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## Technical Notes

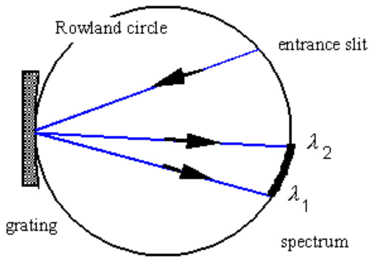
### Technical Note 3
### CONCAVE GRATINGS

Many spectroscopic applications use a plane grating in conjunction with lenses and/or mirrors, which form an image in which the spectral components of the source are clearly separated. Concave gratings have an advantage over conventional plane grating systems in that concave gratings perform both imaging as well as dispersion (wavelength separation). This reduces the cost of the optical components in the instrument, reduces alignment time, and perhaps minimizes reflective and refractive energy losses as well.

#### ROWLAND CIRCLE SPECTROGRAPHS

A "classical" concave grating (one whose grooves are straight, parallel and equally spaced) can be generated on a ruling engine or by recording a laser interference pattern in photoresist (to form a holographic grating). If the object (e.g., entrance slit or fiber) is placed on the Rowland circle (whose diameter equals the radius of curvature of the grating blank), high spectral imaging resolution is obtained (see Fig. 1).

**Figure 1** – Rowland Circle spectrograph. The entrance slit and diffracted spectrum lie on the Rowland Circle, which also passes through the center of the grating surface.

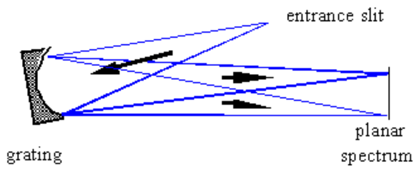



The detectors or output fibers must be located on the Rowland circle, since that is where the slit images are focused. While the images are narrow in the spectral direction, they suffer from a large amount of astigmatism inherent in this type of grating system. This leads to relatively "tall" images (see Fig. 4a).

#### FLAT-FIELD SPECTROGRAPHS

By suitably curving the grooves on the grating, usually by holographic means, adequate spectral resolution can be achieved on a line instead of a circle (see Fig. 2). This lends itself naturally to use with linear or area detector arrays. While astigmatism is reduced, which increases throughput, the resolution of a flat-field spectrograph is never as great as for a Rowland Circle spectrograph. The advantage of flat-field spectrographs lies in achieving compact spectrometers with no moving parts. For image formation, see Fig. 4b.

**Figure 2 –** Flat-field spectrograph. Spectral resolution is optimized for a planar spectrum.




#### CONSTANT-DEVIATION MONOCHROMATORS

Curving the grating grooves can also reduce aberrations in monochromators, in which only a small part of the spectrum is viewed at a time; wavelengths are scanned by rotating the grating (see Fig. 3). Again, astigmatism is usually reduced (though for part of the spectrum only) to increase throughput, but the resolution is less than for a Rowland Circle spectrograph. Image formation would be similar to Fig. 4c.

**Figure 3 –** Constant-deviation monochromator. The angle between the slits remains constant as the grating is rotated to scan wavelengths.

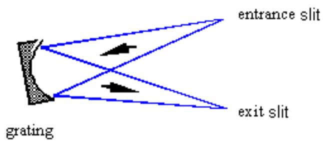
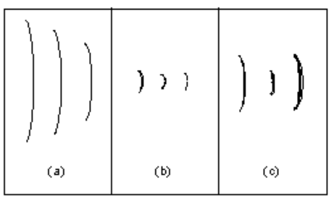



**Figure 4 –** Typical spectral images at three wavelengths from (a) a Rowland Circle spectrograph, (b) a flat-field spectrograph, and (c) a constant-deviation monochromator. Note that resolution (image width) degrades as astigmatism (image height) is reduced.




#### CONCAVE GRATING EFFICIENCIES

Efficiencies vary, depending on the particular grating parameters and the configuration in which it is used. Two typical curves are shown below; the efficiency of a ruled concave grating is shown in Fig. 5, and that of a concave holographic grating (with sinusoidal grooves) is shown in Fig. 6. Ruled concave gratings are usually blazed as a natural consequence of the ruling process, and some holographic gratings can be blazed by ion milling.

**Figure 5 –** Efficiency curve: ruled concave grating, 1440 g/mm, radius 998.8 mm [2813]. 45° polarization shown.

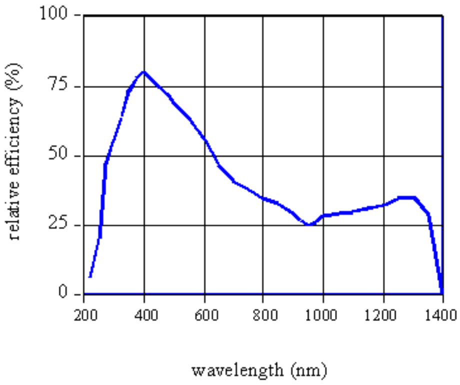
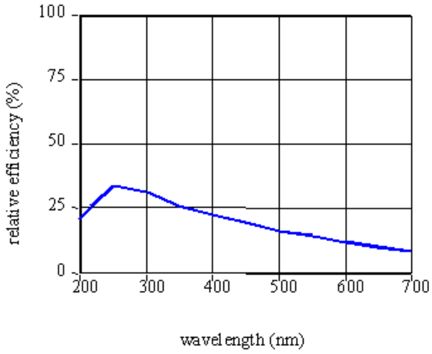



**Figure 6 –** Efficiency curve: concave holographic aberration-reduced grating, 436 g/mm, radius 112.2 mm [5615]. 45° polarization shown.




While ruled concave gratings usually offer higher diffraction efficiencies, they operate with higher ƒ/numbers. Concave holographic gratings may provide lower efficiencies but can collect more light due to their use in lower ƒ/number systems.

**CATALOG CONCAVE GRATINGS**

Richardson Grating Lab has a wide variety of concave ruled and holographic gratings to suit any application. Please contact us which grating has the best performance for your specifications.

**CUSTOM DESIGN SERVICE**

The Richardson Grating Laboratory can design a custom concave grating to best suit your specifications. Contact us for more information.

**ORDERING INFORMATION**

Popular concave grating sizes and prices are listed in the *Diffraction Grating Catalog* and *Price Guide*. Different specifications can be accommodated: please contact us for price quotations. Prices are subject to change without notice.

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