A Follow-up Paper to:

"Optical Designs that Amateur Astrophotographers and CCD Users should Know"

by Rick Blakley

A 317.5mm, F/3.68 Honders Camera and a 254mm, F/23 Cassegrain with a secondary assembly consisting of a spherical mirror with two, plano-curved, corrective lenses.

Mr. Klaas Honders had indicated to me before the presentation of the paper referenced above (ALCON 2002) his intention to pursue a patent of his excellent design. Without repeating detail that is provided in that paper, let me simply declare that I refrained from publishing his design to assist in keeping his work confidential until he had satisfactorily protected his idea (there was some discussion with commercial firms, I understand). Within a few years of that presentation, however, Mr. Honders lamentably expired, and I remained unclear as to the status of the idea until I recently conferred with Mr. James Daley. He had communicated with Mr. Honders later than had I and indicated that Mr. Honders had hoped his invention would be considered and embraced by the amateur community. Thus, I have chosen to offer this follow-up.

The issue remains as to the precedence of others work that is similar to Honders', but there is no doubt that Mr. Honders developed his idea independently and that his expression of this derivative of the Schupmann is elegantly simple when compared to the other, very fast designs requiring more elements.

I have searched my notes to no avail for the F/4.5 Honders design (modified by Massimo Riccardi) presented in the ALCON 2002 paper. Anyway, the astrophotographer who dares to wield his instrument against the sky often covets more speed for the aperture. So I have chosen to advocate for an F/3.68 design, modified by Riccardi and myself, as being suitably fast for film or CCD and suitably slow for relative ease of fabrication. But I expect that the making of any Honders isn't going to be an easy endeavor. The 100%-illuminated field is 3.4° but could be pushed with the suitable enlarging of the field-lens' aperture to manage 4° (~140mm). On the other hand, with the mounting of a reduced-aperture field lens within an extended and *stable* eyepiece holder, an exceptional rich-field, Newtonian-style instrument would result. But the builder should be aware that *all* of the optical elements of the Honders are finicky for accuracy of fabrication and alignment, and deviation and sloppy execution may dispose the "bird's" transmution to lead. It's *not* a forgiving design!

I have made no new diagram since the earlier paper contains an example (bottom of Fig. 2, page 5), but I will provide the old dimensions in parentheses coupled with the new in a later table so that a correspondence may be made. The F/3.68 design table follows. All surfaces are spherical and the stop is on surface one.

Honders Anastigmat

surface number	aperture radius	radius of curvature	spacing or thickness	medium
1	158.75mm	4566.78mm	33.23mm	BK7
2	158.75	-7789.99	992.72	air
3	162	-1341.88	33.23	BK7
				mirror
4	162	-2212.565	-33.23	BK7
5	162	-1341.88	-1000.76	air
6	61	-338	-15.5	BK7
7	61	-9000	-126.646	air
8	34.72			focus

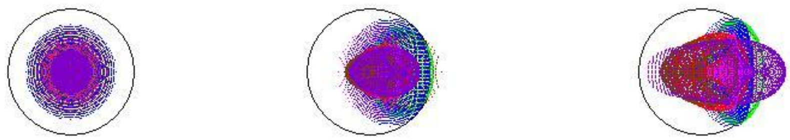
The comparisons with the dimensions on the example of Fig. 2, page 5 are listed:

Aperture of entrance lens: 317.5mm (old 317.5mm)
Aperture of mangin mirror: 324mm (old 338.7mm)
Aperture of field flattener: 122mm, 38% (old 138mm, 43%)
Film: 69.4mm (old 84.8mm)
Last surface of field flattener to film: 126.6mm (old 154.4mm)
Concave face of mangin to film: 1142.9mm (old 1402.8mm)

These dimensions are for gauging sizing and construction. The focal length of the system is 1168.213mm. A four-degree full field will require a film diameter of 81.7mm.

Spot diagrams (ATMOS 7.3, http://www.atmos-software.it/) follow for the flat field at 0.015mm inside focus. The circle is the comparison, 0.0049mm-diameter Airy disk, so the diffraction limit is modestly exceeded by the spot at the 1.7° half-field radius. For the same at 2°, the elongated violet blur exceeds the Airy disk by about 50%. The 0.025mm-diameter criterion for photographic film is slightly over five times the circle size shown.

The colors in the spots are indicators for the wavelengths of dark red: 0.7065 microns, red: 0.6563 microns, green: 0.5461 microns, blue: 0.4681 microns, fuchsia: 0.4358, and violet: 0.4046 microns.



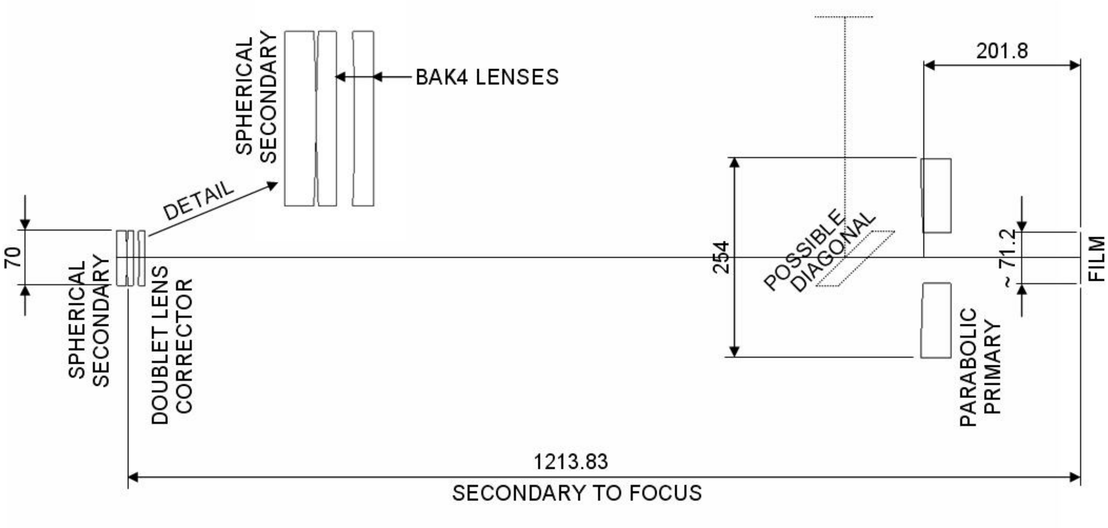
Center Field 70% Field 100% Field (1.7°)

Visual & Photo: Honders Anastigmat; F/3.68
(modified by Riccardi & Blakley)
(Each spot shown imposed on Airy-disk circle.)

Fig. 1

The F/23 Cassegrain is slow considering the aspirations of the astrophotographer (especially with respect to the Honders), but I chose to hold the secondary's obstruction of the primary to 28% to enhance the resolution of planetary detail. Faster versions may be designed if the increase in %-obstruction is considered tolerable. A geometric layout of the design occurs in Fig. 2.

The primary is intended to be a 254mm, F/5 paraboloid that may be purchased from a commercial supplier. The dread of the Cassegrain maker is the fabrication of its convex hyperboloid, not to mention the difficulty of testing and the cost of the extra optics required for it. The Dall-Kirkham offers a convex, spherical secondary but requires an ellipsoidal primary, something not so easily found on the commercial market. I chose to retain the spherical secondary and make the correction of the resulting aberrations with a couple of plano-curved lenses mounted near the secondary. These *corrector* lenses should be made from the same glass, one plano-convex, the other plano-concave, to null their chromatic aberrations in the double pass of converging wavefronts (one from the primary, the other from the secondary). The design concept proves very successful, and with the variables of the various spacings involved, provisions for adjustment allow for reasonable accommodation in the focal length of the commercial primary.



Harmer & Wynne 254mm, F/23: 0.7°
(Designed by Blakley)

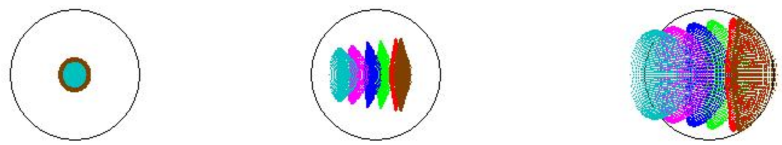
Fig. 2

Most commercial primaries come without central holes, but a diagonal may be employed to turn the final conjugate to the side, conveniently down the declination axis if desired to a Nasmyth focus. The full size, 71.2mm focal plane would be available there (and more if desired) whereas a focus behind the primary will require a central hole larger than the secondary for the same field. Reducing the maximum, full field to 0.5° results in a focal plane of 50.9mm diameter and requires a secondary aperture of 65mm (26% obstruction). The focal length is 5832.433mm. Design specifications follow.

Harmer & Wynne

surface number	aperture radius	radius of curvature	spacing or thickness	medium	conic (spherical unless noted)
1	127mm	-2540mm	-990.6mm	mirror	-1
2	35	0	-6	BAK4	
3	35	-763.7	-7.38	air	
4	35	0	-8	BAK4	
5	35	730.625	-0.0508	air	
6	35	-666.837	0.0508	mirror	
7	35	730.625	8	BAK4	
8	35	0	7.38	air	
9	35	-763.7	6	BAK4	
10	35	0	1192.399	air	
11	35.63			focus	

Spot diagrams follow in Fig. 3. The best-averaged foci fall on a field radius of -278.5mm, 0.15mm inside the focal plane. The color/wavelength scheme used before has been applied except that the computer(!) insists on substituting turquoise for the violet at 0.4046 microns.



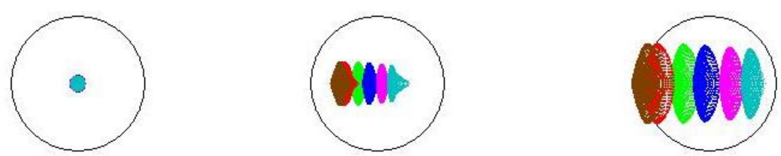
Center Field 70% Field 100% Field (0.7°)

Visual: Harmer & Wynne; F/23
(Each spot shown imposed on Airy-disk circle.)

Fig. 3

Notice the "stacked" appearance of the spots, a testament to the presence of residual lateral color caused by the spacing of the lenses. Still, the system is diffraction limited across the field from 0.7065 microns to 0.4358 microns, so the presence of the residual is incidental. Even with the 0.4046 microns blur extending off the left boundary of the right-most spot, the system is well corrected, presenting no manifestation of a comatic flair and only a modest amount of astigmatism. In fact, the design is an aplanat.

With the addition of a plano-concave, BK7 lens just inside focus, the field is flattened conveniently for film or CCD. The aperture required for 0.7° full field is 76mm. I designed for a lens of 5mm center thickness with radius -111mm, which slowed the system speed to F/23.8. The plano side faces the focal plane and is located 4.372mm inside focus. Spots follow.



Center Field 70% Field 100% Field (0.7°)

Visual & Photo: Harmer & Wynne; F/23.8
(Each spot shown imposed on Airy-disk circle.)

Fig. 4

These are the best-average over the field for a location 0.03mm inside focus. The field-flattener lens seems to have improved the image quality. The Airy-disk diameter in this case is 0.032mm, actually larger than the 0.025mm criterion for film. Faster designs may generate more lateral color than is tolerable. One may increase the radius on the concave side of the field flattener to eliminate lateral color (-205mm for present design), though this will leave some field curvature. However, a unique position for the lens inside focus with its radius suitably altered may allow the correction of lateral color while flattening the field.

This design has a superficial resemblance to one by David Shafer in *Telescope Making 29*, (pp10, 11, Ed. R. Berry, Kalmbach Pub., 1986). His design, however, requires the doublet corrector to manage the aberrations of a spherical secondary *and* primary. The late Robert Cox indicated to me that the corrector of that design appeared a bit overwhelmed with the duty. As in the Shafer, the doublet corrector here may be rendered as a Maksutov-style meniscus. But employing that technique places a lot of emphasis on getting the thickness of the meniscus very close to the design value, so I prefer the adjustment potential of the analog pair.

The plano-concave element of the Shafer corrector has the concave surface facing the primary (mimicking the Maksutov corrector) whereas I have it facing the secondary. Converging rays from the primary's edge have high inclinations with respect to the optical axis, and facing the plano side against these rays generates slightly smaller aberrations in the lens. The element may be reversed but re-optimizing the system may be necessary.

I designed this system some five years ago and Scott Tucker at *Starizona* has recently conceived of something similar, but I have since learned from Dr. Richard Buchroeder that the concept originated with Charles Harmer and Charles Wynne who wrote equations for design. I can say that their concept of using a doublet corrector for managing the aberrations of a spherical secondary when combined with a parabolic primary in the Cassegrain configuration seems to be born out. Naturally, one would have to evaluate the potential for ghosting and determine the tolerances before one could comfortably proceed with fabrication.

Dr. Buchroeder has indicated to me the difficulty of establishing the priority of designs and has encouraged me to avoid the issue. In that regard, please understand that the ascribing of names to designs in this and the ALCON 2002 papers should be seen as nothing more than convenient labelings for the schematics and spot diagrams included.