The Barlow Lens

S. J. ANDERSON
1 The Finches, Primrose Hill, Mellor, near Blackburn, Lancashire

Observational Techniques Section Director: Commander H. R. Hatfield, RN (ret'd)

The Barlow Lens is a well-established piece of optics and was named after its inventor, Peter Barlow, who was born in Norwich in 1776. One of its first users is reported to be Dawes as far back as 1833[1], but such notable observers as Denning, Webb and Espin also held it in high esteem[2].

A Barlow Lens is a negative lens placed a short distance inside the focus (generally in the focusing mount) of the primary objective. As it is a diverging lens it will considerably increase the focal length of the telescope while moving the actual focal point only a small distance. A typical Barlow Lens is an achromat consisting of a nearly plano-convex flint cemented to a bi-concave crown and having a negative focal length of the order of 100 mm. Such a lens when placed 50 mm inside the focus of the primary objective will double the focal length of the system.

Thus one of these lenses in an eyepiece collection will provide the observer with 'twice' as many eyepieces, and bearing in mind the current retail price of eyepieces, there is an obvious cost-saving advantage. This saving can be further increased to some extent inasmuch as those eyepieces that work poorly at lower focal ratios (*e.g.* Huyghenians with a typical Newtonian) work better when a negative lens is added to the optical train. In effect, the eyepieces are working on a system with twice the focal ratio, hence their own aberrations are accordingly less significant. Also, in using a Barlow for increasing the magnification, the more comfortable eye relief of a lower-power eyepiece is kept and the need for using a high-power eyepiece with small eye relief is avoided, though the field contrast is retained[3].

As was suggested above, for correct performance, a negative lens must be placed at a certain fixed distance inside the primary focus (as in the formula below). This point can even be between the diagonal and primary mirrors of a Newtonian. By placing it in that position a smaller diagonal prism may be used, and planetary definition may accordingly be improved. For those with some practical ability a prism–Barlow combination may be constructed to good effect[4,5].

However, it must be borne in mind that movement of the Barlow towards the primary necessitates a larger lens and any aberrations present in it will become more dominant, so for a more practical and flexible system negative lenses are usually held in the focusing mount, and the slight movement required to bring the system to focus with different eyepieces is generally acceptable.

In the extreme case of the lens being positioned at its own focal length inside the primary focus, then the divergence will be such that a parallel beam will emerge and this will obviously be of no use to anyone.

For more detailed information on the properties of negative lenses I refer the reader to the references, but for the practising observer the means of determining the amplification factor and focal length of the Barlow are shown below. The amplification factor is easily calculated from the formula

$$A = \frac{F}{F-d}$$

where A = the amplification factor, F = the Barlow focal length (ignoring the negative sign), and d = the distance of the Barlow inside the focal point of the mirror or objective.

The focal length of a negative lens may be measured by allowing light from the Sun, for example, to pass through the lens onto a card on which a circle of twice the clear aperture of the lens is drawn. The card is adjusted until the drawn circle is fully illuminated, when the distance between the lens and the card is the focal length of the Barlow.

The above covers the visual observer, but to what use can the ever-growing list of astro-photographers put the negative lens? Unless a telescope is custom built or very flexible, Spode's Law will prevent the focusing mount fixed to the instrument being racked in far enough to allow use of a camera at prime focus. Insertion of a Barlow Lens will push the focal point farther out bringing it to an accessible position for a typical 35 mm camera body.

Obviously this will make photography of deep-sky objects more time consuming, but its biggest advantage is, for example, in full-disk photography of the Moon. The average lunar image captured by this technique (with a 150 mm f/8 reflector) will almost fill the frame of a 35 mm film, resulting in less enlarging problems during subsequent processing of the film.

Note by the Director:

A Barlow Lens is not likely to be very useful unless it is achromatic. When mounting it, be sure to place the flat side towards the telescope objective. I do not myself favour the prism/Barlow combination, since a prism (as opposed to a flat) will introduce spurious colour.

Be very careful when mounting your Barlow that in your desire for amplification you do not place it too far inside the primary focus, and thereby cut off the outer rays coming from the objective; if in doubt make a scale drawing of the light rays converging to the focal point from the edges of the primary lens or mirror, and leave a bit to spare.

Mr Anderson gives the formula for the Barlow amplification factor A. I think readers may like to know the equivalent formula which gives the position of the new focal plane:

If F = Barlow focal length, A = amplification factor, and d' = distance of Barlow inside the new focal plane, then $d' = F(A-1)$.

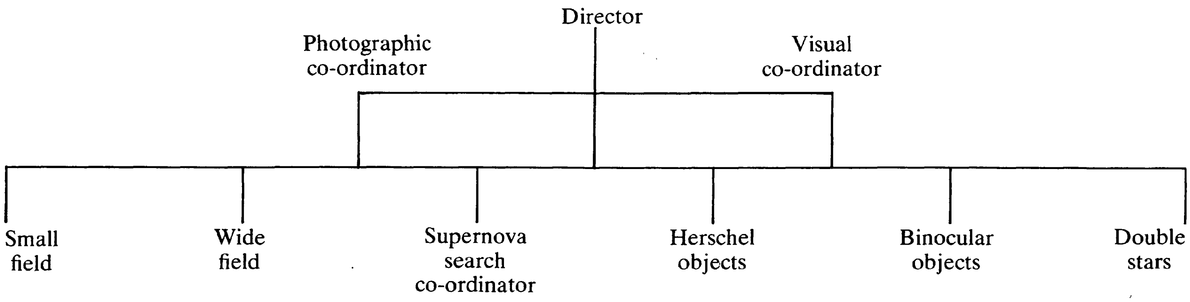
REFERENCES

1 Chambers, G. F., *Handbook of Astronomy,* 21, London, 1890.
2 Webb, T. W., *Celestial Objects for Common Telescopes,* **1,** 6, (Dover reprint) New York, 1962.
3 Houston, W. S., *Sky & Telesc.,* **63** (1), 97 (1982 Jan.).
4 Sidgwick, J. B., revised Muirden, J., *Amateur Astronomer's Handbook,* 116, London, 1979.
5 Ingalls, A. G., ed., *Amateur Telescope Making,* Book Three, 277, New York, 1953.

Deep-sky Section

Director: R. W. Arbour

Those members who have glanced at the list of Sections at the back of the *Journal* will have noticed, in the last two numbers, an addition to the list, namely a Deep-sky Section. The aim of this new Section is to observe and study all classes of objects that reside outside our Solar System, with the exception of variable stars. There can be no doubt that astrophotographers will have a very active part to play in the Section but, at the same time, we wish to encourage visual observers to participate. To this end the Section will be divided into photographic and visual, and sub-divided as below:



The observation of deep-sky objects is one branch of amateur astronomy in which observers can participate no matter how simple their telescope or camera. Indeed, there are many objects that can only be observed well with small instruments. At the other extreme, it is the ideal testing ground for new and highly sophisticated instrumentation that will shortly be flowing from the new Observing Techniques Section. So, in short, the Deep-sky Section should have something for everyone interested in observing these objects. If you are interested in finding out more about the Section, or would like to join, please write for details. It is the hope of the Director that the Section will have produced a Deep-sky Bulletin by the time that this note appears in the *Journal.*

We will be putting on a display of photographs and drawings at the exhibition in May, so, if you intend to exhibit observations and are unable to attend, please forward them to me and I will display them for you.

R. W. Arbour
Pennell Observatory, 29 Wright's Way, South Wonston, Hants, SO21 3HE.