1976JBAA...86..280W

A MINIATURE SPECTROGRAPH—ITS CONSTRUCTION AND APPLICATION

C. J. Watkis
136 Cannons Close, Bishops Stortford, Herts.

Introduction

During the British Astronomical Association Meeting of 1974 June 26, Patrick Moore explained that a new stage in the Transient Lunar Phenomena project of the Lunar Section was required. He explained that the Lunar Section had amassed a large number of sightings, and although it was now almost universally considered that the Moon was not a dead world, spectrograms of a TLP were necessary, not only as additional proof, but also to attempt to establish the nature of such events. He felt that such an ambitious project was outside the province of an amateur and had enlisted the help of the Dundee and Keele University Observatories. They were to go into action when alerted by the TLP Network. It was decided that Patrick Moore's challenge should be accepted, and an investigation into the possibility of constructing a spectrograph by an amateur began.

Design

Before a design could be attempted a set of limitations for the spectrograph were devised. These were as follows:

1. It had to be small enough to attach to a small amateur telescope.
2. It had to be light in weight so as not to put a strain on either the instrument or its mounting.
3. Its cost had to be low enough to be within the reach of most amateurs.
4. All the materials had to be easily obtainable.
5. It had to be effective and must split the two 'D' lines of sodium.

It was considered that the basic design of a conventional spectroscope was not only bulky and heavy, but too cumbersome for use on a small telescope, and therefore required modification. The basic parts, namely the collimator and the view telescope were kept, but placed parallel to one another (figure 1), and two front surface mirrors angled at 45° used to divert the light beam from the collimator to the view telescope. The dispersing medium was placed between the mirrors.

It was decided to use a good quality replica diffraction grating in preference to a prism for the following reasons:

1. It was lighter in weight.
2. It was low in price.
3. It diffracts the spectrum evenly over the whole range unlike a prism spectrum which compresses the red end and extends the blue.
4. It allows a zero order spectrum (white light) to pass straight through.

In a conventional spectroscope, viewing different parts of the spectrum requires moving the view telescope in relation to the dispersion medium, but

1976JBAA...86..280W

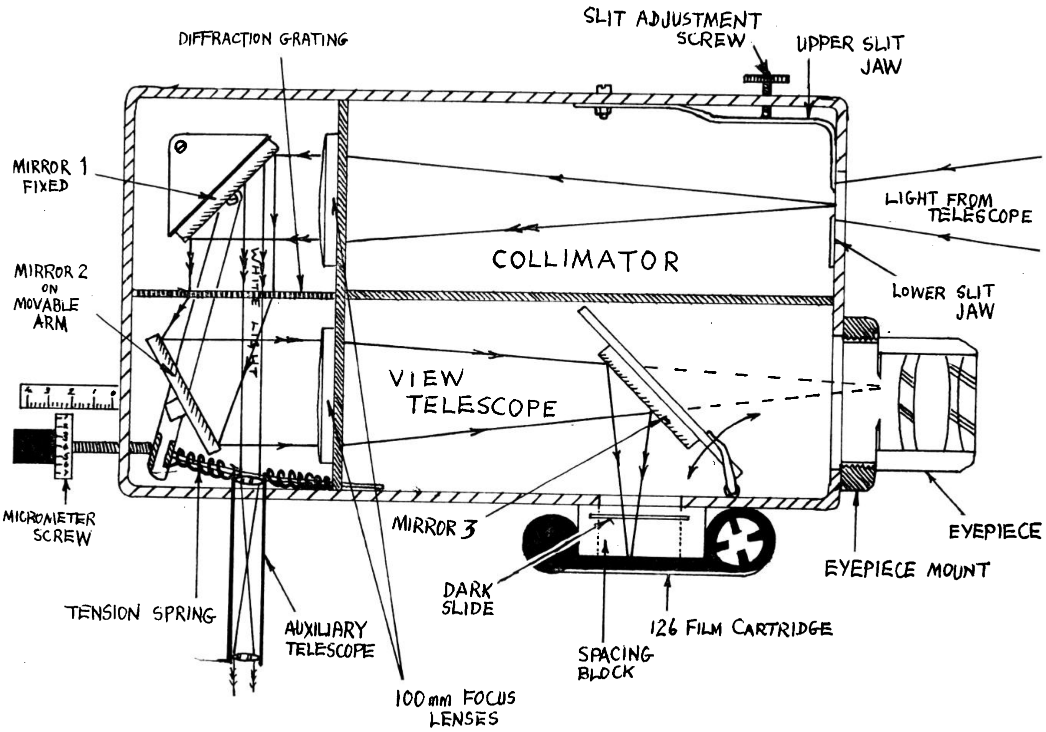

FIGURE 1. Layout of miniature spectrograph.

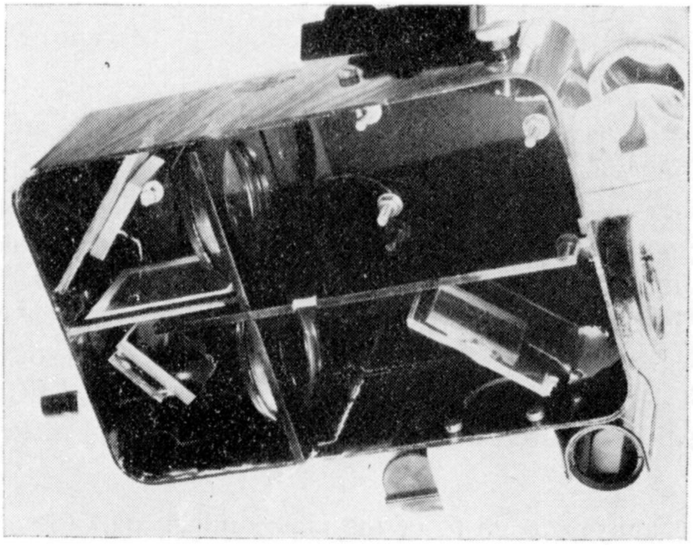

FIGURE 2. Interior of spectrograph.

where the view telescope is rigidly fixed, as in this design, normally known as a fixed-arm spectroscope, some alternative method has to be used. This is achieved by making mirror 2 moveable.

The mirror is mounted on a pivoted arm, tensioned by a spring and adjusted by a micrometer screw. Movement of the screw changes the angle of the mirror and therefore the angle of reflection, and directs a particular part of the spectrum to the view telescope. Thereby only one adjustment is required to view any part of the spectrum and allow measurements to be made with the micrometer.

MATERIALS AND CONSTRUCTION

To conform with the limitation of weight, cost, and ease of acquisition, it was decided to base the majority of the construction on plastic, which also has the property of being easily cut and 'machined' using very simple hand tools.

The materials used consisted of:

1. A clear, plastic sandwich box of the rigid variety, 175 mm × 115 mm × 60 mm. This was to form the housing of the spectrograph.
2. A sheet of 3 mm ($\frac{1}{8}$-inch) Perspex to hold the lenses and divide the collimator part of the box from the telescope side.
3. 'Plastic Padding' to fabricate a threaded eyepiece mount.
4. A sheet of 1 mm aluminium for the adjustable slit and to form a bracket for mirror 1.
5. A tube of glue (an impact adhesive is best, but care must be taken that it will not react chemically with the Perspex).
6. An assortment of brass nuts and bolts. (Ordinary steel bolts could have been used, except that they were susceptible to rusting.)

The optics, apart from the flat mirrors previously mentioned, consisted of two matched achromatic lenses of 100 mm focus taken from an old pair of opera glasses, and complete with their screw threaded mounts. The short focus was to enable the majority of the spectra to be captured on a normal size slide.

Although the tools used were a fine toothed 'junior' hacksaw, a hand drill, various files, fine sandpaper and a knife, it was found necessary to drill and tap holes in the plastic for the micrometer screw and the slit adjusting screw. Since no 'tap' was available the following method was used, and proved to be very successful. A hole, slightly smaller than the screw, was drilled through the plastic. The screw was then warmed sufficiently to soften the plastic and pushed into the hole. The heat in the screw softens the plastic sufficiently for it to mould to the thread exactly, thus forming a perfect tap without backlash. When the plastic has hardened the screw can be removed in the conventional way.

The slit mechanism proved to be the most difficult part to construct, due to the necessity of the knife edges having to be ground exactly parallel to one another, in order that when they meet no light can be passed between them. Two pieces of aluminium were cut and carefully ground, first to a knife edge and then the edges were made parallel. The final grinding was executed on a piece of plate glass using a gentle rotary motion. One half of the slit was stuck on to the plastic case half covering a hole to emit light from the object to be studied, and the other half was left with a long tongue bent at right angles to act as a spring, in order that the width of slit could be varied. Care had to be taken in order that the two edges met exactly.

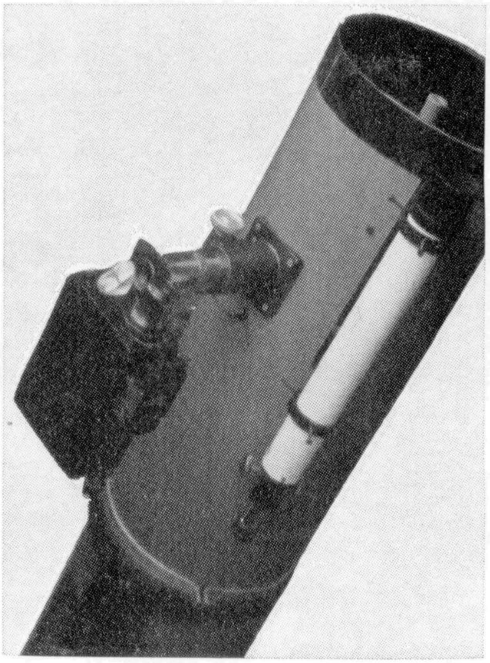

FIGURE 3. Spectrograph fitted to 216 mm telescope.

At this stage the instrument was purely visual, and in order to photograph the spectra the camera part had to be made. An ordinary 35 mm camera could have been attached in place of the eyepiece, but this would have made the instrument very heavy, and it would also have made the changeover very time consuming. It was therefore decided to use an Instamatic 126 Cartridge for the following reasons:

1. It was light in weight.
2. No time required to fit the film as it could be left in position at all times.
3. The cartridge was itself light tight and therefore no special housing was required.

Since the camera was to be an integral part of the spectrograph it was considered necessary to place this on one side of the box at right angles to the view telescope. In order to divert the light beam to the film plane a third mirror was fitted by a hinge to one side of the case inside the telescope. This allowed the spectrograph to be used visually, but the spectrum could also be recorded by flicking the mirror into the light beam. To attach the cartridge a spacing block was made from a piece of plastic 20 mm thick with a 25 mm hole drilled in the centre. A dark slide of blackened aluminium was incorporated to act as a shutter. Nothing more sophisticated was required as exposure times for taking spectrograms of the Sun were 2 or 3 seconds, and many times longer for stellar objects. The film plane was fixed in approximately the focal plane, but exact adjustment in focusing was achieved by slight movements of mirrors 2 and 3.

The results so far have been very encouraging. A 25 mm orthoscopic eyepiece is normally used, though sometimes this is replaced with a 12·5 mm orthoscopic when it is necessary to scrutinize a small portion of the spectrum.

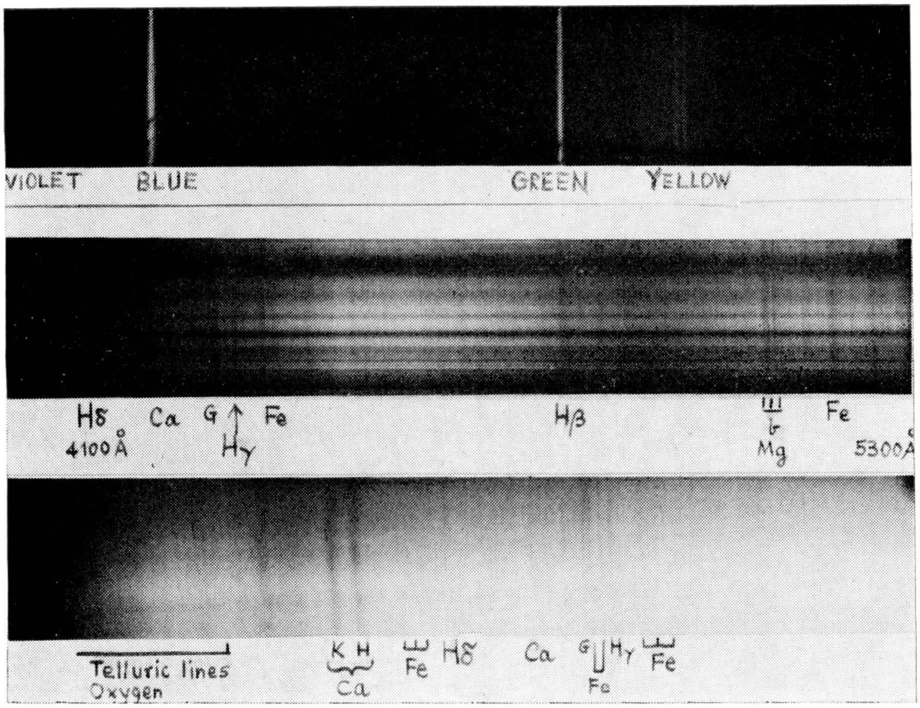

FIGURE 4. Three spectra photographed with the equipment. *Top:* spectrum of fluorescent light; *middle* and *lower* spectra: the solar spectrum.

Considering the small size of the spectrograph, resolution is very good. Splitting the 'D' lines of sodium poses no problems and, in fact, the separation of the lines is easily measurable using the micrometer. When viewing the solar spectrum, hundreds of lines are immediately evident, and it became quite a task trying to identify some of them.

The photographs so far obtained are on a smaller scale than the viewed spectrum. This is due to the short focus of the view telescope objective, and requires three instamatic frames to cover the range red to violet and allow an overlap to facilitate recognition of the spectral lines.

The instrument weighs only 680 grammes fully loaded and costs in the region of £5 to build, yet its performance exceeds what was originally anticipated. However, there is a great deal of work to be done, not only by improving the design, but in evaluating the results already obtained. It must be remembered that a spectrogram is only the first step in understanding the information locked up in a beam of light.