Steinheil in Munich and J. B. L. Foucault in Paris, after which silver-on-glass mirrors became very popular and soon replaced metal specula. It was the optimum time for such an advance, as during the next few years pioneers such as Kirchhoff, Ångstrom, Huggins and Lockyer began their work in the new science of astrophysics, physical rather than positional astronomy became much more important, and periodicals such as *English Mechanic* and *Nature* were founded. These factors contributed to a considerable increase of interest in amateur astronomy, at a time when reasonably-priced telescopes became much more readily available. In England, one of the first to produce silver-on-glass mirrors for this growing market was G. H. With.

Figure 1. G. H. With *(Hereford City Library).*

Life and career

Born in London in 1827, George Henry With passed his boyhood and received his formative education in Chelsea, afterwards spending two years at St John's College, Battersea, training for the profession of schoolmaster. He subsequently became one of England's first Certified Masters – at a time when the education of the masses was in the hands of untrained and generally uneducated people – and obtained his first appointment at Alverstoke National School,[2] Gosport, where his abilities came to the attention of Richard Dawes,[3] rector of Kings Somborne. Dawes was one of the leading advocates for reform in the education of the lower and lower-middle classes, and in 1842 had founded several schools which under his personal management became a great success, Kings Somborne School being considered a model establishment. In 1850 he was appointed Dean of Hereford, and thereafter took great interest in the city's educational system, particularly the Blue Coat Schools.[4]

In 1851 the Mastership of the Blue Coat boys' school fell vacant, and With was one of forty-three applicants for the post, which offered a salary of £85 per annum and a house. He was then unknown in Hereford, but with Dawes' strong support he became one of the two final contestants, a surprising result which aroused widespread interest, as the other candidate, Henry Yapp, was sponsored by the Rev John Venn, vicar of St Peter's, and was the younger son of the parish clerk of St Peter's. With, however, was appointed with 27 votes against 25, and took up his appointment as Master in November 1851.[5] This proved to be a very popu-

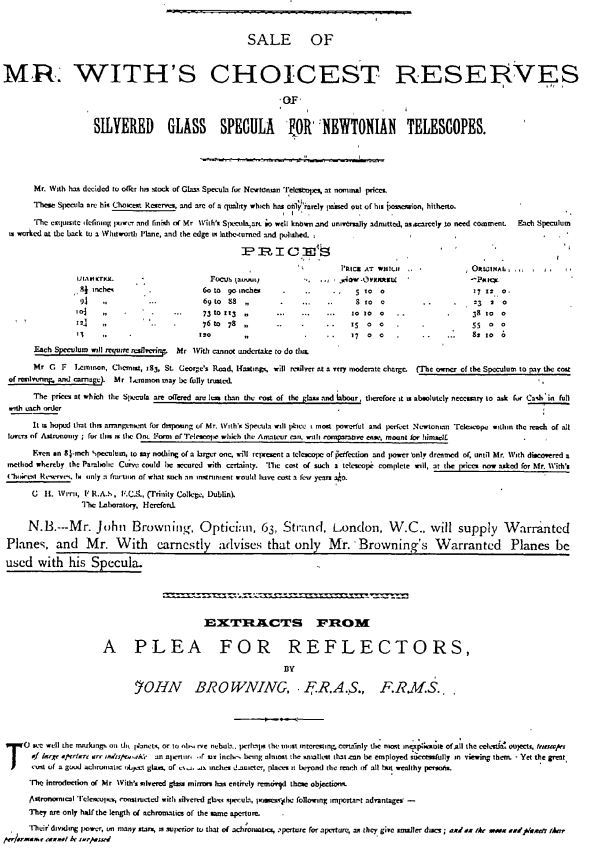
lar result, and was recorded in a capricious 97-line verse entitled *The Blue Coat School Contest in 1851*,[6] reputedly written by the previous Master, Thomas Carpenter, who had been summarily dismissed after 26 years' service. Although outwardly hostile to With, who is described as 'A graceless boy with a graceless name, Unknown to God, unknown to fame', it is in reality a jibe at the very pious Yapp – a 'walking Bible', a 'precious pet' and a 'darling son', whose sponsors 'had doubtless many fears, Lest learning might o'er run the land, And educated boys refuse to brush our coats and black our shoes.'

With remained at the school for almost 25 years, and during his tenure increased its educational and moral standards so much that it was considered a privilege to attend. His approach to education based on scientific methods was ahead of its time, and was extended to the fostering of several scientific movements, besides which he also took part in philanthropic and theological work, and was a prominent figure in Hereford's intellectual and social life. His resignation in 1876 was therefore a considerable disappointment for the school's Committee of Trustees, who expressed 'deep regret at the prospect of losing his services, and desire to place on record their entire approval of the able and efficient manner in which he has conducted the school for the 25 years during which he has held his present and very responsible position.'[7] It was also felt 'that the friends of Mr With and the public in general would be disappointed if they had not an opportunity afforded them of testifying in some substantial manner their High Esteem for Mr With and their grateful appreciation of the benefits he has conferred on the City, and on the cause of Education.'[8] It would appear, however, that this testimonial was the only appreciation which With received, as the Trustees decided that they were unable to offer him a pension out of school funds.

With's departure from the Blue Coat School did not end his career in education, as he had previously been appointed Professor of Science at Hereford Ladies' College, and later also taught science at Hereford Cathedral School, Barr's Court School and Ludlow Grammar School, besides being for many years a lay preacher in Hereford Cathedral. His enthusiasm for science probably first developed through the influence of Richard Dawes,[3] and despite the heavy responsibilities of running a school with 140 pupils and six assistants he always found time to work in his own laboratory.[9] Besides being a first-rate optician he was also a very able chemist, specialising in soil science and in particular the production and applications of fertilizers for agriculture and horticulture, an expertise which he was later to apply to the work of the Industrious Aid Society, founded by John Venn. This was important work for which he was well qualified; he was a Fellow of the Chemical Society (now the Royal Society of Chemistry) and a member of Trinity College, Dublin, and counted Thomas Huxley, Michael Faraday, John Tyndall and Edward Frankland among his associates.

Early success

With began making mirrors around 1860, at about the same time as the Rev Henry Cooper Key, of Stretton Sugwas, near



A Remarkable Opportunity for Amateur Astronomers.

SALE OF

MR. WITH'S CHOICEST RESERVES

OF

SILVERED GLASS SPECULA FOR NEWTONIAN TELESCOPES.

Mr. With has decided to offer his stock of Glass Specula for Newtonian Telescopes, at nominal prices.

These Specula are his Choicest Reserves, and are of a quality which has only rarely passed out of his possession, hitherto.

The exquisite defining power and finish of Mr With's Specula, are so well known and universally admitted, as scarcely to need comment. Each Speculum is worked at the back to a Whitworth Plane, and the edge is lathe-turned and polished.

PRICES

Diameter.	Focus (about)	Price at which now Offered	Original Price
8½ inches	60 to 90 inches	5 10 0	17 12 0
9½ "	69 to 88 "	8 10 0	23 9 0
10½ "	72 to 115 "	10 10 0	38 10 0
12½ "	76 to 78 "	15 0 0	55 0 0
13 "	120 "	17 0 0	82 10 0

Each Speculum will require resilvering. Mr With cannot undertake to do this.

Mr G. F. Lemmon, Chemist, 183, St. George's Road, Hastings, will resilver at a very moderate charge. (The owner of the Speculum to pay the cost of resilvering, and carriage). Mr Lemmon may be fully trusted.

The prices at which the Specula are offered are less than the cost of the glass and labour; therefore it is absolutely necessary to ask for Cash in full with each order

It is hoped that this arrangement for disposing of Mr. With's Specula will place the most powerful and perfect Newtonian Telescope within the reach of all lovers of Astronomy; for this is the One Form of Telescope which the Amateur can, with comparative ease, mount for himself.

Even an 8½-inch Speculum, to say nothing of a larger one, will represent a telescope of perfection and power only dreamed of, until Mr. With discovered a method whereby the Parabolic Curve could be secured with certainty. The cost of such a telescope complete will, at the prices now asked for Mr. With's Choicest Reserves, be only a fraction of what such an instrument would have cost a few years ago.

G. H. With, F.R.A.S., F.C.S. (Trinity College, Dublin).
The Laboratory, Hereford.

N.B.—Mr. John Browning, Optician, 63, Strand, London, W.C., will supply Warranted Planes, and Mr. With earnestly advises that only Mr. Browning's Warranted Planes be used with his Specula.

EXTRACTS FROM

A PLEA FOR REFLECTORS,

BY

JOHN BROWNING, F.R.A.S., F.R.M.S.

TO see well the markings on the planets, or to observe nebulæ, perhaps the most interesting, certainly the most magnificent of all the celestial objects, *telescopes of large apertures are indispensable*: an aperture of six inches being almost the smallest that can be employed successfully in viewing them. Yet the great cost of a good achromatic object glass, of even six inches diameter, places it beyond the reach of all but wealthy persons.

The introduction of Mr. With's silvered glass mirrors has entirely removed these objections.

Astronomical Telescopes, constructed with silvered glass specula, possess the following important advantages:—

They are only half the length of achromatics of the same aperture.

Their dividing power, on many stars, is superior to that of achromatics, *aperture for aperture*, as they give smaller discs; *and on the moon and planets their performance cannot be surpassed.*

Figure 2. Front page of With's broadsheet, issued in 1887 (original dimensions, 17×11 inches).

Hereford, and a little earlier than George Calver, later of Widford, Chelmsford. In his early efforts he was encouraged by the Rev T. W. Webb,[10] of Hardwicke, near Hay-on-Wye, who had made a considerable impression on the amateur community with the publication of *Celestial Objects for Common Telescopes* in 1859, and who was well known both at home and abroad. Cooper Key began making mirrors in 1859 and, using a machine very similar to that of Lord Rosse,[11] succeeded in first producing a 12-inch f/10 (later sold to David Gill[12] for his observatory in Aberdeen) and afterwards an 18¼-inch of 11-foot focus, the mount for this instrument – weighing nearly two tons – being designed by the Rev E. L. Berthon.[13] In 1863 Cooper Key reported that With had 'completed three or four glass specula of the highest class, 6¼-inches aperture and 6-feet focus, and 5¼-inches and 4½-feet focus. With the larger telescope he is able to elongate the disk of the small companion of γ Andromedae readily. Its definition of a large fixed star is reasonably fine, giving a perfectly round clean disk, surrounded at a little distance by one faint concentric ring, and without any appendage or false light whatever. This was his first attempt. One of his 5¼-inches specula is, however, slightly superior to this, and is presumed to be perfect; not the least trace of error of figure can be detected over the entire surface after the strictest scrutiny.'[14] Two years later Webb wrote that With was 'going on admirably with his

specula. Those of 6¼ inches and 5½-foot focus have, I hear, most marvellous definition. He has just sold a splendid thing of 10⅛ inches,[15] the performance of which greatly delighted me.'[16]

More praise was soon to follow. In 1867 W. R. Dawes published the results of his investigations into the resolving power of object glasses,[17] including his now well-known formula, r = 4.56 arcsec/D in inches. This induced John Browning – who provided tubes and mounts for With's optics – to write to the Editor of the *Astronomical Register*, informing him that according to Dawes 'a fine achromat of not less than 7¾ inches is necessary to fairly divide γ^2 Andromedae, and that an aperture of 7⅓ may be required to give an appearance of a division.[18] I have in my possession a silvered-glass speculum, which was parabolised for me by Mr With, of 6½-inches aperture, and 4 feet 10 inches focus. The mirror divides γ^2, as does also another of 6¼ inches in the possession of Mr Slack.'[19]

By this time George Calver was also making mirrors. Around 1850 he had moved from Walpole, Suffolk, to Yarmouth, where he lived for several years, and where he became acquainted with the Rev Matthews. There is no firm evidence of when he began mirror-making, but he seems to have been inspired by Matthews who, having acquired a telescope with a mirror by With, challenged him to make one of equal quality. Thus begun, Calver devoted the rest of his life to the production of instruments. By about 1870 he had moved to Widford, and in 1904 he returned to Walpole, where he continued his work into old age.[20]

Methods

After a few years With and Calver became familiar with each others' work. They corresponded frequently, and there appears to have been no rivalry between them – at least outwardly. Neither was there any secrecy concerning their methods, and in 1893 With provided Calver with a full account of his working techniques, intimating that he was free to use the information however he wished. However, there is no evidence to suggest that With was still producing mirrors at that time, and the information would perhaps have had no more than comparative interest for Calver, although several years after With's death he made it known to the world by publishing it[21] (see Appendix).

In 1859 Foucault had published an account of his knife-edge test,[22] a simple but effective test which With apparently never used, although it seems unlikely that he never knew of it. Instead, during figuring he used various images – a watch dial at a distance of 100 feet, the Sun's image in a ⅜-inch diameter spherical black glass bead and in a small thermometer bulb, and the appearance of the fine bright line of mercury in the stem of a thermometer. When these tests had been satisfied the unsilvered mirror was tested on stars and any errors corrected, after which it was silvered and again tested on stars. If necessary a final correction was made, and the mirror was resilvered and tested on stars again. In general the figure was then found to be right, but if not then correction, resilvering and testing were repeated. With always aimed at full correction, or a little over-correction, 'as *harder* star disks were thus obtained, and very sharp definition on planets. No doubt this process must seem to you very clumsy and unscientific,' he told Calver (who disagreed), 'but you know, even better than myself, what the results were. The graduated tools were my great agents in figuring; until I had fully mastered *them*, I was groping in the dark... Cooper Key and I worked together. *He* discovered the graduated tool value, I only worked out the matter.'[21] Calver later wrote that he never saw one of With's mirrors 'that was for the whole surface over-corrected – always more or less under-corrected. Neither is it correct that an over-corrected one is better than either fully or slightly under. To my eye it is the reverse of this, and theoretically it is not correct. How could such a master think thus? He did not test at the centre of curvature, and sometimes his work was more corrected in the centre than the outward zones. This at the telescope on stars would appear like over-correction, yet it is strange that he should not realize that the sum total effect was under-correction.'[23] But Calver also added that he respected With's opinion, and regarded him as the older and better authority.

With knew that his methods did not give complete control of a surface, and that they were not well suited for removing small amounts of general aberration or small local errors. If, therefore, he found through testing that a mirror was near-perfect he would not risk further correction. He usually signed and dated his mirrors, frequently added an inscription in Latin, Greek or Hebrew – sometimes all three – and often labelled them 'absolute perfection' or 'wonderful perfection', although he was the first to admit that not all of them were of the same high standard. Those he considered perfect were kept as 'choice reserves'.

With also made flats, but according to Calver not all of them were good. 'I mounted equatoreally,' the latter wrote, 'a beautiful 12-inch mirror that was mated to an imperfect plane, although Mr With himself had passed the plane as perfect. It appears that workers of plane surfaces have not a severe test – certainly not to equal star tests – and they do not seem to be sure whether they are fairly good or perfect.'[24] With's flats were probably made only for those mirrors which he did not keep as 'reserves', as he later strongly advised that 'only Mr Browning's Warranted Planes be used.'[25]

Over a period of almost thirty years With produced about two hundred mirrors – considerably less than Calver, whose output has been variously estimated at up to several thousand instruments, including mirrors either made or refigured. However, Calver was a professional who employed several assistants and sub-contracted iron foundries, besides apparently attaching his name to the work of others, whereas With was effectively an amateur – albeit selling his mirrors – with one or no assistant and many other responsibilities. He never made a complete instrument for sale, instead leaving the construction of the telescope to the customer, but he sent many of his mirrors to John Browning to be mounted, and a complete instrument with With optics could therefore be purchased.

The Browning connection

Unlike With, Browning had a well-established background to his trade. Since 1760 his family had specialised in the manufacture of nautical instruments, but on succeeding to the business in the early 1860s he decided to concentrate on the production of purely scientific instruments, especially telescopes and spectroscopic equipment, some of which he used himself, as he took every opportunity to spend time in his observatory in Sevenoaks. As a young man he had studied medicine at Guy's Hospital, and by utilising this early training he also gained a considerable reputation among ophthalmic surgeons by producing spectacle lenses. His interests also extended to other sciences, including early experiments in the development of the telephone and phonograph, and the erection of the first electric light in London for a visit of the Shah of Persia to the Guildhall in 1873. By 1870 his work-force numbered more than 70, and he therefore transferred the factory from 111 The Minories to larger premises at 63 The Strand, at the same time taking on the services of the recently-immigrated Adam and Otto Hilger, who had both worked under Foucault at Lerebours & Secrétan in Paris. Within a short time Adam was appointed foreman, and in 1875 he and his brother established their own business. Browning continued to work until 1905, when, having been given a short lease of life by his physicians, he retired to Cheltenham, where he died twenty years later, aged 90.

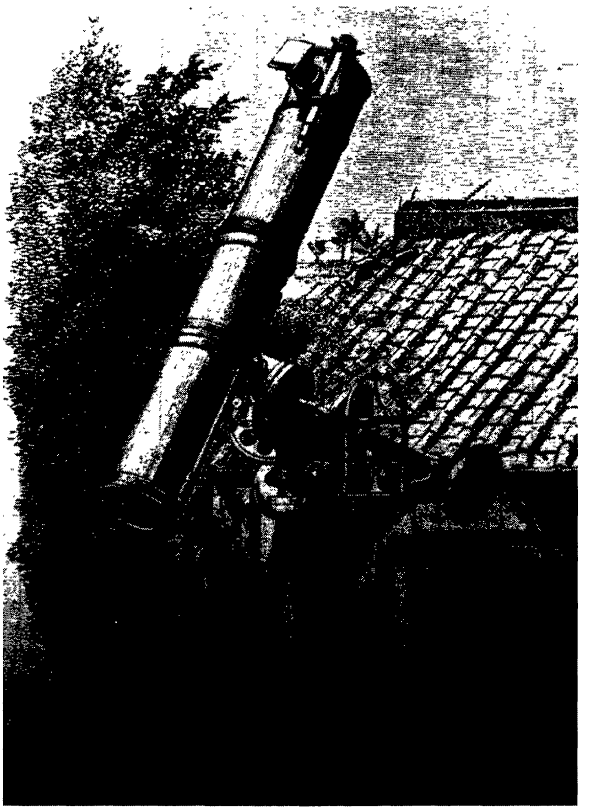


Figure 3. 9-inch With–Browning used by J. F. Tennant to observe the Indian eclipse of 1868.

Publicity and sales

In 1867 Browning issued *A Plea for Reflectors* (republished several times), extolling their virtues and advantages, recommending With's mirrors, and quoting letters from satisfied customers. These commendations were taken up by With, who later quoted part of this work, together with selected testimonials he had received over many years not only from casual observers but also from distinguished amateurs and professionals.[25] In 1869, for example, 'S. T.' of Dublin possessed an 8½-inch which 'turned out far better than even in my most sanguine moments I could have anticipated... of most perfect figure and defining power.' In 1871 E. B. Knobel,[26] in Burton-on-Trent, declared that his 8½-inch gave 'astonishing views... I am more and more delighted with it', and in the same year a colleague of H. C. Russell, Government Astronomer in New South Wales, considered his 8½-inch superior to Sydney Observatory's 7¼-inch Merz refractor, while T. N. Hutchinson, of Rugby School, wrote that his 6½-inch 'suffers nothing by comparison' with the 8½-inch Clark refractor at the Temple Observatory.[27] In 1872 J. Norman Lockyer[28] described the 'exquisite definition' of his 9¼-inch, and in 1875 A. De Bourbon, in The Hague, stated that his 9¼-inch was 'a most beautiful instrument, doing more than I had expected', while J. H. Pope, of Dunedin, New Zealand, wrote that he was 'extremely delighted with the 8¼-inch... the instrument is a perfect treasure.' It would not, of course, have been in With's interest to quote adverse remarks – if any – but there is no doubt that the best of his mirrors were difficult to surpass.

'Choicest reserves'

In 1887 With decided to sell his entire stock of 'reserves' of more than one hundred mirrors, each of them regarded as an example of his finest work. He therefore issued a four-page broadsheet entitled *Sale of Mr With's Choicest Reserves of Silvered Glass Specula for Newtonian Telescopes* (Figure 2), with the heading 'A Remarkable Opportunity for Amateur Astronomers', as the price reductions were considerable. Five sizes were offered, each over a range of focal ratios, but generally between f/6.2 and f/11: 8½ inches, f/7 to f/10.6, £17 12s (£17.60) reduced to £5 10s (£5.50); 9¼ inches, f/7.5 to f/9.5, £23 2s (£23.10) reduced to £8 10s (£8.50); 10¼ inches, f/7.1 to f/11, £38 10s (£38.50) reduced to £10 10s (£10.50); 12¼ inches, f/6.2 to f/6.4, £55 reduced to £15; and 13 inches, f/9.2, £82 10s (£82.50) reduced to £17. The full amount in cash was required when ordering, as it was claimed that the prices amounted to less than the cost of glass and labour, and that each was less than one thirtieth the price of a good object glass of the same aperture. Each required resilvering, but With declared that he could not undertake this work, and recommended G. F. Lemmon, a chemist in Hastings who, he said, could be fully trusted. Neither could he provide flats, for which he recommended John Browning. He also emphasised that with one of these mirrors a complete telescope made by an amateur would cost only a

Figure 4. W. F. Denning and his 10-inch With–Browning *(BAA archives).*

fraction of what such an instrument would have cost a few years earlier.

There is no evidence indicating the success of this offer, but it is likely that With's reputation and the comparative paucity of his mirrors would have provoked an immediate response.

Distribution

With's reputation spread worldwide, as did his mirrors, and during the century or so since they were made their fates have been various. Some were sold into obscurity, some have been refigured (and occasionally ruined), a number of them now reside in museum collections, and others which were used for many years have since disappeared. A few are still doing valuable work in capable hands, but there must also be the perennial examples of those lying unrecognised or neglected in some dusty corner. Very few have a traceable provenance.

In 1868 J. F. Tennant[29] used a 9-inch With–Browning (Figure 3) to observe the total solar eclipse of August 17–18 at Guntoor, India. His results,[30] which included a series of excellent photographs, considerably increased his reputation within the astronomical community, and also provided valuable publicity for the makers of the instrument. Four years later G. M. Seabroke mounted a 12⅛-inch With mirror at the Temple Observatory,[27] Rugby, and together with spectroscopes of his own making used it for many years for the study of stellar radial velocities. Charles Pritchard[31] added two With mirrors to the equipment of Oxford University Observatory – a 10-inch in 1878 and a 15-inch ten years later. Scriven Bolton, a well-known lunar and planetary observer, used a 10¼-inch With–Browning and an 18¼-inch Calver for many years, and in 1871 W. F. Denning[32] acquired a 10-inch With–Browning (Figure 4) which, in conjunction with a 12½-inch Calver, he used for planetary observations until shortly before his death in 1931.

Other With mirrors reappeared after many years' delitescence. In 1922 P. M. Ryves[33] acquired a 10-inch which had 'evidently never been used, and was wrapped in a copy of the *Herefordshire Times* dated about 1870. Described by its maker as 'absolute perfection', this was certainly a very fine mirror.'[34] In 1942 J. L. Cummergen obtained a 6½-inch accompanied by With's own label: 'Focus 5 feet 7 inches. This 6½-inch easily divides γ^2 Andr. and μ^2 Boötis. It carries a power of 1000 easily on stars. Wonderful perfection. August 1872.'[35] Unfortunately these mirrors have since disappeared, but it is some consolation that others still reappear. Recently, the granddaughter of the Rev C. D. P. Davies[36] produced the 9-inch which he had purchased around 1880, and a 5½-inch was bought for £1 at a car-boot sale, the vendor describing it as 'no good for shaving.'

BAA instruments

Several With mirrors have been added to the Association's instrument collection, the first of them being acquired in 1941, when Colonel (later Brigadier) F. W. Nicholls presented an 8½-inch[37] accompanied by a letter, dated 1887 March 30, from With to W. S. Franks:[38] 'Amongst my choicest of the choicest, I find one recorded thus: '8½, focus 5 feet 3 inches. Absolute Perfection. Not for Sale.' This

Figure 5. 10-inch With–Browning presented to the Association by A. G. Batley *(R.A. Marriott).*

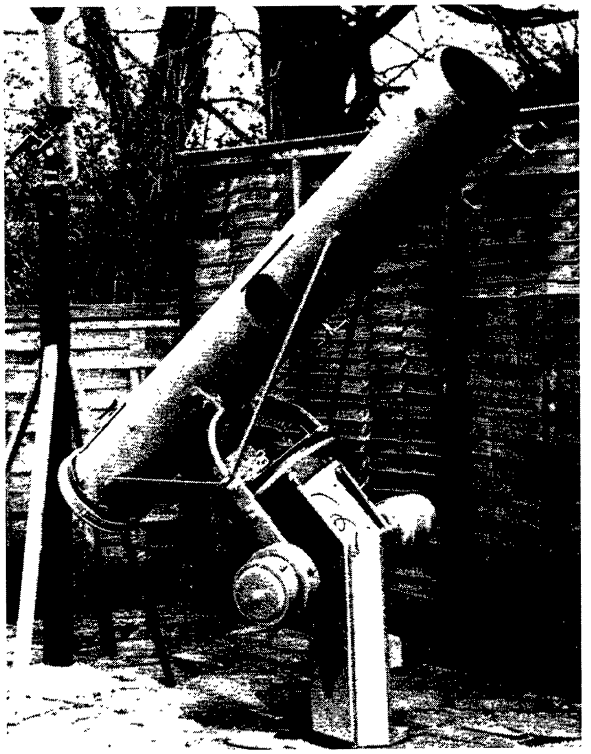


Figure 6. 9¼-inch With–Berthon presented to the Association by C. Waller *(D. G. Buczynski).*

means that it is as perfect as my skill could make it, and that it was reserved as out of the commercial track and quality; for such specula as I am now offering have seldom left my possession.'[39] Franks immediately purchased this mirror, and a month later reported that it was 'everything you claim for it... Its performance was really marvellous... I can only say how pleased I am at having become its fortunate possessor.'[25] This report was included by With in his broadsheet, indicating that he had already begun selling his reserves before publication.

Three other mirrors have mounts by Browning: an 8½-inch[40] presented by H. G. Tomkins[41] in 1932, a 10-inch (Figure 5)[42] presented by A. G. Batley in 1934, and a 9-inch[43] bequeathed by H. E. Kersey in 1949. The 10-inch mirror is inscribed 'Withus Herefordensis, me ad astra investiganda, A.D. 1875', but a second inscription reveals that it was refigured by H. N. Irving in 1923. Whether or not With's figure was improved will never be known; nevertheless, the mirror is of high quality and on fine nights bears extremely high powers, whilst Browning's mount is the archetypal 'Victorian battleship' weighing half a ton.

A 9¼-inch (Figure 6),[44] presented by C. Waller in 1943, is equipped with an 'equestrian' mount designed by E. L. Berthon[13] and described by him in 1873,[45] although he gives no indication of the date of the design. In the late 1970s D. G. Buczynski carried out extensive research into the provenance of this instrument, as all available evidence indicated that it may have originally been owned by T. W. Webb. The earliest of Webb's observations made with a 9¼-inch reflector, as recorded in his journal,[46] is dated 1863 August. Unfortunately – and uncharacteristically – With did not date the present mirror, and the evidence must therefore be deemed inconclusive.

The 18-inch

With's largest mirror was an 18-inch,[47] made in 1877. The first owner appears to have been the Rev Jevon J. Muschamp Perry, vicar of St Paul's, Alnwick. In 1879 Perry wrote to Calver: 'I was very much interested in reading your account of the grinding and polishing of the 37-inch [*sic*] speculum in this week's E. M....[48] Had I only the wealth of my neighbours, I would give you an order for the largest telescope you could construct.'[49] This may have been a slanted reference to the Duke of Northumberland; nevertheless, Perry obviously had sufficient means to indulge his interests. He already had a 6½-inch Calver, and after Cooper Key's death in 1880 acquired the latter's 18¼-inch mirror, which he had refigured by Calver as it was perfect only over the interior 14 inches. At the same time he also purchased With's 18-inch, and again referred to Calver, who after testing it 'pronounced it to be an exceptionally fine one, and heartily congratulated me on the possession of such a beauty.'[50] Perry considered it to be 'a magnificent specimen of that eminent maker's handiwork', and even on an indifferent night 'divided such extremely difficult tests as η Coronae, μ^2 Herculis, and δ^2 Cygni; and these results were quite sufficient to show me that the very high reputation of its excellent maker is worthily and proudly maintained by this mirror.'[50] And after using the instrument on one occasion C. Piazzi Smyth[51] stated rather more sombrely that he 'could not expect any telescope, reflector or refractor, upon the same object, and on the same night, to do better.'[44] But Perry seemed prone to hyperbole, and on testing the refigured 18¼-inch declared it to be 'super-excellent'.

Figure 7. The 18-inch as mounted by T.E.R. Phillips *(Royal Astronomical Society).*

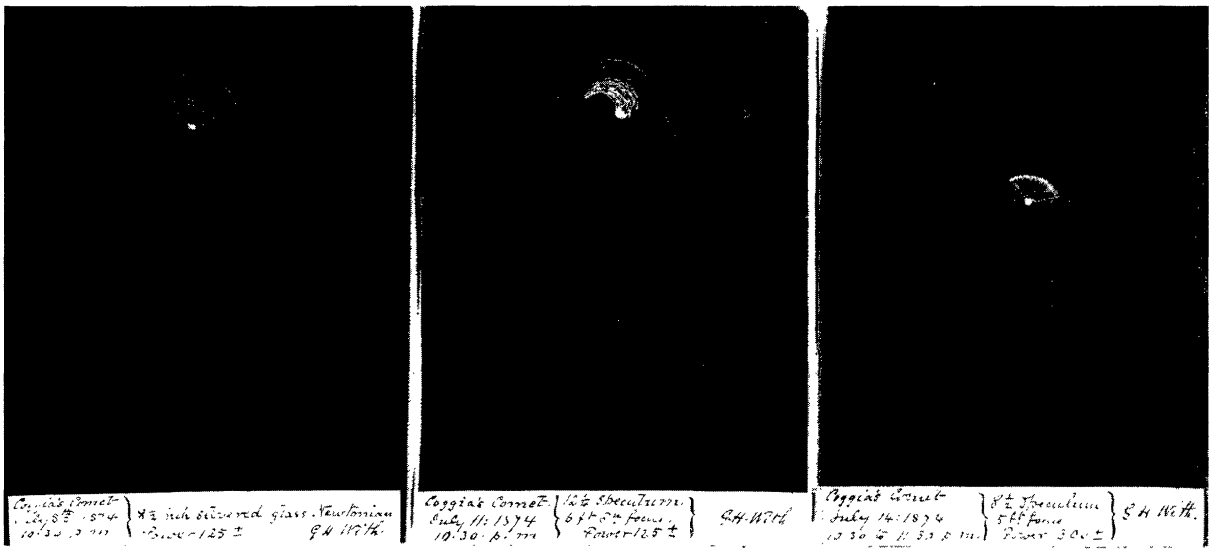


Figure 8. With's drawings of Coggia's comet, 1874 *(Royal Astronomical Society)*.

Perry's enthusiasm for the 18-inch was short-lived, and in 1882 he sold it to N. E. Green,[52] who already had three other With mirrors – a 9-inch, a 13-inch which he had used to observe Mars from Madeira in 1877,[53] and a 15-inch. After the acquisition of the 18-inch Green used all four mirrors, chiefly for observations of Jupiter, of which he made several hundred drawings.[54] During 1894–95 he advertised the 18-inch for sale at £100; but he received no offers, and in 1897 presented the complete instrument to the Association[55] for installation in the proposed observatory, which never materialised. It was therefore placed in the care of the Rev J. M. Bacon until being loaned to J. M. Baikie in 1905. After Baikie returned it in 1910 it lay unused until 1917, when it was remounted by the Rev T. E. R. Phillips[56] (Figure 7) so that it could be used by visiting members of the Association. Since Phillips' death in 1942 it has been remounted three times, and is now on loan to D. G. Buczynski.

A life of achievement

George Henry With died at the home of his son-in-law Peyton Levason, at 8.00 p.m. on Tuesday, 13 September 1904, bequeathing his estate in trust to his children, Alfred,[57] Lavinia, Alice and Elizabeth, and his grandson James. After his death, Calver wrote of his 'greatly esteemed and excellent ally... He was a most conscientious man, without envy or jealousy... I can only say he was a master of his methods, as his excellent work testifies... Such of Mr With's mirrors as have been put into my hands I have touched with a loving care,[58] feeling that I am still his ally, and shall always hold in deep regard his memory as a good man and excellent artist.'[23] With's reputation rests on his skills as a mirror-maker rather than as an observer, as his only extant observations consist of three drawings of Coggia's comet of 1874 (Figure 8).[59] But his appreciable contribution to astronomy was probably surpassed by his endeavours in the field of education, and his friend William Collins later reflected on 'the young minds he influenced, and the incomparable good he accomplished. His soul was full of great thoughts, and great sympathies; in fact, his whole career was an object lesson of single-minded devotion to a great ideal... It is men of his standing to whom we owe a deep debt of obligation for keeping our thoughts abreast of the times, and for fixing our eyes on the things which are to come.'[60]

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Notes and references

1 John Herschel, for example, used three 18¼-inch mirrors during his sojourn at the Cape in 1834–38. A mirror could deteriorate in as little as a week – probably due to the proximity of the ocean – and each repolishing entailed several hours' work at the machine.

2 Alverstoke National School was built in 1842. In 1941 it was bombed but only slightly damaged, although it was eventually demolished by bulldozers in 1971.

3 Richard Dawes (1793–1867) was ordained in 1818, and in the same year was elected a Fellow of Downing College, Cambridge. In 1836 he became rector of Kings Somborne, Hampshire, and on being appointed Dean of Hereford in 1850 immediately initiated the restoration of the cathedral, which was reopened in 1863. Throughout his life Dawes retained a keen interest in physical and chemical sciences, and in 1864 served as Vice-President of the British Association at the meeting in Bath. He was not related to W. R. Dawes.

4 The Hereford Blue Coat Schools – one for boys and one for girls –

were founded in 1710 by Bishop Humphrey Humphries, Dean John Tyler, and the vicars of St Peter's and All Saints, John Rodd and Hugh Lewis. In 1921 the boys were transferred to St Owen's (founded in 1905), and the Blue Coat School – now the Bishop of Hereford's Blue Coat School – became a school for girls only.

5 Although With took up his appointment in 1851, his name appears in the 1852 Gosport directory. In 1855 the population of Hereford was 12,000.
6 Collins W., *Modern Hereford*, Hereford, 1911, p.136
7 Minutes of the Meeting of Trustees, 1876 February 7. Blue Coat School archive, Hereford
8 *Ibid.*, 1876 February 22
9 In later years With gave his address as 'Laboratory, Experimental Garden, Venn Road, Bath Street, Hereford.'
10 On Webb's death in 1885 With, T. H. E. C. Espin and S. Palmer acted as his executors. Webb's death certificate records his occupation as 'Prebendary of Hereford and Saver of Souls'.
11 An account of Cooper Key's machine is given in *Mon. Not. R. Astron. Soc.*, **23**, 199 (1863)
12 Sir David Gill (1843–1914) was HM Astronomer at the Cape of Good Hope 1879–1907.
13 E. L. Berthon (1813–1899) was a prolific inventor and designer of nautical instruments and telescope mounts. He also designed the 'Romsey'-type observatory and the dynamometer named after him, and was well-versed in medicine, theology, architecture, philosophy, mechanics, sculpture and art.
14 *op.cit.* (ref. 11), p.202
15 The extra 1/8 inch included the bevelled edge.
16 Parry Jenkins G., 'A plea for the reflecting telescope', *J. R. Astron. Soc. Canada*, 1911, p.59. Parry Jenkins was a friend of With, and had lived in Hereford for ten years before emigrating to Canada.
17 Incorporated in 'Catalogue of micrometrical measurements of double stars', in *Mem. R. Astron. Soc.*, **35**, 154 (1867)
18 Reference to Dawes W. R., 'On the performance of object glasses on γ Andromedae and δ Cygni', in *Astronomical Register*, **5**, 49 (1867)
19 *Astronomical Register*, **5**, 111 (1867). Henry Slack was an amateur in Forest Row, Sussex.
20 For a short account of Calver's life and work, see Dall H. E., 'George Calver: East Anglian telescope maker', in *J. Brit. Astron. Assoc.*, **86**, 49 (1975).
21 Letter from With to Calver, 1893 October 12, in *English Mechanic*, **90**, 307 (1909)
22 *Annales de l'Observatoire de Paris*, **5**, 197 (1859)
23 *English Mechanic*, **80**, 252 (1904)
24 *J. Brit. Astron. Assoc.*, **2**, 172 (1892)
25 *Sale of Mr With's Choicest Reserves*, Hereford, 1887.
26 E. B. Knobel (1841–1930) served as President of the Association 1910–12.[27] See Marriott, R. A., 'The 8¼-inch Clark refractor of the Temple Observatory, Rugby', in *J. Brit. Astron. Assoc.*, **101**, 343 (1991).
28 J. Norman Lockyer (1836–1920) is remembered for his pioneering work in solar physics. He founded *Nature*, which he edited for almost 60 years, and in 1911 founded the Hill Observatory at Sidmouth.
29 Lieut-General J. F. Tennant (1828–1915) was an officer engineer during the Indian Mutiny of 1857. He was later appointed Master of the Mint at Calcutta – a post from which he retired in 1884 – and served as President of the Royal Astronomical Society 1890–92.
30 *Mem. R. Astron. Soc.*, **37**, 1 (1869)
31 C. Pritchard (1808–1893) was Savilian Professor of Astronomy at Oxford University and first Director of the University Observatory, founded in 1870.
32 W. F. Denning (1848–1931) was an eminent meteor and planetary observer, and was Director of the BAA Meteor Section 1899–1900.
33 P. M. Ryves (d.1956) was an Original Member of the Association, and was Director of the Mars Section 1942–56.
34 *J. Brit. Astron. Assoc.*, **51**, 332 (1941)
35 *ibid.*, **52**, 71 (1942)
36 C. D. P. Davies (1859–1931) was BAA President 1924–26.
37 Instrument No.78, on loan for many years and untraced in 1968.
38 W. S. Franks (1851–1935) was Director of the BAA Star Colour Section, 1890–94, and later worked at the observatories of Isaac Roberts, John Franklin-Adams and F. J. Hanbury.
39 *J. Brit. Astron. Assoc.*, **51**, 206 (1941)
40 Instrument No.46, on loan to A. W. Lane Hall from 1932 to 1993.
41 H. G. Tomkins (1869–1934) was for many years Accountant-General of Bengal Province. After his retirement he served the Association as a member of Council and as Secretary and Vice-President.
42 Instrument No.50, on loan to E. H. Collinson from 1934 to 1987, and to the author since then. Collinson (1903–1990) was Director of the BAA Mars Section 1959–79, and President 1952–54.
43 Instrument No.126, not returned to the Association after the borrower's death in 1986.
44 Instrument No.83.
45 *Mon. Not. R. Astron. Soc.*, **35**, 106 (1873)
46 RAS MSS Webb 5
47 An advertisement offering an 18-inch f/10 mirror, supposedly made by With, appears on the last page of the *Journal* index for 1961, but no other reference to this mirror has been found.
48 Reprinted from *Mon. Not. R. Astron. Soc.*, **49**, 17 (1879)
49 Calver G., *Hints on Silvered-Glass Reflecting Telescopes*, p.45, 4th edition, Chelmsford, 1884
50 *English Mechanic*, 1880 September 3, quoted by Calver in *ibid.*, p.47
51 C. P. Smyth (1819–1900), son of W. H. Smyth, was Astronomer Royal for Scotland 1844–1900.
52 N. E. Green (1823–1899) was a highly skilled planetary and lunar observer and a professional artist, at one time Drawing Master to Queen Victoria. He was Director of the BAA Saturn Section 1891–93, and President 1896–98.
53 RAS MSS Green 1; *Mem. R. Astron. Soc.*, **44**, 123 (1879)
54 RAS MSS Green 3, 4.1 and 4.2; *Mem. R. Astron. Soc.*, **49**, 259 (1887)
55 Instrument No.3.
56 T. E. R. Phillips (1868–1942) was Director of the BAA Jupiter Section 1901–34, Director of the Saturn Section 1934–39, and President 1914–16. He also served as Secretary of the Royal Astronomical Society 1919–26, and as President 1927–29.
57 His eldest son George predeceased him.
58 Calver's allusion is to mirrors which he refigured.
59 RAS Add MS 161
60 Collins W., *op.cit.*, (ref. 6), p.139

Appendix

With's account of his methods of grinding and polishing.[21]

'In order to make the matter as clear and concise as possible, I will divide the subject into sections:

'1. The glass disc was roughed out on a leaden tool, of the proper curvature, with coarse emery. This was done by hand.

'2. It was then fined up on the machine, by means of emery of increasing degrees of fineness, until the surface was good enough for the last step of the fining process. Water was the medium used, so far, to keep the tool moist.

'3. The fining of the surface, a most important part of the process. This was done with emery, in an impalpable powder. The first dose of emery was wetted with water, and only one dose of emery was used. The fining-up occupied from eight to nine hours, during which my assistant never left the machine. In order to keep the *one dose* of fine emery moist so long, I used glycerine – just a few drops scattered over the glass disc, as the work required it.

'4. The machine used was a simple form of Lord Rosse's machine, with stroke and side motion.

'5. The tool used during the machine-grinding and fining process was of cast iron, and the surface was divided into facets of ½ in. square by grooves ⅛ in. deep.

'6. The polishing. This was done by rouge on a pitch-tool – pitch tempered with rosin, of course. This tool was divided into facets. The polishing was done on the machine, and generally took about from thirty to forty hours. The facets were equally sized on this tool.

'7. Figuring. This was done by hand, on tools of three kinds: (a) No.1 tool. Facets equal in size all over the tool. (b) No.2 tool. Facets becoming smaller and smaller towards the margin of the tool. (c) No.3 tool. Facets becoming smaller and smaller towards the centre of the tool. The first was called the plane tool, the second and third the graduated tools. The first step in figuring was to work the polished spherical figure, on the plane tool, in circular strokes, by hand, using a 'holder' to move the mirror; for the hand could not, of course, be suffered to touch the mirror, for fear of local expansion. The working was done for a few minutes – about – and then the alteration in figure tested on a fine watch-dial at 100 ft. distance. Wide strokes abraded the centre, narrow strokes – circular – abraded the margin. Cross strokes were also used; about six cross strokes to one minute's working of circular. When it became necessary to operate especially on the centre of the mirror, the graduated tool (b) was used. When the marginal portion needed abrasion, tool (c) was used. When the medial zones needed a touch, the plane tool, on the machine, with medium stroke and side motion, was used. The rouge was always used with water – *never with glycerine...* In all working the speculum was face downwards.'

And as a final characteristic touch, each mirror was worked at the back to a Whitworth plane, and the edge lathe-turned and polished.

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