Symmetry in Optical Design

Designing with symmetry about the stop is one of the classic methods of reducing aberrations. We've seen previously that stop shifting in a landscape lens can reduce coma and that splitting a lens can reduce spherical. Here we combine these principles in a symmetric "periscopic" lens.

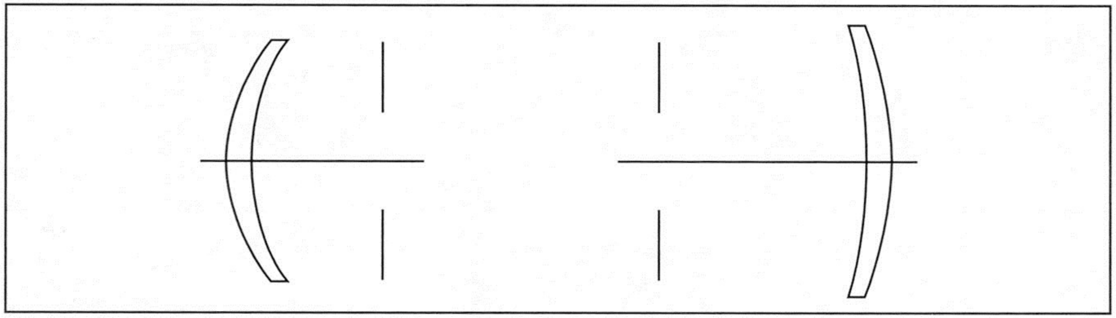

Fig. 12.1 *Front and rear landscape lenses.*

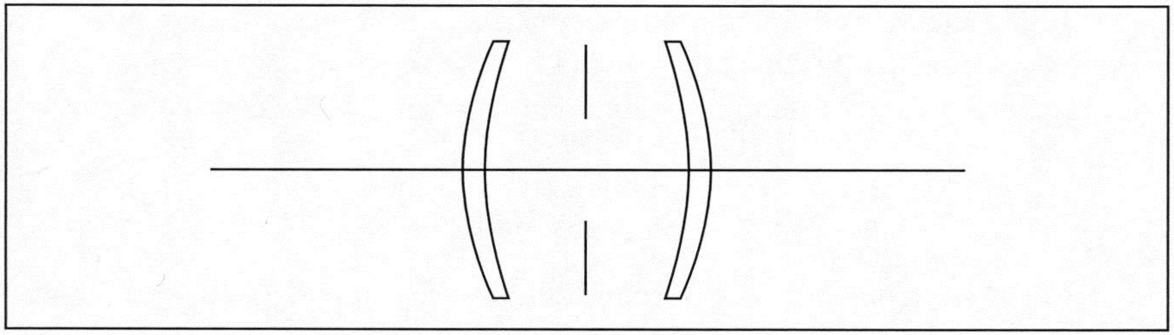

Fig. 12.2 *The periscopic lens.*

J. Geary, *Introduction to Lens Design with practical Zemax examples,* Figs. 12.1, 12.2

Symmetry reduces aberrations that depend on chief ray height

Three transverse ray aberrations whose signs depend on the sign of the chief ray height. These depend on even powers of aperture *(ρ)* and odd powers of field *(H)*.

Coma	$W_{131} \propto \mathrm{B}$
Distortion	$W_{311} \propto B, B^3$
Lateral color (chromatic variation of magnification)	$\propto \mathrm{B}$

Transverse ray aberrations that depend on even powers of the chief ray height cannot be reduced with symmetry…

Spherical	W_{040} independent of *B*
Astigmatism	$W_{222} \propto B^2$
Field curvature	$W_{220} \propto B^2$

Symmetric periscopic lens: 1st-order design

Periscopic lens with front (F) and back (B) elements separated by distance *t* in air.

$$\varnothing = \varnothing_F + \varnothing_B - t\varnothing_F\varnothing_B$$

Lens splitting: $\varnothing_F = \varnothing_B \cong \dfrac{\varnothing}{2} \longrightarrow \varnothing = 2\varnothing_F - t(\varnothing_F)^2 \ \ldots \ t(\varnothing_F)^2 - 2\varnothing_F + \varnothing = 0$

Quadratic solution: $\varnothing_F = \dfrac{2 \pm \sqrt{4 - 4t\varnothing}}{2t} = \dfrac{1}{t}\left[1 \pm \sqrt{1 - t\varnothing}\right]$ (± solutions)

Equiconvex lens elements: $\varnothing_F = (n-1)\left(\dfrac{1}{R_{F1}} - \dfrac{1}{R_{F2}}\right) = (n-1)\left(\dfrac{1}{R_{F1}} + \dfrac{1}{R_{F1}}\right) = \dfrac{2(n-1)}{R_{F1}}$

$$\therefore \ R_{F1} = \frac{2(n-1)}{\varnothing_F}$$

J. Geary, *Introduction to Lens Design with practical Zemax examples,* Sec. 12.2

Symmetric periscopic lens in Zemax

We choose the following parameters and calculate surface radii to enter in Zemax …

- f/10
- EFL = 200 mm
- *t* = 180 mm
- Glass = SF2
- Glass thickness = 15 mm
- Fields = 0°, 10.5°, 15°
- λ = 0.55 μm (*n* = 1.65174)

$$R_{F-} = \frac{2(0.65174)}{0.0038} = 343.02 \text{ mm}$$

(choosing + solution leads to higher element power)

→ Enter in Zemax

J. Geary, *Introduction to Lens Design with practical Zemax examples,* Sec. 12.2