I & I News

New Series No. 7 | Newsletter of the Instruments and Imaging Section | 10 July 2012

For amateur astronomers, conditions of observing remain familiar. The text below consists of a few extracts from a short article entitled ‘Hints to amateurs’, published in the second issue (February 1863) of *The Astronomical Register* – the first British astronomical periodical designed for ‘popular’ consumption. The first part consists of relevant and still valid advice, and ‘observing in a room’ is the equivalent of using an observatory – though observing indoors is now rather different from the practice of 150 years ago.

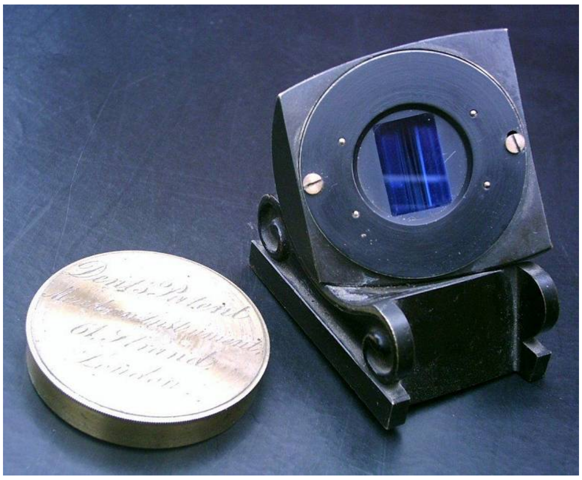
It is allowed by all who have any experience on the subject that the open air is the best place for using a telescope upon celestial objects. It requires, however, a large amount of enthusiasm on the part of a beginner to encounter the various difficulties with which this is attended, when the observations are to be made in the night time. Taking the telescope out into the garden, arranging the stand, etc., to find, perhaps, the weather change, and the sky become overcast just as the instrument is ready for use. Here, however, the beginner may be reminded that one maxim must be steadily remembered—‘never be disappointed by the weather’; in this uncertain climate an Astronomer who should yield to vexation because the sky becomes thick, had better give the thing up altogether. There are in reality fine nights enough, as any one who has gone a little way into the subject will soon discover; for even with an amateur, Astronomy does not consist entirely of gazing at the Stars; there is abundant occupation for dull evenings in recording what has been accomplished and arranging what has still to be done. Those, however, who undertake the trouble of observing in the open air, will be repaid by the command of the heavens which is thereby acquired, and the great steadiness obtained from the instrument being actually upon *terra firma.*

When observing in a room, it is necessary that all doors and windows should be closely shut, excepting that at which you are using the telescope—this should be opened as widely as possible. You will then experience little or no draught, which is equally prejudicial to the observer and to the performance of the instrument. By means of a great coat, a thick wrapper, and a warm cap for the head, you will be effectually protected from cold, for it need scarcely be remarked that there must be no fire in the room.*

The observer must likewise be steadily and comfortably seated; a music stool with a screw seat; a chair used the reverse way, so that the arms may rest on the back; a large book or two to raise the body to the required height; in one way or other the head, the arms, and the body must be steadily at rest, or no observation can be made with precision.

When engaged upon small Stars, Nebulæ, or other faint objects, use no more light than you can possibly help; it will be all the better if you know where to put your hand on the eye-pieces, etc., in the dark. The eye cannot perceive a faint object if it has been subjected even to a moderate light, and rest for a short time in total darkness is the best preparation for this kind of work. A small lantern, with means of shutting off the light is exceedingly useful; in fact necessary, and a little constant attention paid to the lamp, keeping it properly trimmed and supplied with oil and wick, will not be thrown away. It is a terrible nuisance if it refuses to burn properly when wanted in a hurry.

* A friend of ours highly recommends a ‘wadded dressing gown’, and states that he has carried on operations with impunity during the coldest evenings when so provided.



The dipleidoscope was patented by James Bloxam in 1843, and was marketed by Edward Dent. The instrument is used for timing the meridian transit of the Sun, accurate to within a few seconds. The mirror cell contains a hollow, right-angled prism, with two sides silvered and one of glass. The transit is determined by the coincidence of two images of the Sun by single and double reflection – one from the top glass and the other from both mirrors. The base of this particular version measures 2.8 x 1.9 inches.

The Astronomical Register

A Medium of Communication for all interested in the Science

The Astronomical Register was founded by Sandford Gorton in January 1863, and he later initiated the short-lived Observing Astronomical Society, begun in 1869 though surviving barely two years, but nevertheless representing the first attempt to establish a national astronomical organisation at an amateur level, coinciding with the technological innovation of silver-on-glass reflectors and the new age of amateur telescope-making. The *Register* was published for 23 years, until being suddenly terminated by its editor, Rev John Jackson, in 1886 – the last words on the last page of the last issue being ‘Finis. Valete’ (‘The end. Farewell’). By that time, however, *English Mechanic*, *Nature*, and *The Observatory* were well established, while the publications of the Royal Astronomical Society were becoming ever more technical and theoretical.

In general, to be able to continue, all publications require a regular influx of contributions and a degree of goodwill. So, here I reiterate the sentiments expressed by Sandford Gorton – though for ‘the *Register*’, read ‘*I&I News*’: ‘We desire to gratefully acknowledge the exertions of many friends, and to express our satisfaction at the decided approval the *Register* has met with, and our thanks for the kind wishes we continue to receive for its success.’

Bob Marriott, *Director*

Imaging the Sun with a 60-mm Coronado SolarMax II Hα telescope

Mick Nicholls

Since the publication of my article on imaging the Sun with Coronado PSTs (*I&I News*, New Series No. 3) I have joined in the work of the BAA Solar Section, and contribute my images and observations on a regular basis. I have also purchased a 60-mm Coronado SolarMax II Hα telescope. This instrument differs from the PST in several ways: the aperture is larger, as the PST is only 40 mm; the focal ratio is faster (PST is f/10, SolarMax II is f/6.6); and the band-pass is narrower (PST is 1 Å, SolarMax II is 0.7 Å). The focal lengths are the same, but due to the larger aperture and larger blocking filter the SolarMax II will on days of good seeing allow me to push the focal length to 1,600 mm with a 4x powermate, whereas the PST allows only 800 mm on days of good seeing. I chose the model with the 10-mm blocking filter because I can obtain better views and images than with the 5-mm model, and because the 15-mm version is beyond my budget. It can only be expected, of course, that the larger the aperture and blocking filter, the more expensive the instrument. (At the time of writing, Meade's prices for this range of instruments have increased by around £150–£250 since February 2012, not including any discounts at Astrofest).

My reason for purchasing this piece of equipment was that I am a very keen solar observer and imager, and I wanted to produce images and observations better than those I was acquiring with the PSTs. It must be said that the PST is an excellent little solar telescope with nothing to beat it at entry level, but its performance is limited by its aperture and band-pass, though it is ideal for anyone with a limited budget or insufficient time for solar observing.

It must be noted that unlike the PST the SolarMax II is too heavy to fit on a camera tripod, so an equatorial mount or a substantial altazimuth mount is required. If I use the instrument only visually then I attach it to an ordinary EQ5 mount, while if I use it for acquiring images or for producing solar animations then I utilise my HEQ5 Pro mount. Sometimes, however, if cloud is imminent or there are gaps between clouds or breaks in bad weather, I set up the instrument on my EQ5 mount and take 'smash and grab' images. These images are not as good as those taken when I have more time or a completely cloudless sky, due to rushing in order to beat the weather, but the method provides an advantage in that I have captured solar features that have eluded other observers and imagers. The disadvantage, of course, is that three pairs of hands and three pairs of eyes are required in order to monitor everything that is happening, and also to manually track the mount, press all the buttons on the computer, and still hopefully capture a decent image. Imaging in this manner can therefore be quite hectic, and is not for the faint-hearted (I do not recommend it for beginners). Visually, the instrument performs very well, producing excellent views of the solar surface and prominences.

It should be noted that a narrower band-pass improves only the surface detail, not the prominences – and yet views of the prominences are still better than those that can be obtained with a PST, due to the larger aperture and the blocking filter. I recommend that every opportunity be taken to use or purchase a SolarMax II. Anyone doing so will not be disappointed.

As far as imaging with this instrument is concerned, I employ the same techniques as those I used with the PSTs. The settings on the DMK21 camera may be set differently to account for a larger aperture, blocking filter, and weather conditions; but that is about all. Even when I intend to produce an animation I still use the same techniques as with the PST. For wide-angle images I use exposures of from $^{1}/_{1000}$ to $^{1}/_{1600}$ sec; for surface features, from $^{1}/_{100}$ to $^{1}/_{350}$ sec; and for prominences, from $^{1}/_{15}$ to $^{1}/_{45}$ sec. For prominences, sometimes the gain may need to be increased. For the surface detail, as with the PST I change the gamma setting by 40–75% to reveal the contorted file-lines on the solar surface. As ever, local seeing conditions dictate the settings to be used, and the best settings can be determined by trial and error to suit personal requirements.

Focusing with the SolarMax II is also a little easier because it has a helical focuser (though it would be even better with a Crayford focuser) with sufficient travel – unlike the PST, which to achieve focus requires screwing of the bottom lens of a Barlow attached to the nose-piece of the camera.

I use the same camera settings and capture the same number of frames as with the PST – about 500–600 for a single image; and again, a large hard drive is required to store the gigabytes of data captured. Any image-processing software that allows adjustment of shadows, midtones, and highlights is to be recommended, and I use the same colour settings as before:

Shadows	Red channel	+50%
Midtone	Red channel	+83%
	Yellow channel	–100%
Highlights	Red channel	+44%
	Yellow channel	–28%

In my previous article I also mentioned that I use a little device I have made to assist in producing solar animations. This device works perfectly with the SolarMax too; in fact, it will work with any camera/telescope combination. At the moment, however, I am keeping it confidential, as I am in the process of developing it, and at some point I would like to have it manufactured and mass-produced for sale (well, I can dream).

For the production of animations I use the same process as with the PST. To capture a prominence, and for rapid movements on the solar surface, such as a flare, at least an hour of data is required (though others may disagree). I capture 500–600 frames, wait 90–120 seconds, capture the next 500–600 frames... and so on. I then process each set of images exactly the same way, and use Registax to create the animation. I find this easier than producing animated GIFs, although file sizes can be much larger. The results depend on personal preferences.

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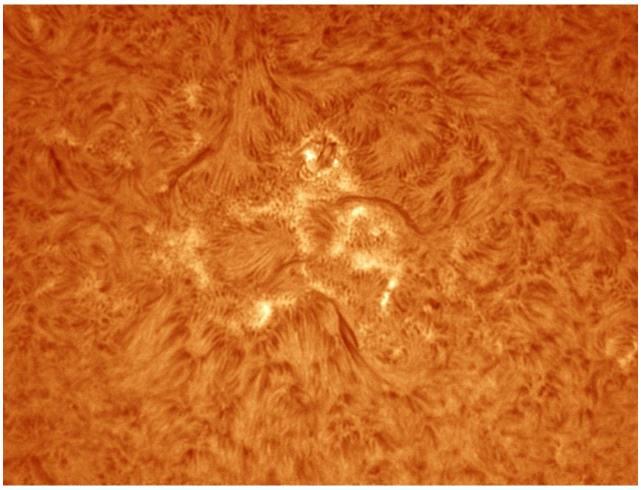
http://www.pbase.com/solarman



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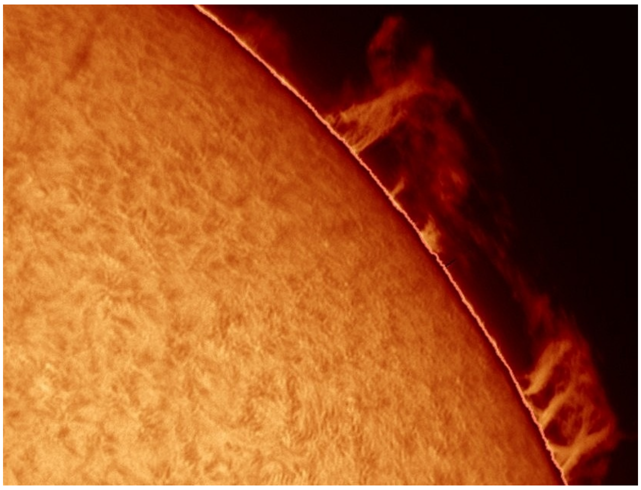

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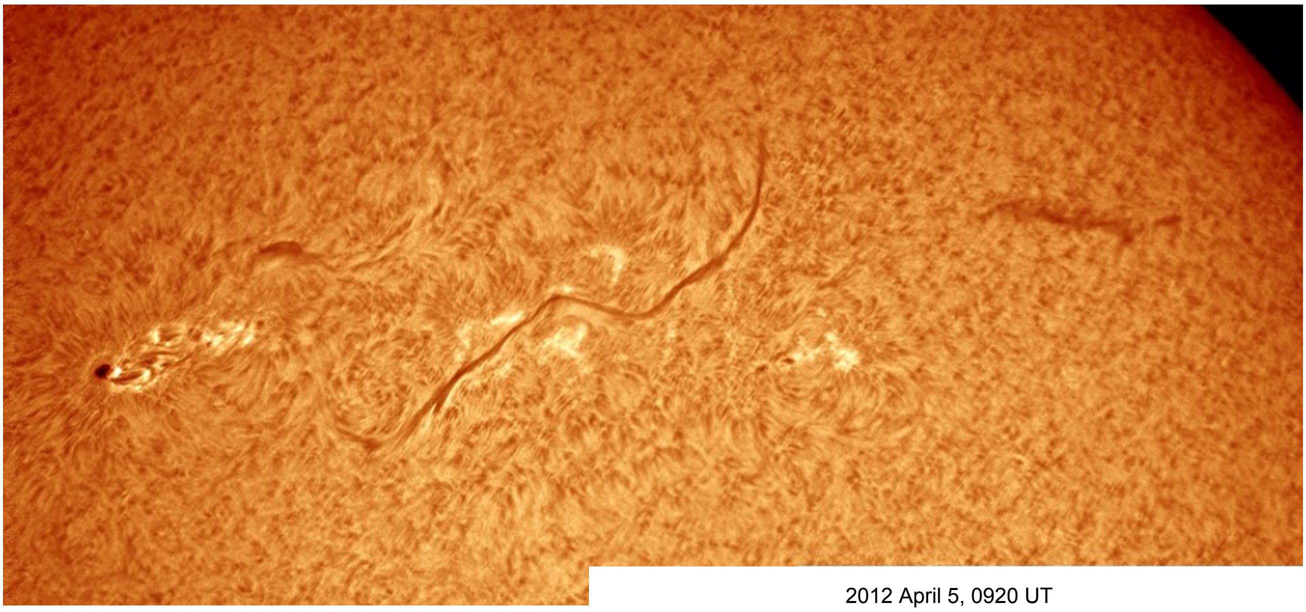

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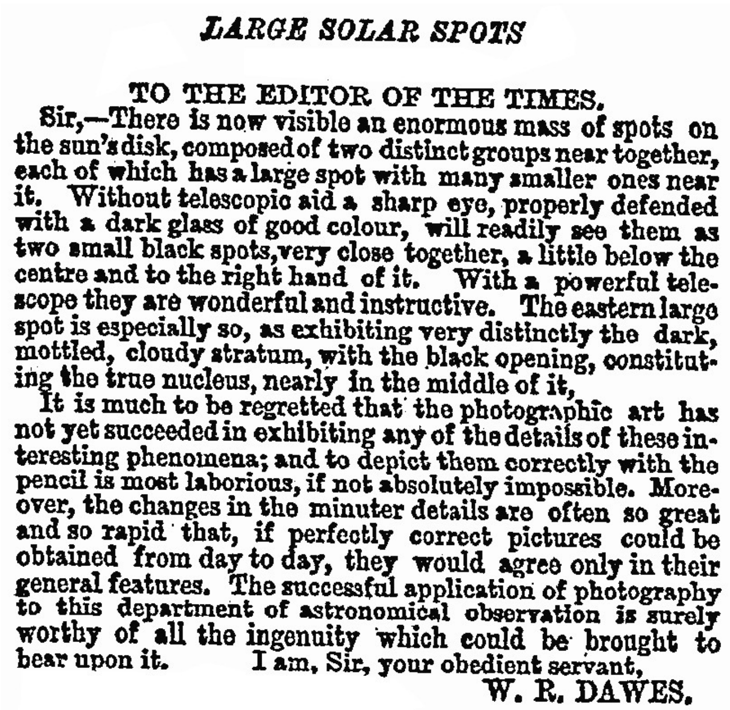

LARGE SOLAR SPOTS

TO THE EDITOR OF THE TIMES.

Sir,—There is now visible an enormous mass of spots on the sun's disk, composed of two distinct groups near together, each of which has a large spot with many smaller ones near it. Without telescopic aid a sharp eye, properly defended with a dark glass of good colour, will readily see them as two small black spots, very close together, a little below the centre and to the right hand of it. With a powerful telescope they are wonderful and instructive. The eastern large spot is especially so, as exhibiting very distinctly the dark, mottled, cloudy stratum, with the black opening, constituting the true nucleus, nearly in the middle of it.

It is much to be regretted that the photographic art has not yet succeeded in exhibiting any of the details of these interesting phenomena; and to depict them correctly with the pencil is most laborious, if not absolutely impossible. Moreover, the changes in the minuter details are often so great and so rapid that, if perfectly correct pictures could be obtained from day to day, they would agree only in their general features. The successful application of photography to this department of astronomical observation is surely worthy of all the ingenuity which could be brought to bear upon it. I am, Sir, your obedient servant,

W. R. DAWES.

A letter from William Rutter Dawes to *The Times*

28 January 1859

In 1874 the Royal Observatory, Greenwich, utilising a network of observatories, began a programme of daily photography of the Sun.

R.A.M.

Collimating a CCD camera: a practical solution

Richard Miles

The nature of the problem

Bigger and bigger CCD camera chips are good news for the amateur astronomer – or so it might be thought. With these larger chips, however, a problem can be encountered that is not nearly so apparent with the chips that measure only a few millimetres across: the problem of ensuring that the plane of the detector is orthogonal to (is positioned at 90° to) the optical axis – in other words, avoiding having the CCD chip tilted with respect to the optical axis, so that the areas towards and in all four corners of the image are perfectly in focus. With a Newtonian reflector it is possible to collimate the primary and secondary mirrors to ensure that an eyepiece or camera is orthogonal, but with a refractor it is usual to rely on the dimensions of adapters and so on being accurately engineered, so that it has already been collimated by the manufacturer.

We take it for granted that when we use a full-frame (36 x 24 mm) DSLR camera to photograph, say, a test chart, the image is properly in focus throughout, provided the chart is orientated correctly. But what about the large CCD or CMOS chip mounted in the camera body? What if this is not orthogonal to the optical axis? Fortunately, the machined dimensions of the camera and of the adapter at the rear of the camera lens are made to an accuracy of a few microns, and so all is well.

It should be considered, however, what happens if a cooled CCD camera is to be used with a camera lens. One difference between most telescopes and many camera lenses is that the focal ratios can be very different: for example, the native focal length of a Schmidt–Cassegrain telescope is around f/10 or f/11, whereas a camera lens might be f/2.8 or even faster. The faster the optics, the smaller the depth of field, and the more sensitive the focus to misalignment of the detector with the optical axis. I discovered this the hard way when I purchased a Starlight Xpress H18 camera fitted with an 18 x 13.5-mm Kodak KAF 8300M chip and mounted it on a Canon 300mm f/2.8 EOS lens, using an adapter to connect the T2 female thread on the camera body (M42 x 0.75 (F) screw thread), as shown in Figure 1.

I found that when imaging the night sky, if the stars in the centre of the frame were brought to focus, then two opposite corners of the image remained slightly out of focus, as depicted in Figure 2. The full image measures 3326 x 2504 pixels (5.4-micron pixels). Here I show small segments from the original image, each comprising about 0.8% of the total frame area. Four of the segments are from the extreme corners of the frame, and the fifth is from the centre. Note that in the upper left and lower right segments the star images are slightly out of focus and are distorted.

Attempted solutions

The Starlight Xpress Yahoo e-group has carried several discussions concerning the best way to collimate CCD cameras – the latest of them during February–March this year. The problem is a general one: for example, one owner reported that on the SBIG STL-11000M camera, 'the nosepiece mount came with two shims to compensate for the lack of orthogonality between the chip and the nosepiece, so I had to reshim when getting an external filter-wheel to make it orthogonal.' He did this by a process of trial and error, taking photographs and shimming until the frame looked good. On 6 February 2012, Terry Platt, of Starlight Xpress, reported: 'The basic problem is that we use sockets for easy replacement, or refurbishing of the CCD assembly, and so the CCD is not locked to the camera body in a permanent way. In addition, the thermal path from the CCD to the camera body needs to be as high-impedance as possible, so mechanical clamps on the CCD are undesirable. The result of all this is that the CCD alignment is largely determined by the alignment of the top surface of the cooler stack, and this can be out by a degree or two (especially on the two-stage coolers).'

The larger SX cameras can be adjusted. To quote from my manual: 'The front plate of the SXVR-H18 incorporates three sets of antagonistic screws that allow the plate to be tilted by up to about ±1° relative to the CCD surface. To make an adjustment, slacken the appropriate set screw and then turn the adjacent cap head screw in the required direction. Complete the adjustment by retightening the set screw.' However, to make the adjustment requires removal of the camera from the optics, as it is not possible to access the screws provided whilst it is mounted on, say, a Canon EOS lens. Also, the adjustment screws are relatively coarse in that a movement of the corner of the focal plane of just a few tens of microns (when working at f/2.8) is enough to put stars slightly out of focus, and this small adjustment is difficult to accomplish.

In response to the collimation problem, people have sought various solutions, including building dedicated collimation rigs, or, as tried by David Arditti, mounting the camera on a lathe and shining a laser at the chip so as to find the collimation point where rotation of the lathe position leaves the reflected laser-beam stationary.

Finally an answer

Following last year's BAA Christmas Lecture I retired to the pub (as one does) and entered into conversation with Tony Morris (author of one of the BAA's best-sellers, *Introduction to DSLR Astrophotography*). I explained the collimation problem and we worked out what sort of device was needed, but neither of us knew whether something suitable was available commercially. Later, I tried searching the Internet for such a device, but succeeded only in finding the Atlas Focuser available from Finger Lakes Instrumentation (see the links at the end of this article). This can be used with a Zero Tilt Adapter, but may not be exactly what is needed; and in any case, it is far too expensive (more than $2,000). Tony, however, was more successful, and had found that a special-

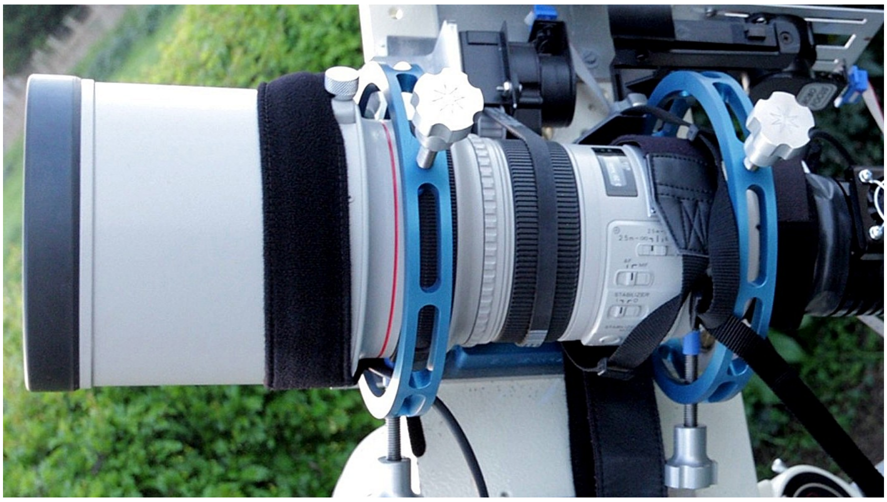

Figure 1. Canon 300-mm f/2.8 EOS lens + SXVR-H18 camera, mounted on rings and fitted with a focusing belt controlled by a RoboFocus stepper motor.

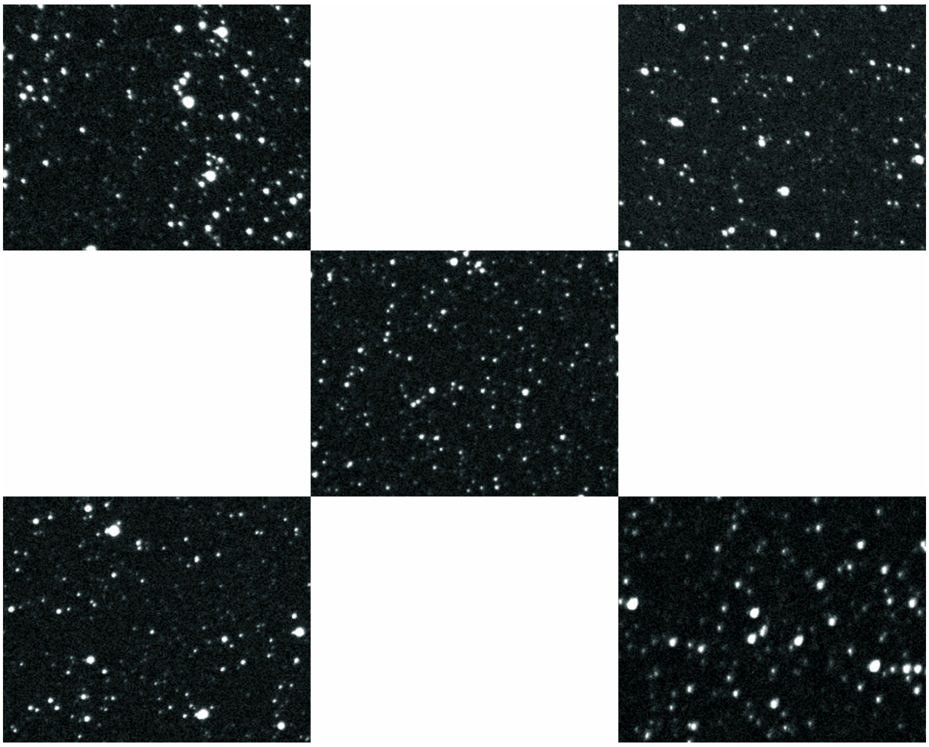

Figure 2. Subframes from a 60-sec exposure obtained with a non-collimated H18 CCD camera and Canon 300-mm f/2.8 lens.

ist German manufacturer of adapters and other equipment for astronomical purposes, Gerd Neumann jr, had recently brought out two different-size models of a Camera Tilting Unit, or CTU (Figure 3, and see links).

The central adjusting mechanism in the CTU consists of three radial screws which are in contact with an interior conical surface. By turning the collimation screws clockwise, a narrow slot opens between the main parts of the CTU, which are held in tension/compression by internal springs. Turning one of the screws 360° opens the slot by just 200 microns. By turning all three screws as required, and observing the effects of these adjustments on an image of a dense star-field, the tilt of the sensor can be adjusted so that it exactly matches the focal plane of the instrument, such that all stars are properly in focus. The maximum adjustment is about 0.8–1.0 mm, corresponding to a total tilt adjustment of about 1°.

The next question I faced was whether the CTU could be adapted to fit the SXVR-H18 camera onto a Canon lens having the EF bayonet fitting. One limitation is the size of the back-focus distance (when focusing at infinity) from the flange on the lens to the focal plane, which for the Canon EF is 44 mm (see links). By comparison, that for the Nikon F-mount is 46.5 mm, and lenses having the T2 mount (the same thread as the H18 camera) have a back-focus distance of 55 mm. The CTU device occupies 17.5–18.5 mm (dependent on the collimation screw settings) of the back-focus distance, leaving just 25.5–26.5 mm allowance. The H18 camera has a mechanical shutter which occupies physical space on axis, and so the CCD chip sits some 23 mm below the flange on the camera. There remains just 2.5–3.5 mm distance, and it is still necessary to fit an EF bayonet flange as well as an adapter to step down from the M48 x 0.75-mm thread on the CTU to the M42 x 0.75-mm (T2) thread on the camera body! Impossible, you might say.

Fortunately, Gerd Neumann jr. have a nice range of adapters, so the M48-to-M42 stepdown adapter with male threads on both sides occupies just 1 mm on axis (an item described as an M48 x 0.75 (M) to T-thread (M) adapter). The manufacturer can also sink a Canon EF flange into the other side of the CTU device such that it occupies only another 2 mm on axis (on their website this is called the CTU-EOS). Therefore, up to a maximum of 0.5 mm remains for focusing, dependent on the tilt adjustment required. As it happens, the Canon 300-mm f/2.8 lens will focus a short way beyond infinity, and it is this feature which enables successful focusing, as I found after receiving the equipment a few days after placing my order.

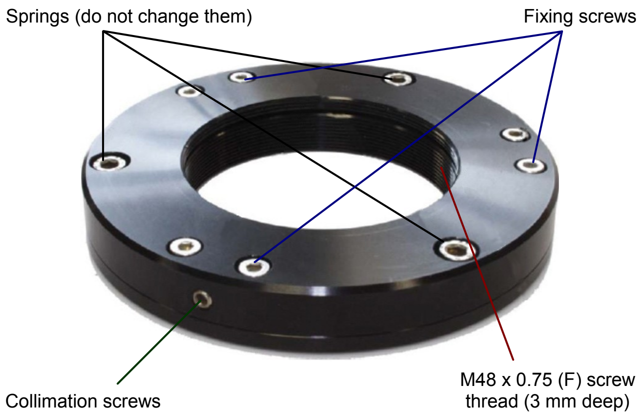

Figure 3. Camera Tilting Unit.

Results

On 23 December 2011 I tested the CTU by taking an image of a fairly densely packed star-field, followed by single adjustments of two of the collimation screws. Three adjustments were required to collimate the camera reasonably well, as shown by Figure 5. Compared with Figure 4, an earlier image of the same region, the improvement is clear. I should really check the collimation with fine tuning, though even now, after several months, I have not needed to do so, as the system performs satisfactorily.

Filters

If you are planning on using a full-frame (36 x 24-mm) CCD camera with whichever optics you have, then you may also

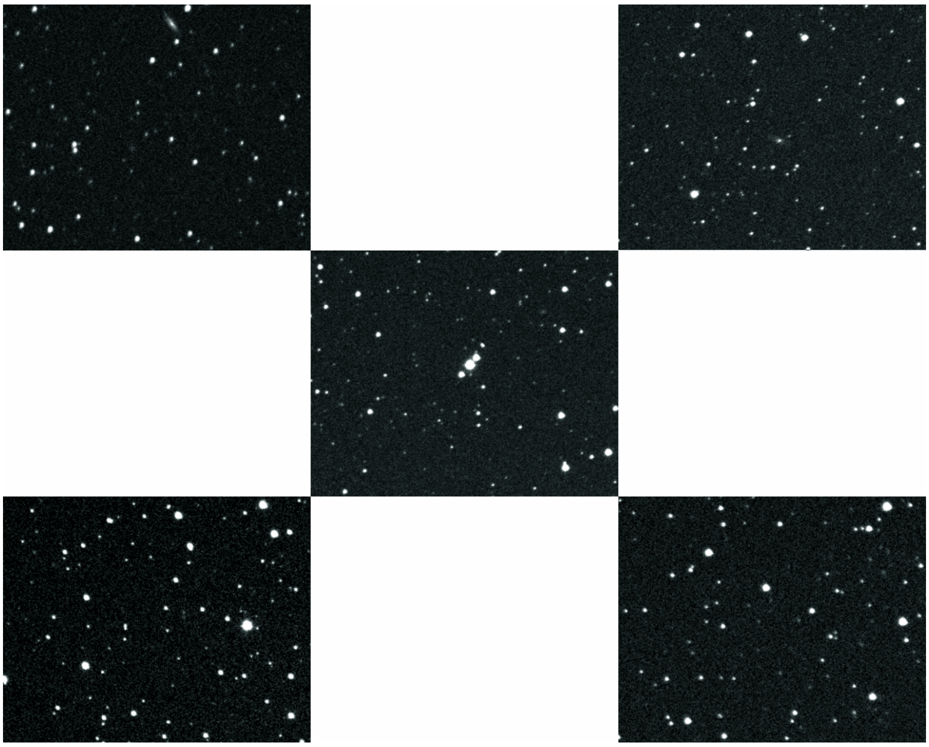

Figure 4. Selected portions of an image taken prior to fitting the CTU device.
2011 March 15. Centre: RA 01h 40m 22.8s, Dec +34° 19' 18" (in Triangulum).

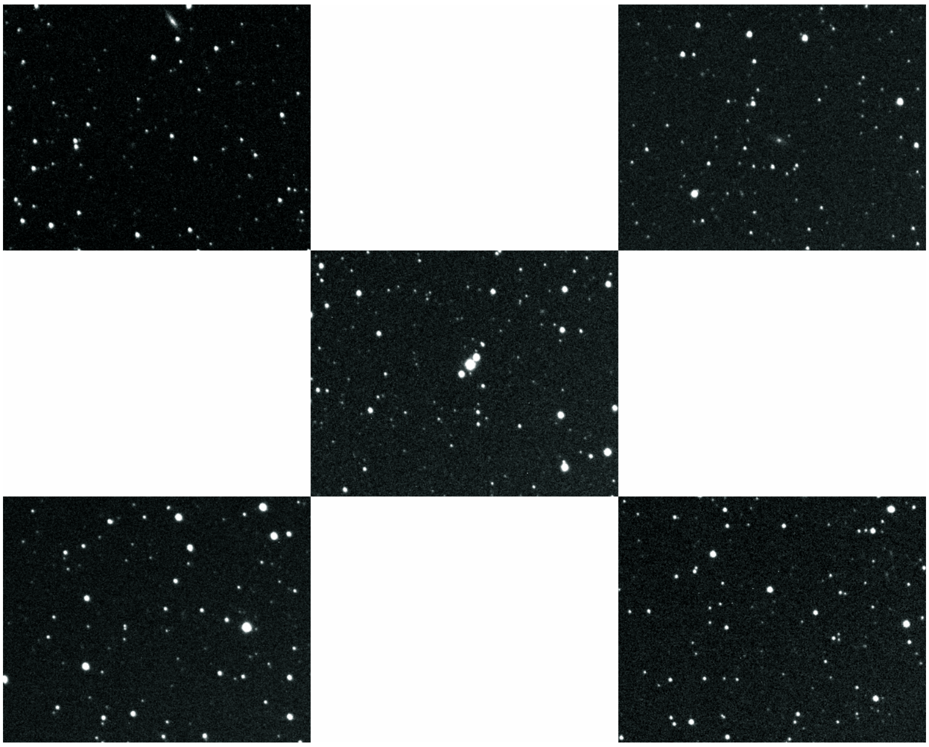

Figure 5. An image of the same region, after collimation. 2011 December 23.

want to consider the use of the CTU device, as it makes the task of collimation very straightforward. One limitation of my set-up with the Canon camera lens is that there is no room available along the optical axis for interposing filters. However, the lens has a slot for 52-mm drop-in filters which I find works well. I mainly switch between unfiltered operation for comet-searching and a 48-mm Astrodon dichroic V filter which just fits in the drop-in filter holder, where it is fixed with with a few spots of araldite. Interestingly, the drop-in filter is so far from the focal plane that any dust shadows are larger than the size of the image frame, so the same flat-field works whether or not the V filter is in position.

The cost of the CTU-EOS and adapter (excluding the lens, mounting rings, and RoboFocus) was €233.60.

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Asteroids and Remote Planets Section http://britastro.org/asteroids/
Finger Lakes Instrumentation http://www.flicamera.com/focusers/index.html
Camera Tilting Unit http://www.gerdneumann.net/english/astrofotografie-parts-astrophotography/ctu-camera-tilting-unit.html
Flange focal distance http://en.wikipedia.org/wiki/Flange_focal_distance

The Thompson 30-inch reflector at Herstmonceux

Gerald North

The East Gate barrier rises, and I drive my car onto the great estate that surrounds Herstmonceux Castle. Emerging through a tunnel of thickly planted trees and bushes, my destination comes into view on the rising ground to my right. It is not the castle but a complex of six domes, with buildings connecting the back row of three domes. The Sun has set, the now darkening sky is deep blue and clear of clouds, and my anticipation of the pleasures to come mounts on that evening back in the 1980s. A few minutes later my car is parked at the back of the easternmost of the two blocks that connect the rear domes, and I enter through the great doors.

Alone in the building, my footfalls echo as I walk further eastwards along the corridor until I arrive at the plate store. Retrieving my box of cut Kodak IIa-O plates, I walk back along the corridor and then further westwards, through the cylindrical area above which is Dome B, and onwards, until I reach the staircase of the western block. I ascend the stairs, turn right onto a long gallery extending westwards, pass a door labelled 'Dome A Darkroom', and walk towards the end of the gallery. Having passed a door to my right (the observer's rest-room), I open the door facing me. I then step out into the evening air and onto the short walkway that connects to Dome A and its balcony.

In front of me is the door to Dome A. I open it and enter. All is dark inside, so I reach forward and open the door of the little wall-mounted cupboard just in front of me. 'Clunk!'... I have pulled the shiny handle, a quiet buzzing begins, and lights come on. I am in a small vestibule, little more than a metre square. Facing me is the door to the mezzanine level, where I will be entering shortly; but for now I turn right and start to climb the narrow staircase that curves around the inside wall of the dome and up to the observing floor. As I do so, I cannot resist again turning my head to look at the multi-ton telescope that begins to come into view. It is bathed in the light of the strip-lamps shining brightly from the interior of the great dome and the softer lights glowing from their flush fittings in the wooden-clad walls below. I step up onto the observation floor, cross to the desk, put down the box of plates, and use the telephone to notify the security staff in the castle lobby that I am on site: 'Hi Martin, it's Gerald North in Dome A…'

Beginnings

I very much enjoyed the article by Len Clucas about his years of working for Grubb Parsons in Newcastle (*I&I News*, New Series No. 5). Many famous telescopes issued from Grubb Parsons' workshops, as well as from the preceding company owned by Sir Howard Grubb in Ireland. Grubb telescopes included those purchased originally for the Royal Observatory at Greenwich, most of which were eventually, in the mid-1950s, resited at Herstmonceux in Sussex, near Hailsham and Eastbourne and just inland of the Pevensey marshes. It was at that time that the establishment was renamed the Royal Greenwich Observatory.

Between January 1985 and March 1990 I enjoyed the enormous privilege and pleasure of being a Guest Observer at Herstmonceux. Using a range of equipment, I carried out many projects and observational tasks throughout my time there – but notably lunar research, which involved taking spectra of sunlight reflected from the Moon's surface, using the Thompson 30-inch reflector. At the time, this telescope was configured to feed light into a high-dispersion spectrograph – an instrument built external to the telescope, and the parts of which spanned all three storeys of the building. However, that configuration was far from the original design and purpose of the telescope.

Conjoined twins

The Thompson telescopes resulted from a financial gift to the Royal Observatory from Sir Henry Thompson (1820–1904) – a surgeon and amateur astronomer. In 1896 when it was built, and for the next half century, the Thompson 30-inch reflector and the Thompson 26-inch refractor occupied the same German equatorial mount, the optical tube assemblies being situated at either end of the declination shaft, in the manner of mutual counterweights.

Figure 1 shows the 30-inch reflector during its early years at Greenwich. I have no further information about this photograph, but what appears to be a low-dispersion spectrograph can be seen attached to the Cassegrain focus. The primary mirror is perforated, so the instrument was presumably intended for optional use as a Cassegrain from the outset. Dr Henry C. King, in *The History of the Telescope* (1955), states that the primary mirror was made by Andrew Ainslie Common (1841–1903), but the rest of the telescope was manufactured by Sir Howard Grubb.

Originally this telescope was intended as a photographic instrument, and so would generally have been used in a Newtonian configuration. Figure 2 shows a photograph of the Pleiades taken in 1918. Again I have no further information, but the size of the field suggests that it was acquired at the Newtonian focus (and would also have required a coma corrector). Dr Derek Jones, astronomer at the RGO, told me that a long time previously he had indeed used the telescope as a Newtonian. Another source quotes the focal length of the primary as 11 feet 5 inches, producing a focal ratio of f/4.6, though I have no information on the original effective focal ratio at the Cassegrain focus. The instrument was also used extensively to photograph comets, asteroids, and planetary satellites, and during the course of that work, Philibert J. Melotte (1880–1961) discovered the eighth moon of Jupiter, named Pasiphae, in 1908.

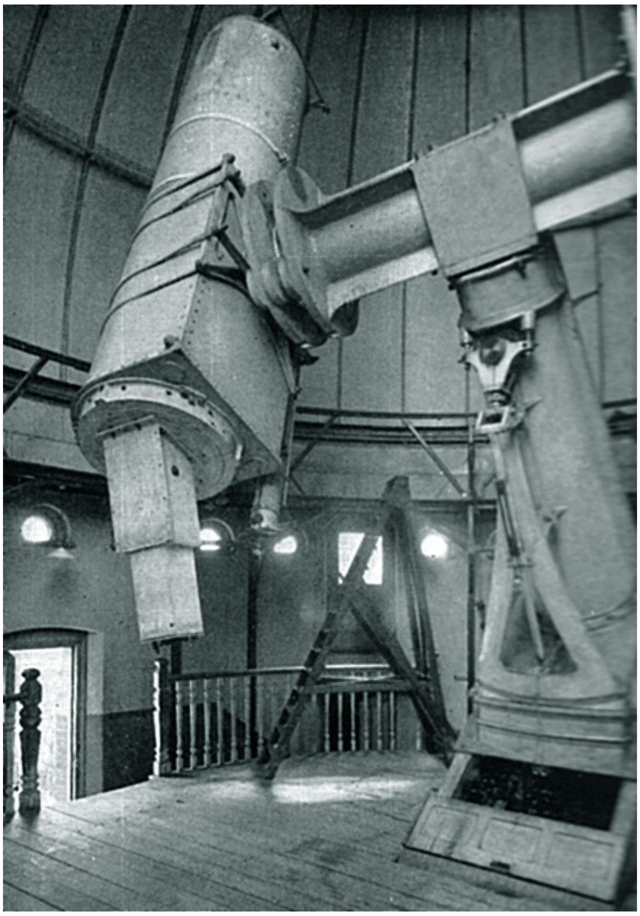


Figure 1. The Thompson 30-inch reflector at Greenwich.

Figure 2. The Pleiades, 1918.

Just before the Second World War, plans were initiated to relocate the observatory and its largest telescopes to a site that afforded better conditions than did London. The war intervened, however, and it was not until 1946 that the Admiralty chose the castle and its associated 380 acres of Sussex countryside at Herstmonceux. Setting up the new observatory was a very slow process, and it was not until the late 1950s that the main telescopes were ready for use in their new home.

In the interim, the 'Thompson twins' were split. The refractor remained on the equatorial mount, with a conventional counterweight added in place of the reflector. (Len Clucas has told me that he remembers seeing the Thompson refractor being worked on at Grubb Parsons.) At the same time, Cox, Hargreaves, and Thomson built a new fork equatorial mounting for the 30-inch reflector, and the instrument was eventually erected in the 26-foot Dome A at Herstmonceux, to become operational in 1956. RGO optical coatings expert David Jackson told me that the figure on the Thompson's primary mirror (and possibly the secondary mirror) was reworked by the telescope-builder George Hole in or about 1960. Figure 3 shows an early view of the dome – the sheet-copper cladding having only just begun to acquire its eventually much lighter green patina. The telescope tube was originally orientated in its new mounting with the flat face of the rear section (seen attached to the declination axis in Figure 1) facing downwards, and the 6-inch acquisition and guide refractor (partially visible in Figure 1) moved to the top.

The Thompson 26-inch refractor was erected in the 34-foot Dome E shown in Figure 4 – a photograph that I took from the balcony of Dome A at sunset on 25 January 1985. Visible in the background is the (by then unused) original dome of the Isaac Newton Telescope.

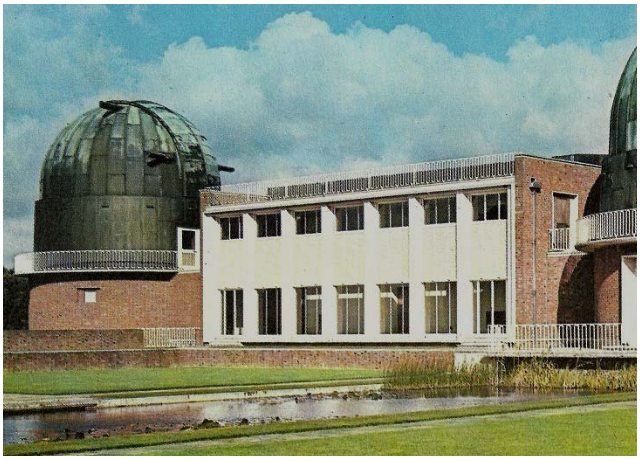


Figure 3. An early view of Dome A.

The Thompson reflector at Herstmonceux

The Thompson reflector's rôle as a general photographic telescope continued until 1963, when some very extensive modifications were made to accommodate the operation of the spectrograph that was installed in the building. The telescope's tube was turned over and then refitted in the forks, so the 6-inch acquisition and guide refractor was underneath (and remained unused from then on), and the flat face of the rear section of the telescope tube then faced upwards (see Figure 5). Doors were then fitted in this flat section (see Figure 6).

Presumably a new convex secondary mirror was made, it being positioned to produce a much less steep convergence of the rays after reflection than previously. I think that moving the existing secondary mirror towards the primary by the amount required would then have caused it to effectively stop down the telescope to a smaller effective aperture unless the secondary's diameter was overly large to begin with. It seems to me most probable that a new secondary mirror of a diameter similar to the original, but with a reduced radius of curvature (greater convexity), would need to have been substituted in a position similar to the original one. However, I cannot find any evidence in the literature to support my supposition of a replacement secondary mirror, although further information might be available.

In this new configuration the light would no longer emerge to focus at the Cassegrain (or indeed Newtonian) position, but would instead be diverted by another flat (tertiary) mirror, and would exit the telescope tube through the open doors. Figure 7 shows the light-path of this new arrangement. I believe that the configuration of the telescope has not been changed since I last used it, but I know nothing concerning the current state of the spectrograph.

The tertiary mirror is fitted inside the telescope tube on a mount slung between the tube's declination bearings that is geared to alter its tilt-angle by half any change in declination of the tube. In that way the beam of celestial light can be maintained pointing in a direction upwards along the celestial polar axis no matter where the telescope is pointed. However, light does begin to be lost through vignetting of the rays for declinations outside the range +55° to –20°, so this defines the nominal operating range of the telescope.

Having the light emerge upwards along the polar axis is highly unusual, as most large reflecting telescopes with a tertiary mirror have it arranged to fire the beam downwards through a hollow polar axle instead. In this case, however, the emergent beam of light is captured by yet another flat mirror situated atop a tall tripodal gantry positioned to the north of the telescope, as can be seen in Figures 7, 8, and 9 (though in the photograph the mirror's cover is not open).

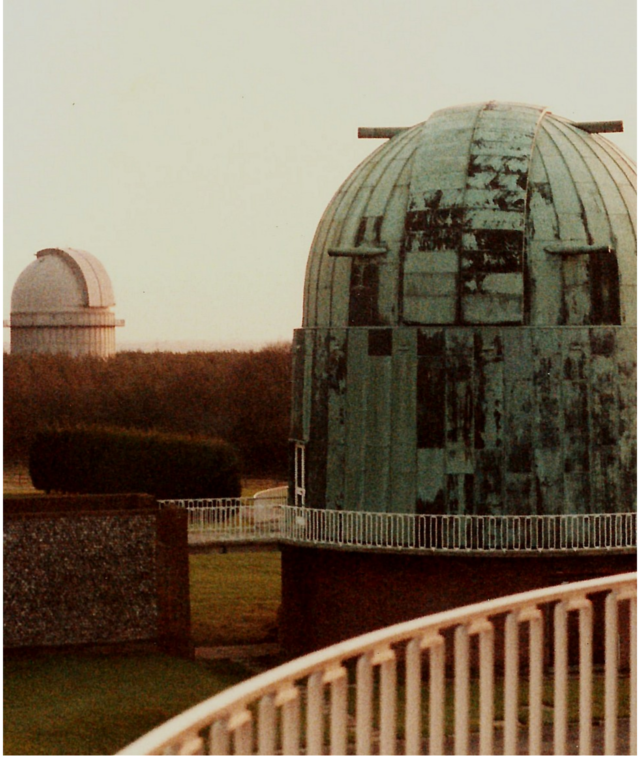


Figure 4. Dome E in the foreground.

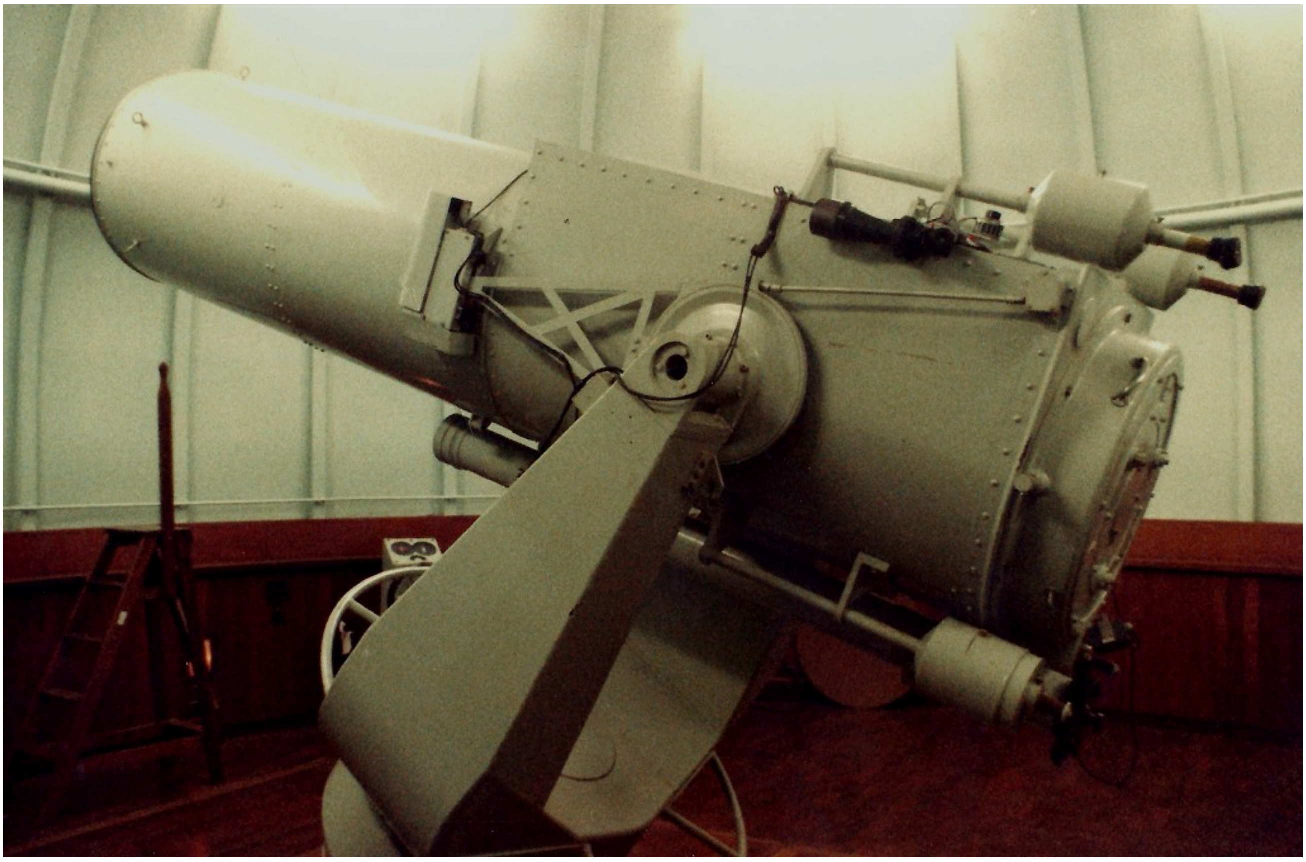


Figure 5. Showing the modifications of 1963.

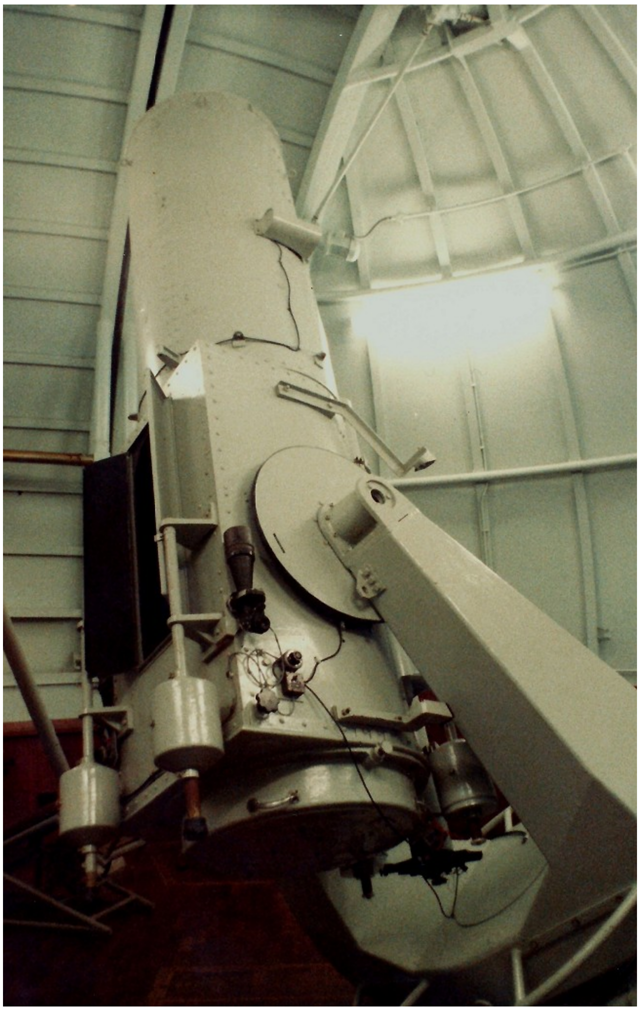


Figure 6. Showing the doors open.

As can also be seen in Figures 7 and 8, the light still has not ended its journey. The fourth mirror directs the beam vertically downwards to the head of the spectrograph.

Within the telescope, the secondary mirror is on a motorised mount (controlled by the observer) that allows it to move back and forth by a small amount for focusing. In normal use the light is focused onto the jaws of the entrance slit of the spectrograph. As might be expected, the effective focal ratio of the telescope at this focal position (the coudé focus) is rather high. Indeed, it is f/47, and so the image scale at the coudé focus is 5.8 arcsec per mm.

The coudé spectrograph

Reference to Figures 7 and 8 may help to clarify the following description of the spectrograph. First we consider the overall layout.

After passing through the slit, situated within equipment on the observation floor (shown in Figure 10), the now diverging light beam passes downwards via the mezzanine floor and further down to a collimating mirror situated on the ground floor. After passing down the 18 feet 8 inches between the slit and the collimating mirror, the beam of light has diverged to a diameter of approximately 121 mm.

After reflection from the collimating mirror the beam is sent back upwards, though now tipped at a small angle from that of its downward journey. The very gentle curve of the collimating mirror also has the effect of rendering the upward-going beam parallel (hence collimated), so it maintains its diameter of 121 mm up to the mezzanine level. There, situated in a gantry within a light-tight cupboard, a diffraction grating is placed to intercept the upward-going collimated beam. The grating is a rectangular piece of glass ruled with 600 lines per mm and aluminised, and held in a metal cell with an incorporated Schmidt-style corrector plate close to its surface. The grating disperses the light into its component wavelengths in a narrowly grouped spread of directions, each specific to a particular wavelength.

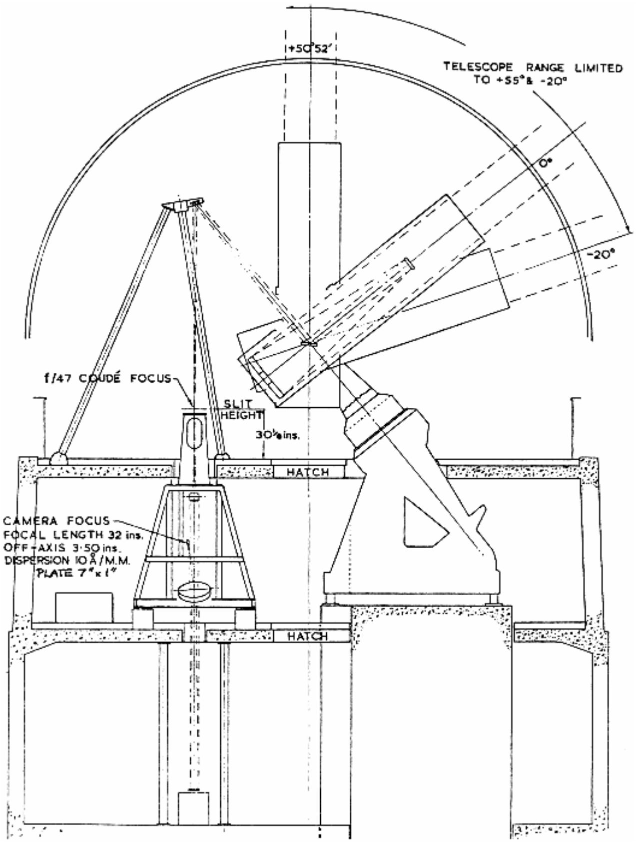


Figure 7. Arrangement of the coudé spectrograph: looking east.

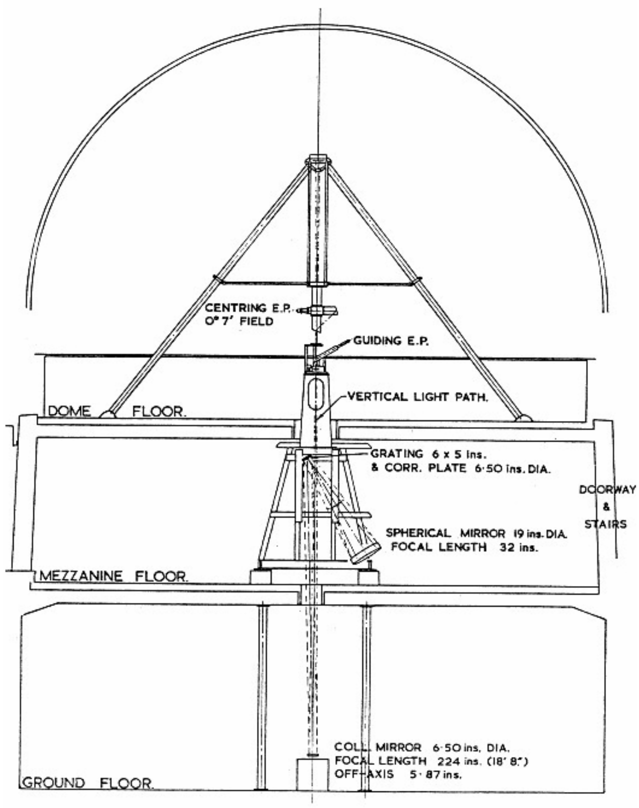


Figure 8. Arrangement of the coudé spectrograph: looking north.

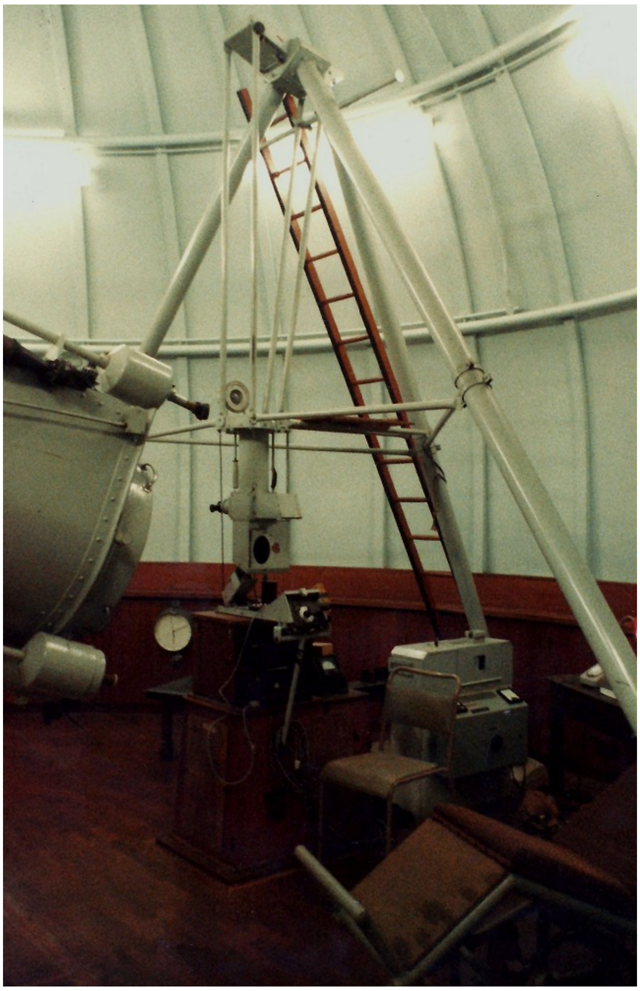


Figure 9. The tripodal gantry.

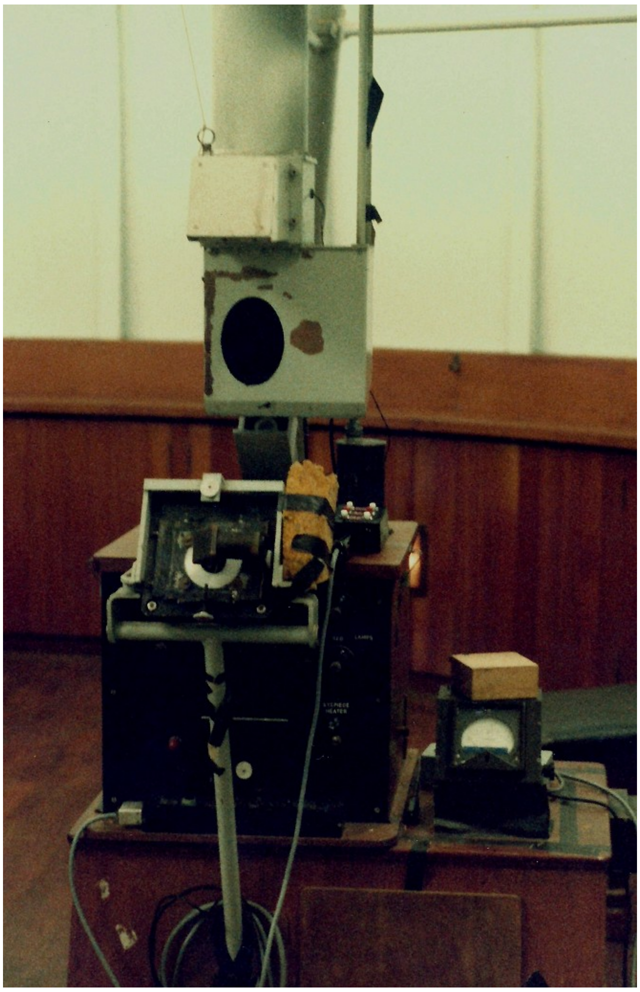


Figure 10. Slit containment.

The diffraction grating is angled to fire the dispersed beam towards a 19-inch diameter spherically concave mirror, also held within the housing. This mirror redirects the light towards a photographic plate and focuses the spectrum on its light-sensitive surface. The plate is held in a special holder attached to the gantry within the light-tight cupboard.

In essence, that is the spectrograph. Of course, in practise some additional technical paraphernalia are required for the observer to operate the system and obtain scientifically worthwhile results. For example, the slits in the spectrograph head have polished surfaces, which enables an optical system to monitor them and the image focused on them, and deliver the composite view to a guiding eyepiece. Figure 11 is a late-1980s photograph of myself at this guiding eyepiece (during daylight, and with the telescope not even pointing out of the dome slit). Looking through this guiding system one can see a very small field of view around the chosen target, and a black line passing down the middle, which is the image of the slit.

As can be expected, the telescope has the usual RA drive working at stellar rate. When taking the spectrum of a celestial body, the aim is to monitor, and correct as necessary, the main tracking using the telescope's ultra-slow-motion motors, operated with a handset. The target object is first moved to the slit, and then further moved to partially render it invisible while spanning the black line. In this way it can be ensured that the light from the target object is indeed dropping through the slit and down into the spectrograph.

In this era of routine auto-guiding, even for many small amateur telescopes, it is easy to forget that it is not so very long ago that even professional astronomers had to spend much of each observing night glued to an eyepiece whilst keeping a star's image on a crosswire or spectrograph slit.

The magnification at the guiding eyepiece is of the order of

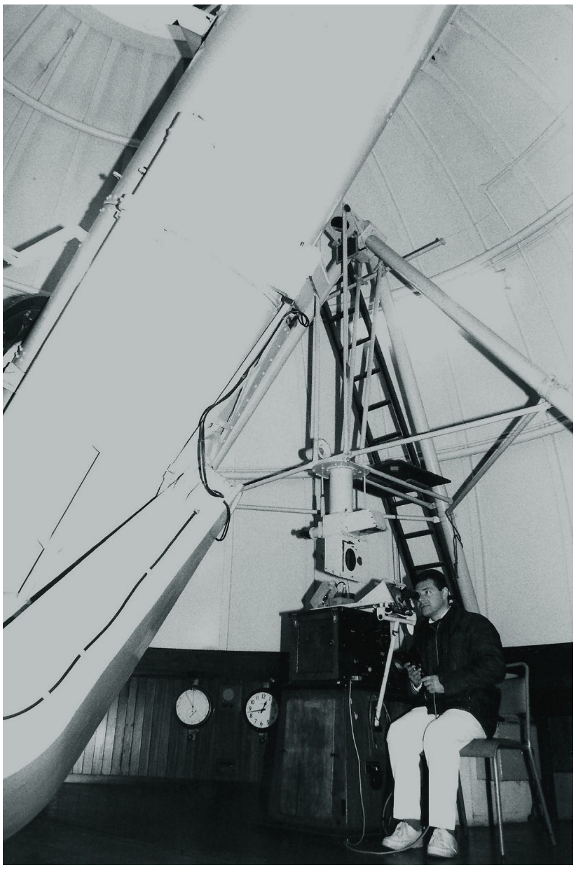


Figure 11. A pose for the record.

x2000, and the field of view is only about 20 arcsec. There is no computer-controlled ‘go to’ on this old telescope, and so acquisition of the target is achieved in two steps. First, using either one of the two small finder telescopes positioned at either side of the telescope tube – one of which is visible (the small black prism monocular) in the upper part of Figure 12 – manually slew this multi-ton telescope and set the target on the illuminated crosswires. Then lock the telescope’s clamps – manually in the case of the declination axis, and electrically by the flick of a switch to lock the telescope in RA. The second stage is for the observer to go to the observing floor equipment situated beneath the great tripod just north of the telescope. There the observer slides a mirror into position that interrupts the light beam before it reaches the slits. This mirror bounces the light off yet another mirror and then into the acquisition eyepiece. Figure 13 shows the eyepiece in the foreground (the eyepiece pointing to the right). Beyond, looking to the south, can be seen a night-time view of the telescope pointing through the open dome slit and towards the Moon. The field of view in the acquisition eyepiece is about 7 arcmin, and the magnification is of the order of x200. Using buttons on the handset to work the slow-motion motors of the telescope, the target is placed central within a small square defined by the crossing of two sets of parallel crosswires in the middle of the field of view. The acquisition mirror is then slid out of the light path, and the observer takes up a seated position at the guiding eyepiece to fine-adjust using the ultra-slow-motion controls, as described previously.

The head of the spectrograph contains some other equipment needing to be set or controlled. The slit gap is adjustable, but I always kept it set to 0.15 mm, corresponding to slightly less than 0.9 arcsec. A narrow slit produces a high resolution in the final spectrum, but with the size of a star’s seeing-disk usually being around 3 arcsec, not all of the starlight is sampled. Actually, I did little stellar spectroscopy. Most times it was the image of certain locations on the surface of the Moon that I set over the slit.

A set of prisms allows the light from a low-pressure discharge lamp to be fed through the slit into the spectrograph alongside the light from the celestial source. Various discharge lamps could be installed, but it was never changed from a copper–argon tube in the years that I used the telescope. The duration of the comparison spectrum burn was set from the electrical equipment-stack situated in the mezzanine floor-level, but set going by pressing a button at the spectrograph head controls on the observing floor.

Normal practise was to make a comparison spectrum exposure just after the commencement of the exposure of the celestial source, and another just before the end. In that way the sharpness of the lines on the comparison spectrum would show that there had been no relative motion between the spectrum and the plate due to any of the spectrograph components moving during the exposure. Such movements might be caused by temperature changes, or perhaps by spurious pulses being fed to the grating drive. In addition, a set of grey-scale stripes could be placed on the photographic plate, similarly fed through the slits from a filtered light source, and again controlled from the guiding position. The purpose of this was to help calibrate the sensitivity-versus-wavelength response of the photographic plate.

There was no CCD camera with that spectrograph! The RGO obtained from Kodak boxes of 10 x 2 x 0.4-inch glass plates coated with the required emulsion. The plates normally used were IIa-O, which had maximum sensitivity at around 4350 Å (435 nm) in the violet, and useable sensitivity ranging from the near ultraviolet to the green. Every so often I opened a new box of these plates in a mildly refrigerated darkroom/plate-store in the Equatorial Group building, and used a special plate-cutter to produce, from each plate, two 7 x 1-inch plates (the waste pieces being discarded). IIa-O

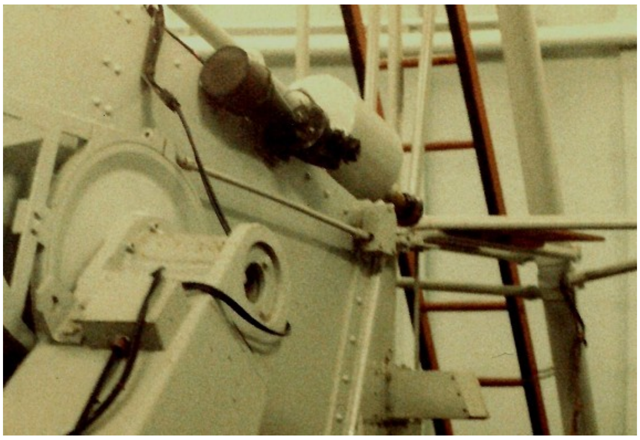


Figure 12. One of the finder telescopes.

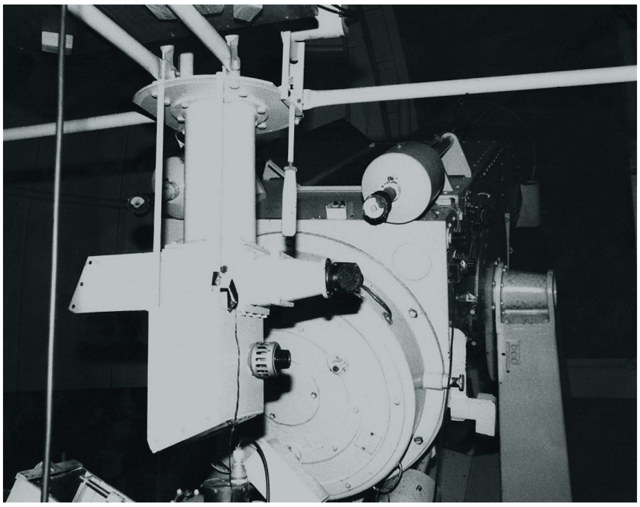


Figure 13. The acquisition eyepiece.

emulsion was relatively insensitive to red light, but the overall sensitivity of the plates was such that I had to work under a red safelight that was so dark that it actually made very little difference to the total darkness in the room. I kept each new batch of these cut plates in a special labelled box.

Moonshine and the Thompson

‘See you later, Martin’. I put down the telephone, cross the observing floor to the dome controls, and start the motors that slowly open the biparting shutters. They will stop automatically when the dome slit is fully open, so while this is happening I become busy, first removing the large lid from the front of the telescope, unclamping the tube in declination and heaving it into position to point at the zenith, and then opening and locking open the coudé doors and reaching in to remove the cover from the tertiary mirror – the primary and secondary mirrors being already exposed. Next I go to the great tripod situated behind the telescope, and by operating a pull-cord I let the cover over the fourth mirror flap open. I then remove the cover over the entrance hole of the spectrograph head.

The shutters have nearly fully opened, and the change in the air inside the dome is noticeable as I pick up the box of photographic plates and head down the stairs to the mezzanine level. There, on a small control box affixed to the telescope’s footings, is the selector knob that I turn to switch on the telescope’s RA drive. It has first to be switched to ‘mains’ for at least a minute, so I next put down the plate box in the small plate-loading enclosure. I check the settings on the electronics stack (for instance, the comparison spectrum tube settings) and then enter the light-tight spectrograph enclosure to open all the covers, and the cover of the collimating mirror (on the ground floor, but opened from here by a pull-cord). I also check that the correct grating is still in place and that the angle is set to 30°, which ensures that my desired range of wavelengths – spanning about 1600 Å (160 nm) and centred on approximately 4350 Å (435 nm) – will appear on the processed plate.

Next I unclamp the brass plate-holder and take it into the plate-loading enclosure. Switching on the extremely dim red light and closing the door behind me, I transfer a plate from my box to the holder. In the near darkness I have to be very careful that I insert the plate in the holder emulsion-side upwards. To ensure this I gently rub my finger on a corner of the plate to detect the silky feel of the emulsion. When the top is placed on the plate-holder the glass flexes, bending into an arc with the emulsion face convex on the outward-facing side. This is because the optics of the camera system produce a curved focal surface; but the inconvenience is tolerated because the optical design generates the great benefit of a linear representation of the spectrum on the plate. Therefore, I also have to proceed carefully and very gently in pushing the cover into place and turning the brass fixing buckles in a way that does not break the plate. After ensuring that the dark-slide is firmly in place over the front of the holder, I exit the loading enclosure.

Passing the telescope's RA drive control, I change the setting to 'amplifier', so the telescope is now being driven very accurately at sidereal rate by a signal delivered via underground cable from the atomic clock in the Time Department on the western side of the castle estate. The signal amplifier has to first warm up and stabilise before it can take the current load for the motor, which is why I have to wait at least a minute before engaging it after start-up.

Entering the light-tight spectrograph enclosure once more, I fix and lock the plate-holder back into its proper place. At this stage I leave the dark-slide in place. It is now time to go upstairs again.

On the observing floor I switch off the dome's bright strip-lights (but leave on the dimmer wall-lights for the moment), turn the dome lead isolator control, and unplug the heavy dome lead and stash it along a section of the narrow dome-ring shelf. Then I press the button to rotate the dome in the direction required. I hear the several powerful induction motors whirr up to speed, and the dome rumbles as it begins to move. I watch as the strip of sky I can see through the open dome slit changes. I judge when to remove my finger from the button, and after a few seconds the dome rumbles to a stop at the correct place for the telescope to view my chosen target.

I set about training the telescope on the Moon, and moments later I am standing at the acquisition eyepiece beneath the tripodal gantry, viewing the Moon's great plains, rugged mountains, and stark craters. The lunar image is very bright, as it is formed at a magnification of less than x7 per inch of telescopic aperture, so at this stage I leave on the dim wall-lights. The image of the Moon I am looking at is a little unfamiliar compared to that through my own Newtonian telescopes at home. First, there is an odd number of reflections, so the image is mirror-reversed; and second, due to the complex configuration of the light-path, the image is 'tipped over' (neither north nor south directly upwards), and slowly rotates during the night as the telescope tracks its target. However, I have no difficulty in navigating the lunar surface.

From the above description it might seem that these procedures must take a considerable amount of time, but the equipment is all so conveniently arranged and of such good quality that it actually takes only a few minutes. What happens next is dependent on my observational programme. For lunar work I often also set up the Yapp 36-inch reflector in nearby Dome B. In practise it took moments to walk along the connecting gallery from one dome to the other, so using both telescopes in tandem in one session was easy to do.

Let us say that at this point I have now moved the image of a particular feature – for example, a section of the north wall of the crater Plato – to the centre of the square defined by the overlapping sets of crosswires, and I am ready to acquire a spectrum. I slide the acquisition mirror out of the light path, take my seat at the guiding eyepiece, and use the ultra-slow-motion controls to bring the target over the slit. Then I leave my post to go downstairs to the mezzanine level, where I open up the spectrograph enclosure, and turn off all the lights! Moving carefully, in total darkness, into the enclosure, I feel for the plate-holder. I have it – and now I feel along it for the protruding small handle, and pull it out as far as it will go. I have now slid open the dark-slide. Any light coming through the spectrograph can now be recorded – but nothing is coming through just yet, of course.

I move out of the enclosure and close its door, then feel my way out through the door of the mezzanine level and into the vestibule. I close the door behind me, climb the stairs back onto the observing floor, and again take my seat at the guiding eyepiece. The Moon moves quite rapidly in both RA and declination relative to the stars, so I have to retrim the telescope's fine pointing to place the target feature back across the black line that defines the slit. In rapid succession I throw the override switch that turns off the wall lights, open the spectrograph shutter, press the button that initiates the first of the 25-second comparison spectrum burns, turn on the grey-scale instrument, and make a note of the time.

The correct exposure time depends on the subject. In the case of the Moon it also depends on its phase and the proximity of the selected feature to the terminator. An exposure of 3 minutes may be right for a lunar feature at the time of full Moon, whereas 20 minutes might be more appropriate at times near first or last quarter. In all cases, I also have to allow for atmospheric transparency.

However long the exposure in the case of the Moon, I have to be attentive and busy making corrections to the telescope's position in RA and declination. In the case of stellar spectroscopy, when a star is on the slits I hardly ever have to touch the ultra-slow-motion controls because the instrument's tracking is amazingly good.

In the last minute of the exposure I press the button to initiate another 25-second comparison spectrum burn, and, at the correct time, close the shutter and make a note of the time. However, the grey-scale exposure has to be 15 minutes, and so this must continue even after the end of a shorter exposure to the celestial light.

Finally, when all is done at the spectrograph head controls, I go downstairs, re-enter the spectrograph enclosure in complete darkness, and finally close the plate-holder's dark-slide. Then I switch on the lights, unclamp the plate-holder, and take it into the plate-loading enclosure. I transfer the plate containing the first spectrum of the night to a special box to await processing, and load the next fresh plate into the holder. I have obtained one spectrum but I may collect several more during an observing session.

Thanks to the quality of the equipment, the whole experience was always thoroughly enjoyable. If I was able to stay for a long session (I did many dusk-to-dawn sessions in those days), then I could take a break part way through the night and avail myself of my stash of provisions in the rest room. I also made time for a short chat with the security officer on his rounds. During a break I might even go for a short nocturnal stroll round the balconies of the domes, to take in the wonderful atmosphere of the observatory on a starry night. It was always with reluctance that I closed down the instruments for the night and drove home.

Endings... and new beginnings

I would normally go back to the site during daylight hours to process the plates in the Dome A darkroom, using the specialist equipment and chemicals there. Subsequent to that, I would book some time on the fabulously expensive Perkin–Elmer Plate Density Scanning Instrument housed in a temperature-controlled basement room in the West Building across the other side of the castle grounds. The equipment and banks of control panels in that room looked like a set that might have been used on a big-budget 1970s science fiction television show.

Figure 14 is a composite of a photographic print I made in sections along one of the plates from the high-resolution spectrograph. It shows a spectrum of sunlight reflected from a short section of the north wall of Plato, recorded in a 3-minute exposure on the night of 5 March 1985, when the Moon was close to full. The convention of 'red to the right' should be observed in presenting spectra; so, here the wavelength range spans 3550 Å (the left-hand side of the bottom strip) to 5040 Å (the right-hand side of the top strip).

The central stripe is the lunar absorption spectrum, and the lines above it and below it are the emission lines of the copper–argon comparison source. On the plate the grey-scale stripes appear below these spectra but are not included here. This spectrum is therefore an example of the typical end-product of the machine that is the Thompson reflector and its high-dispersion spectrograph contained within Dome A at Herstmonceux.

The Thompson reflector was a very useful instrument right from the time off its birth at the end of the nineteenth century, and it remained so until the late twentieth century. Now the RGO is no more, and for several years after 1990 the buildings and observatory were left to decay. Today, though, the staff of the Observatory Science Centre have taken over the Equatorial Group at Herstmonceux and are running the telescopes as an outreach facility, all the while gradually restoring them. I know from their website that people sometimes look at bright celestial bodies through the acquisition eyepiece of the Thompson reflector. I am definitely in favour of that. I would love to think that perhaps some day soon in twenty-first century the Thompson reflector might also once again be used as a research tool. It certainly deserves to be.

Narborough, Norfolk gerald.north@ssesurf.co.uk

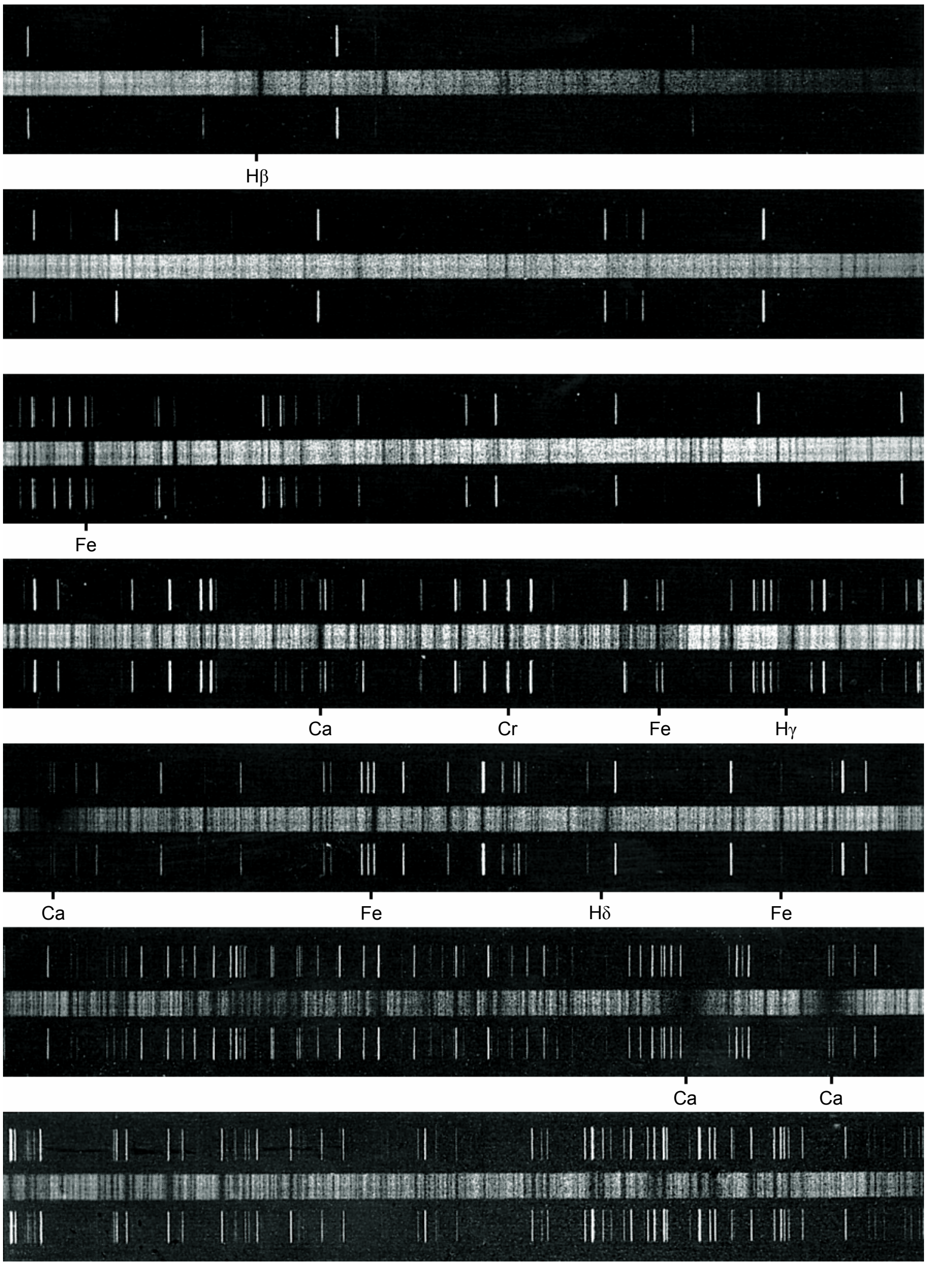


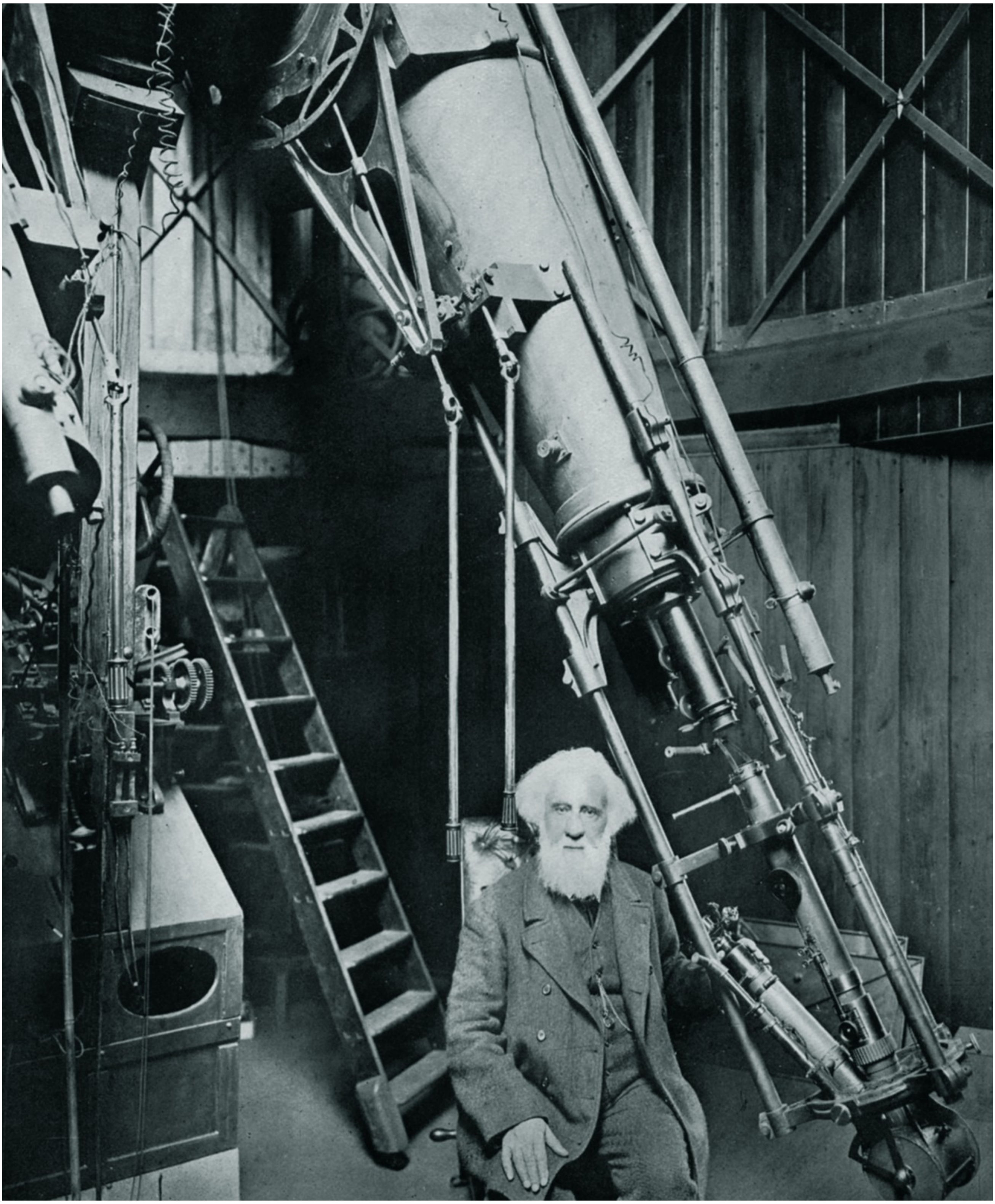
Figure 14. A spectrum of sunlight reflected from a short section of the north wall of Plato.

William Huggins' twin equatorial

Bob Marriott

In *I&I News* New Series No. 5 (9 February) I included an illustration of a Grubb twin equatorial from a catalogue of 1888 – to which Kevin Kilburn responded with a short article and a photograph of the Godlee Observatory twin in Manchester (No. 6, 28 April). The Thompson instruments (above) were originally twinned – so now, here is the first Grubb twin.

William Huggins (1824–1910) was a pioneer in astronomical spectroscopy, and received considerable recognition for his achievements. He was honoured as Knight Commander of the Order of the Bath, and was recipient of the Order of Merit (a personal gift of the sovereign, established by Edward VII and first awarded on 26 June 1902), the Gold Medal of the Royal Astronomical Society, the Royal Society's Royal Medal, Rumford Medal, and Copley Medal, the Bruce Medal of the Astronomical Society of the Pacific, and the Henry Draper Medal of the National Academy of Sciences. He also served as President of the Royal Astronomical Society and President of the Royal Society, and was a founder Member of the Association, serving on the first Council. He was, of course, an amateur astronomer, and his residence and observatory were situated at Tulse Hill, in the London Borough of Lambeth.



Huggins set up his first observatory, equipped with a 5-inch Dollond refractor, in 1856, and two years later acquired an 8-inch Alvan Clark object-glass, with a mount and drive supplied by Thomas Cooke. Eventually, however, routine observation dulled his interest, and in 1862 he began work in collaboration with William Allen Miller, Professor of Chemistry at King's College, London, in comparing spectra of chemical elements with stellar spectra. After the joint publication of several papers, Huggins continued his astronomical work alone. On 29 August 1864 he turned his spectroscope to the planetary nebulae NGC 6543 (HIV37) – the Cat's Eye nebula, in Draco. On obtaining a single bright line and two fainter lines he realised that the light was monochromatic and that it was the spectrum of a luminous gas, and not of unresolved stars. Huggins later wrote: 'The riddle of the nebulae was solved... There remained no room for doubt that the nebulae... are the early stages of long processions of cosmical events, which correspond broadly to those required by the nebular hypothesis in one or other of its forms.'

Here, then, are a few passages selected from Huggins' accounts of the inspiration for his work, the twin equatorial, and the first spectroscope that he designed. The papers were originally published in *Philosophical Transactions of the Royal Society* (1880), *Astronomy and Astrophysics* (1893), and *The Nineteenth Century Review* (1897), and were reprinted in *Publications of Sir William Huggins' Observatory*, vol. 2 (1909).

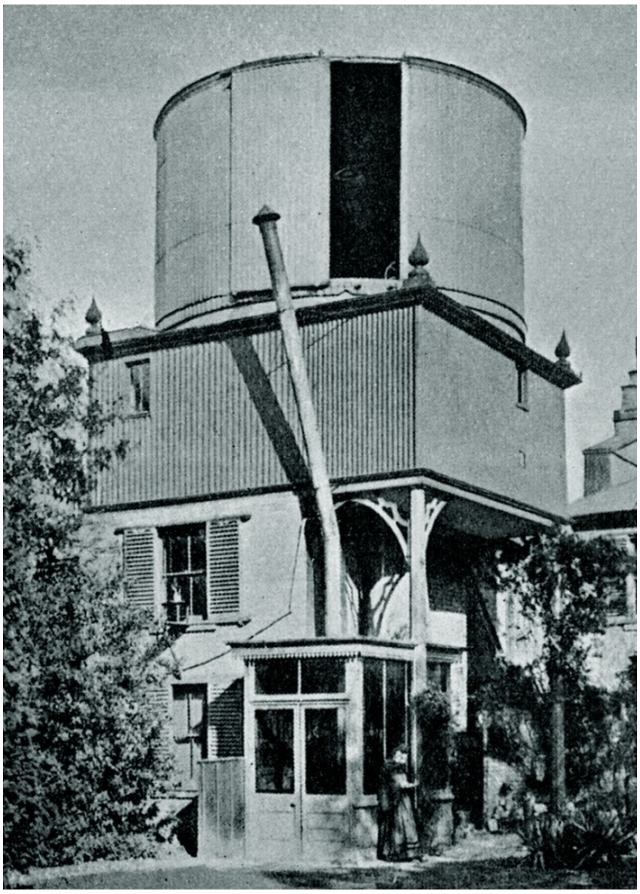
I soon became a little dissatisfied with the routine character of ordinary astronomical work, and in a vague way sought about in my mind for the possibility of research upon the heavens in a new direction or by new methods. It was just at this time, when a vague longing after newer methods of observation for attacking many of the problems of the heavenly bodies filled my mind, that the news reached me of Kirchhoff's great discovery of the true nature and the chemical constitution of the Sun from his interpretation of the Fraunhofer lines. This news was to me like the coming upon a spring of water in a dry and thirsty land. Here at last presented itself the very order of work for which in an indefinite way I was looking: namely, to extend his novel methods of research upon the Sun to the other heavenly bodies. A feeling as of inspiration seized me: I felt as if I had it now in my power to lift a veil which had never before been lifted; as if a key had been put into my hands which would unlock a door which had been regarded as for ever closed to man – the veil and door behind which lay the unknown mystery of the true nature of the heavenly bodies. This was especially work for which I was to a great extent prepared, from being already familiar with the chief methods of chemical and physical research.

...

In 1870 my observatory was enlarged from a dome of 12 feet in diameter to a drum having a diameter of 18 feet. This alteration had been made for the reception of a larger telescope made by Sir Howard Grubb, at the expense of a legacy to the Royal Society, and which was placed in my hands on loan by that society. This instrument was furnished with two telescopes: an achromatic of 15 inches aperture and a Cassegrain of 18 inches aperture, with mirrors of speculum metal. At this time only one of these telescopes could be in use at a time. Later on, in 1882, by a device which occurred to me of giving each telescope an independent declination axis, the one working within the other, both telescopes could remain together on the equatorial mounting, and be equally ready for use.

...

[The Tulse Hill spectroscope] was designed primarily for the purpose of mounting upon the 15-inch refractor belonging to the Royal Society a fine 4-inch Rowland grating which was furnished to me by Mr Brashear.



A condition of fundamental importance in the adaptation of the spectroscope to the telescope is that the instrument shall remain perfectly rigid in all its parts relatively to each other, and also to the optical axis of the telescope, in all positions of the telescope. It appeared to me that this condition would be most certainly secured by making the spectroscope complete and rigid in itself, independently of its attachment to the steel tubes, by which it is supported. The spectroscope if removed from the telescope would remain a complete and rigid instrument.

The firm attachment of this spectroscope to the telescope is carried out by means of three steel tubes of $1\frac{3}{8}$ inch external diameter, which slide in three long brackets strongly bolted to the iron eye end of the steel tube of the telescope. These tubes, as can be seen in the photograph, are further held together and formed into a stiff supporting cage by two iron ring-brackets through which they pass. The ring-bracket near the ends of the tubes supports the heavy part of the spectroscope, consisting of the grating and prism box: the other ring-bracket supports the collimator near the slit end, and strengthens the tube-cage near the middle of its length.

By means of adjusting screws in these ring-brackets the axis of the collimator can be brought into line with the optical axis of the telescope. The other necessary adjustments are also provided for. By the large milled head on the top of the collimator, the spectroscope, as a whole, can be moved so as to bring the slit to the focal plane of the object-glass for the part of the spectrum under observation; and a fine graduation on the sliding tube enables this adjustment, and also any similar adjustment that may be required for changes of temperature, to be found at once after the necessary data have been obtained. The adjustment of the collimator lens can be made by a smaller milled head. By an arrangement, which explains itself in the photograph, the collimator and telescope can be focused simultaneously.

The collimator, and the telescope, fixed at an angle of 25°, are firmly attached to the grating-box, and are further secured from relative flexure by a gun-metal collar fitting into the iron ring-bracket.

The grating is mounted in an air-tight metal case, provided with shutters to open when it is in use. This case slides into the box against a fixed point so as to secure the grating always taking up the same position. A prism of 37°, silvered on one face, similarly mounted, can take the place of the grating when small dispersion is required.

The grating, or prism, is moveable about the axis of the box, by a rod which is placed conveniently for the hand of the observer. At the top of the box, which is strengthened internally by metal compartments, a sector is fixed on the moveable axis, which is graduated on silver, and is read by a small telescope. The graduated edge of the sector, which can be illuminated by a small incandescent lamp, is divided into spaces of 5', and reads by the aid of the vernier to 10".

The telescope of the spectroscope is provided with a micrometer by Troughton and Simms, the fine webs of which are very successfully illuminated simultaneously from both sides from one small incandescent lamp, on an original plan devised by them. The amount of illumination can be varied by means of a small resistance coil to suit the object under observation. With the feeble illumination which is necessary for most celestial objects, it is not easy to read the number of whole revolutions of the micrometer screw, in the usual way, from the teeth of the comb. A simple form of a revolution-counter is geared into the outer rim of the micrometer head, and turns with it without sensible friction. The micrometer heads and their revolution-counters can be illuminated at pleasure by means of two small moveable incandescent lamps suitably placed above them. The micrometer screw has 100 threads to the inch; and when the second order of the grating, ruled to 14,438 [lines] to the inch, is in use, about $^{23}/_{100}$ of a revolution are equal to one-tenth metre.

The collimator and telescope have thin cemented lenses of 2¼ inches diameter; that of the collimator is provided with a diaphragm reducing it to 2 inches, which is its effective aperture; as the collimator has a focal length of 24 inches, and the object-glass of the telescope a ratio of f/15. The telescope of the spectroscope has a focal length of 18 inches, and is provided with four eyepieces magnifying respectively 12, 18, 22, and 29 diameters.

For photography the eye-part of the telescope can be replaced by a camera, and the whole instrument rotated through 90°, so as to bring the length of the slit in the direction of the star's motion.

The grating-box can be uncoupled from the collimator and removed from the supporting iron ring, and replaced by a battery of glass prisms, the same telescope and micrometer, or photographic lens and camera, being then attached.

A novelty in this instrument, which will be seen at once to be one of great practical importance, consists of a simple but very effective arrangement by which a star can be brought at once, and kept steadily, within the jaws of the slit. For my primary photographic work on the spectra of the brighter stars, I devised in 1875 a method of bringing and keeping a star within the slit.

Ridley Grant

The Ridley Grant commemorates the work and beneficence of Harold B. Ridley: Member 1946–95, Director of the Meteor Section 1954–68, President 1976–78, and recipient of the Merlin Medal and Gift (1976) and the Walter Goodacre Award (1992). The Council of the Association makes, at its discretion, monetary grants for worthwhile observing projects and equipment. Grants of up to £1,000 are awarded to individuals or groups, but not to those who have received a grant within the previous five years. An applicant must be a Member of the Association, with a minimum five years' continuous current membership. Applications – which can be submitted at any time – are forwarded to a small committee, which has the task of ensuring that the various rules have been followed and that the proposals are worthwhile. This committee can call on other consultants. If and when an application passes the committee stage, it is presented for discussion and decision at a meeting of Council. A recipient of a grant will normally be expected to provide, within a reasonable time, a written report concerning what has been achieved with the aid of the grant. The report, if appropriate, will be published in the *Journal*.

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Robotic Telescope Project

The Robotic Telescope Project allows BAA Members access to remote telescopes and imaging systems at attractive rates. Members are able to use the service at half the commercial rate up to a limit, then at full rate, and are provided with access to a wide range of equipment beyond a private budget. It also allows users to benefit from observing from a location with a better climate than Britain's, including access to telescopes in the southern hemisphere. This project is managed independently of the Sections, and all enquiries should be directed to the Robotic Telescope Coordinator. For details and an application form, see the RTP website, which includes a selection of results obtained by Members.

Peter Meadows   Robotic Telescope Coordinator   robotscope@britastro.org   http://britastro.org/robotscope

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Many a night from yonder ivied casement, ere I went to rest,
Did I look on great Orion, sloping slowly to the west,
Many a night I saw the Pleiads, rising thro' the mellow shade,
Glitter like a swarm of fireflies, tangled in a silver braid.

From *Locksley Hall*
Alfred, Lord Tennyson

It cannot be determined how the weary soldier, remembering his childhood home, managed to see Orion setting and the Pleiades rising, unless as a child he had leaned out of a south-facing casement to look east or west at various times of night throughout the seasons. And yet, in consideration of the numerous scientific blunders in literature, Tennyson, who was Poet Laureate, usually consulted the Astronomer Royal, George Biddell Airy, about any astronomical occurrence. In the following century, Frank C. Jordan, Director of Allegheny Observatory, recommended: 'Read a little astronomy once a month or oftener, and see your astronomer at least twice a year.'