Table 2. Local circumstances in the British Isles

	Greatest eclipse UT h m	*Sun's alt.* °	*Duration* m s	*Mag.*	*Eclipse ends UT* h m	*Sun's alt.* °
Aberdeen	3 44	1		0.93	4 41	8
Edinburgh	3 43	0		0.93	4 40	6
Inverness	3 45	1	1 10		4 43	7
Kirkwall	3 47	2	1 40		4 45	8
Lerwick	3 47	4	1 24		4 46	10
London	–	–		0.70*	4 32	5
Portree	3 47	0	1 59		4 44	6
Stornoway	3 48	1	2 23		4 45	7

*At sunrise, 3 h 50 m UT.

at these points the Sun's upper limb is apparently on the horizon at the time of greatest phase. Some local circumstances are given in Table 2.

The previous annular eclipse to be visible in the British Isles occurred during the early part of the century on 1921 April 8 when the track also passed over north western Scotland. The next will occur on 2093 July 23. It belongs to the same series as the 2003 eclipse and will be annular for over 5 minutes across Northern Ireland, southern Scotland and northern England.

Address: 46 Vista Way, Harrow, Middlesex, HA3 0SL

Received 31 October 1988; accepted 29 December 1988.

Short Papers

A lensless Schmidt camera

Peter Fawdon and Maurice Gavin

Introduction

Bernhard Schmidt, announcing his unique astrographic camera in the 1930s, noted that if the camera was of slow f-ratio and scaled down in size, the expensive corrector plate could be substituted by a simple hole (Figure 1)! Schmidt assumed the images were still of high quality. In practice, because of seeing conditions, guiding errors and film granularity, these standards can be relaxed slightly by using moderate f-ratios permitting use in moderately light-polluted skies, where commercial f/1.5 models would be unusuable.

This is the basis of the 15-cm aperture f/3.3 lensless Schmidt camera of 50 cm focal length, first described at the BAA Astrophotographic Section Meeting on 1989 April 22 (Figure 2). It uses 120-size roll film and proves to be an eighth-scale model of the Palomar Schmidt, having a similar f/ratio and 5°-wide field.

Spherical aberration limits image quality and this is dependent on the size of the aperture admitting light to the camera. The system uniquely allows the user to trade off image quality against faster f-ratios simply by changing the size of the aperture stop. Recent tests favour a 13-cm aperture at f/3.8. The effective f-ratio is marginally reduced further by the central obstruction. However, the single mirror design and long tube, which baffles extraneous light, compensates these losses.

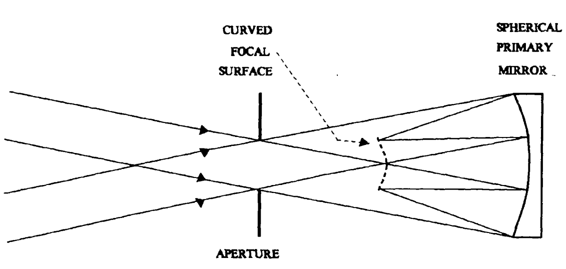

Figure 1. The optical layout of the lensless Schmidt camera.

Optics and engineering

Two items need to be precision made – the main mirror and the film holder. To ensure coverage of the film without vignetting, the mirror diameter should equal the aperture stop plus twice the film diameter. Our mirror measures 20 cm in

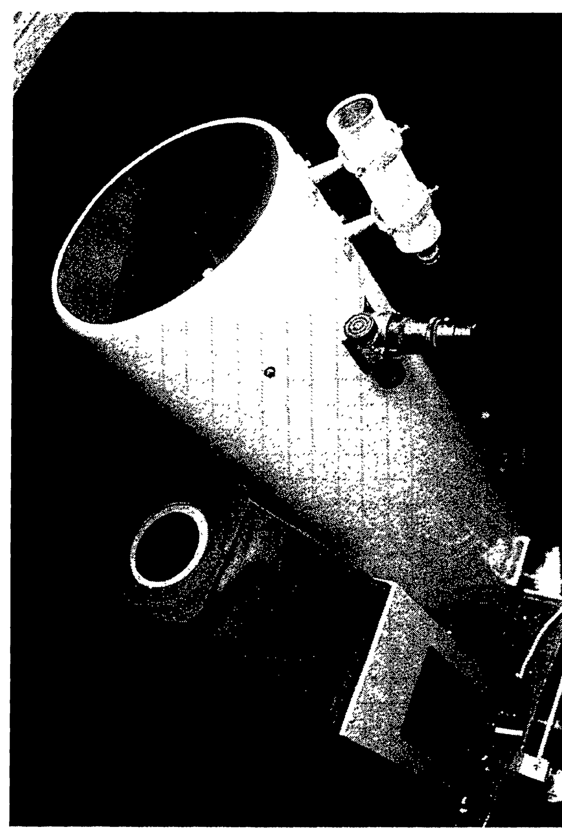

Figure 2. Peter Fawdon's 30-cm Newtonian telescope, which acts as a guidescope for the lensless Schmidt camera.

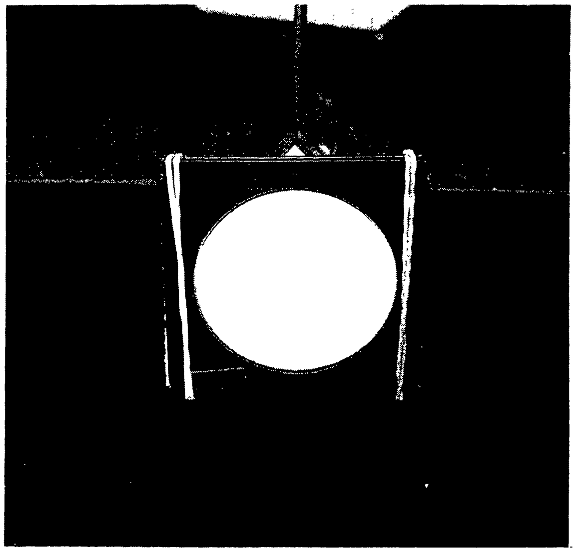

Figure 3. Close-up of the plateholder and spider. The felt strip (lower left) enables the cover plates to be correctly orientated by touch in the dark.

diameter – a reasonable compromise. It was originally made by Tony Mickle and has a spherical surface rather than a parabolic one. However, the curve is very deep with a sagitta (edge-to-centre depth) of about 7 mm giving a gross f/2.5 primary.

The film holder must support the film rigidly within a few microns of the precise curvature, i.e. half the radius of the mirror of 50 cm. A mild steel pin at the back of the film holder locates in a magnetised socket in a threaded rod on the spider. The point of focus is found by test exposures and thereafter remains fixed.

The mirror and film holder (Figure 3) are supported in a simple but rigid plywood box. Such materials have advantages over metal tubes for their lower coefficient of expansion. (Celestron used zero expansion Invar rods as spacers between mirror and the factory preset film holder.) The upper half of the tube only serves to support the aperture stop and can be made of thin black card.

The overall cost of the project should be about a tenth of a Celestron Schmidt camera. When the system was first described in *Sky & Telescope*[1], Coulter Optics made a mirror and film holder kit, since withdrawn. One UK firm[2] is currently making these cameras and should be contacted for advice.

Newtonian *v*. Schmidt camera

Fifteen centimetres is a relatively modest aperture for today's amateur so why not use the regular Newtonian? The answer lies in sky coverage. The Newtonian, with its parabolic primary mirror will produce coma-free photographs about equal to the f-ratio squared, i.e. 11-mm diameter for an f/3.3 system. The 44-mm diameter field of the Schmidt camera covers 16 times this area in a single exposure. The Schmidt camera will be twice the length of a Newtonian of similar

Figure 4. The field of Deneb. 5-minute exposure on HP5. North is at the top. 10-cm aperture lensless Schmidt camera.

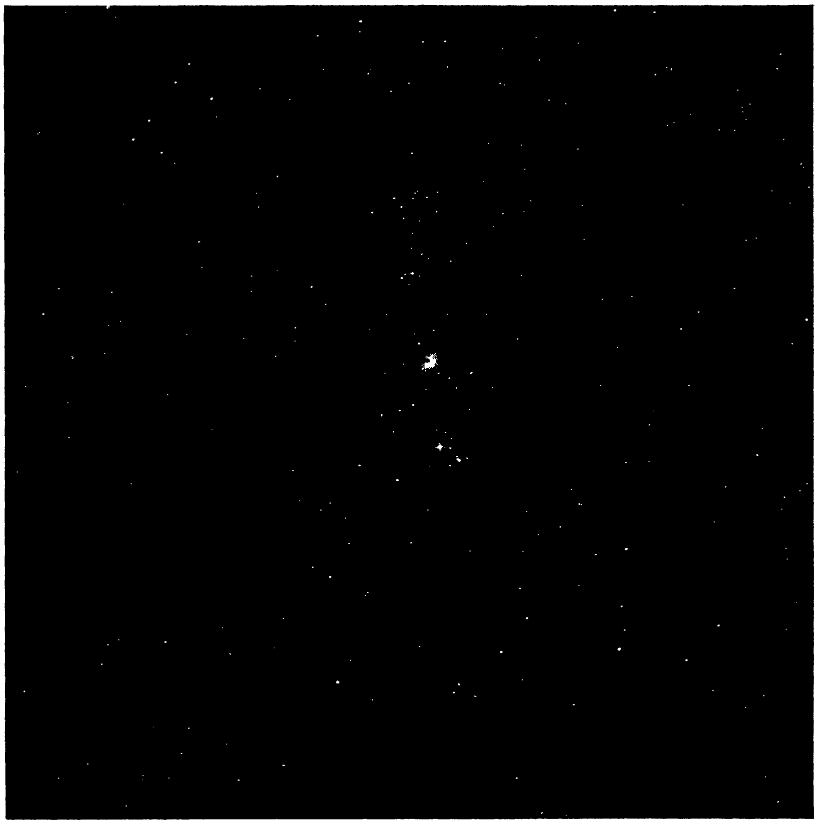

Figure 5. M42 Orion Nebula. $3\frac{1}{2}$-minutes exposure on HP5. Frame size $5\frac{1}{2}° \times 5\frac{1}{2}°$.

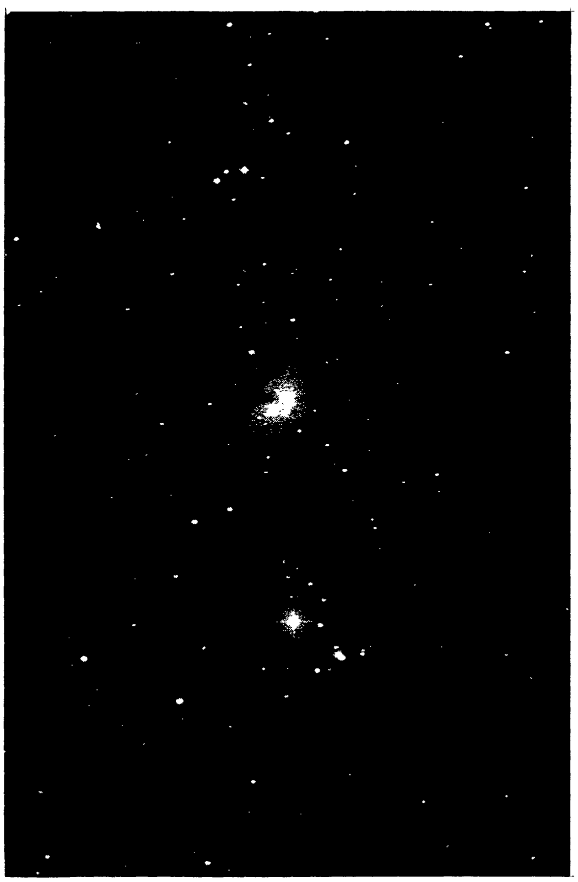

Figure 6. M42. Englargement from part of same print shown in Figure 5.

focal length with the aperture stop at the mirror radius.

Nevertheless the system is ideal for comet and supernova hunting and general photographic patrol work, reaching about 13th magnitude stars in three to five minutes' exposure on regular film like Tri-X or FP4. The relatively fast f-ratio ensures some structure is shown in diffuse objects like galaxies. Photos on 120 Ectachrome 400 ISO have produced pleasing transparencies.

A 55 × 55 mm square format (6° × 6°) on 120 film with some corner vignetting has also been tested. The film was simply held in place at the perimeter of the film holder with double-sided tape.

Scaling the lensless Schmidt camera

Practice indicates that useful focal lengths for these cameras range from 40 cm to 90 cm. Conventional camera lenses serve better below these focal lengths whilst beyond 90 cm (apart from excessive tube lengths and slow f-ratios to give acceptable images) a large film format like 5 × 4 is needed. Such formats are expensive and cumbersome to handle and process.

Handling the film

Perhaps the main reason Schmidt cameras have not found universal appeal amongst amateurs is the need to handle individual pieces of photographic film through loading, exposure and processing. The fragile film must be handled with care at all stages and in complete darkroom conditions to avoid abrasion or fogging. In reality this proves to be less onerous than expected and with a few dummy runs in daylight it becomes routine.

Figure 7. M45 (Pleiades). 3½-minute exposure on HP5. 10-cm aperture.

The technique is as follows. In the darkroom the film, light-tight box (old bromide paper box), scissors, rubber bands, and six film holders with card covers (or enough for an evening's photography) are set out on the bench so they can be located by touch alone.

The film is carefully unrolled from its paper backing and a square of film is cut out. The film is sandwiched between the holder back and face plates, emulsion side to the aperture. Rubber bands looped around opposing corners secure the film firmly. Each loaded film holder with its cover is placed in the light-tight box ready for use at the camera. The unused film is returned to a light-tight bag.

At the camera

A loaded film holder is removed from its box, passed through the light-tight sleeve and located onto the magnetic spider support. The film cover is removed and the exposure begins by uncovering the camera aperture. The process is reversed when the exposure is completed with the used film holder going into a second light-tight box.

In the darkroom

The film is unloaded and transferred one frame at a time into the spiral of a daylight developing tank – perhaps a maximum of three to four frames to avoid contact with each other during processing. The film can be developed and fixed in the normal way. Avoid sloshing the solutions about in the tank otherwise the flimsy film may buckle and become dislodged from the spiral.

Prints are produced on Multigrade 6 (very hard) paper via a 6 × 6 enlarger. An enlargement of × 8 will give an image scale (but not the quality!) similar to contact prints from the 1.2-m Palomar Schmidt Camera plates. Some results are illustrated in Figures 4 to 7.

Addresses: 11 Chiltern Close, Princes Risborough, Bucks. (PF)
79 Ardrossan Gardens, Worcester Park, Surrey KT4 7AX (MG)

References

1 *Sky Telesc.*, **47**(5), 333–337 (1974).
2 Beacon Hill Telescopes.

Received 1989 June 16; accepted 1989 September 6