The Brownie Camera

Lens Design OPTI 517

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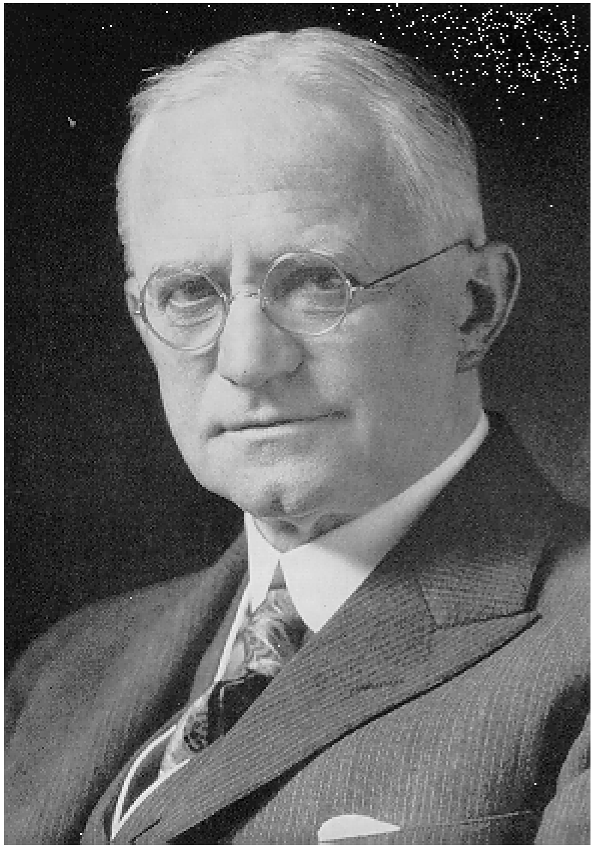


http://www.history.rochester.edu/class/kodak/kodak.htm

George Eastman (1854-1932), was an ingenious man who contributed greatly to the field of photography. He developed dry plates, film with flexible backing, roll holders for the flexible film, a Kodak camera (a convenient form of the camera for novices), and an amateur motion-picture camera. Through his experimental photography, he accumulated a large sum of money.
His philanthropic personality prompted him to give his money to various business endeavors, including the University of Rochester.

The problem

What are the specs?

- The specs follow from the application
- From the specs we define the design tasks
- Need to find out the <u>complete</u> specification list (not always, usually, possible)
- When in doubt re-consider the application

The Application is the guideline

- Focal length
- Magnification
- Afocal
- Telecentric
- F/#
- Field of view
- Image quality

- Packaging
- Efficiency
- Cost

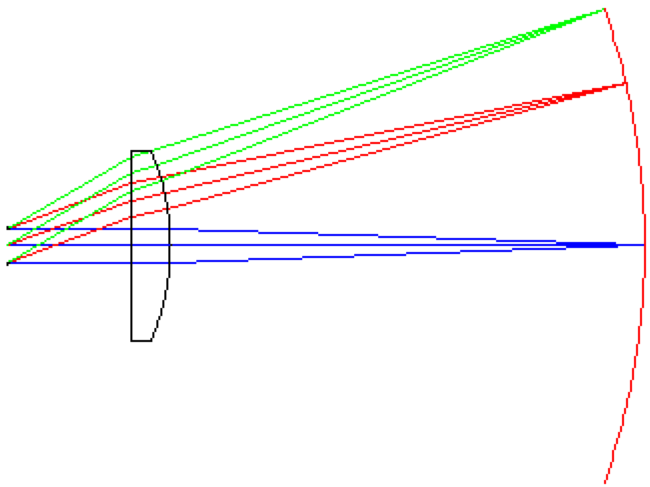
Brownie camera issues I

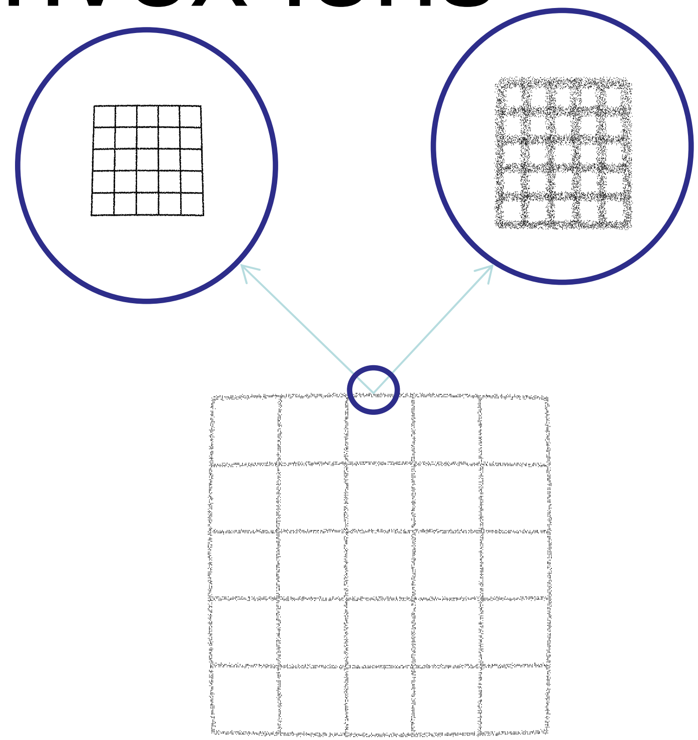
- Specifications: f = 100 mm @ f/15, +/- 30 degrees
- Resolution: observer can resolve 3.4 arc minutes
- Stop location
- Shutter and window
- Manufacturing tolerances
- Use of a plano-convex lens
- Degrees of freedom
- Flattening of the tangential or sagittal field
- Stop sizes
- Limiting aberrations
- Depth of focus and field (geometrical and diffraction limited)
- Film Flatness
- Alignment requirements
- Alternate solution
- Tolerance on positioning the film

Brownie camera issues II

- Tolerance on image plane tilt
- Tolerance in manufacturing the lens and on its placement
- “Spherical and chromatic aberrations tend to increase the depth of field” Kingslake p.268 Optical System Design
- Two-brilliant finders; Opaque finder
- Kingslake p. 211, Lens Design Fundamentals
- Wollanston 1812; Chevalier 1839
- Two sizes for aperture stop
- Optomechanics easy to make
- Simple light Baffles
- Single fixed lens
- Challenges: Parallax, speed, focusing, volume, waist level, no AR coating
- Inexpensive

The plano-convex lens





$$W_{040} = -\frac{1}{8} A^2 \Delta\left\{\frac{u}{n}\right\} y$$

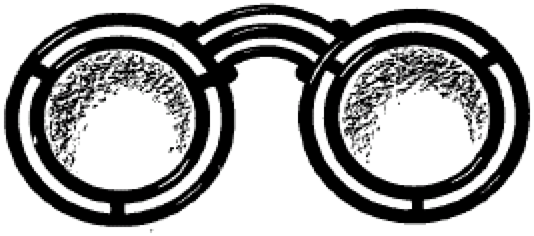
$$W_{222} = -\frac{1}{2} \bar{A}^2 \Delta\left\{\frac{u}{n}\right\} y$$

$$W_{131} = -\frac{1}{2} A\bar{A} \Delta\left\{\frac{u}{n}\right\} y$$

- Simplicity
- Use of Seidel coefficients
- No coma or astigmatism
- Stop size, spherical aberration
- Good imaging on a curved surface (Petzval surface)

Earlier spectacle lenses

~1450



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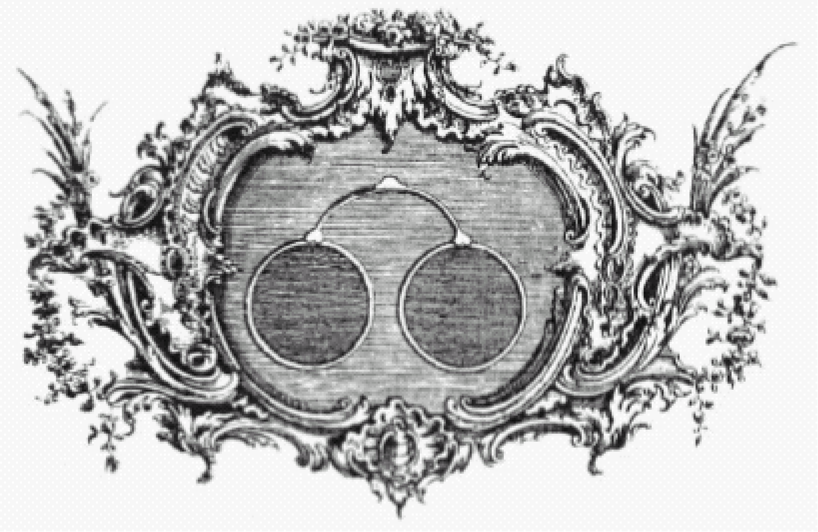

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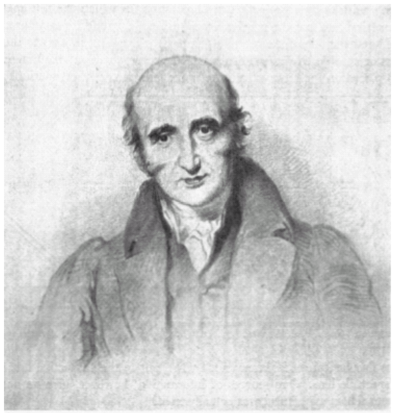
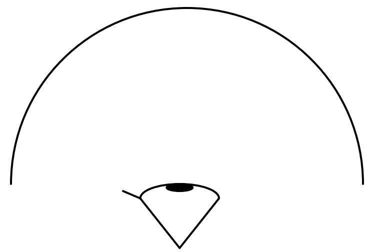
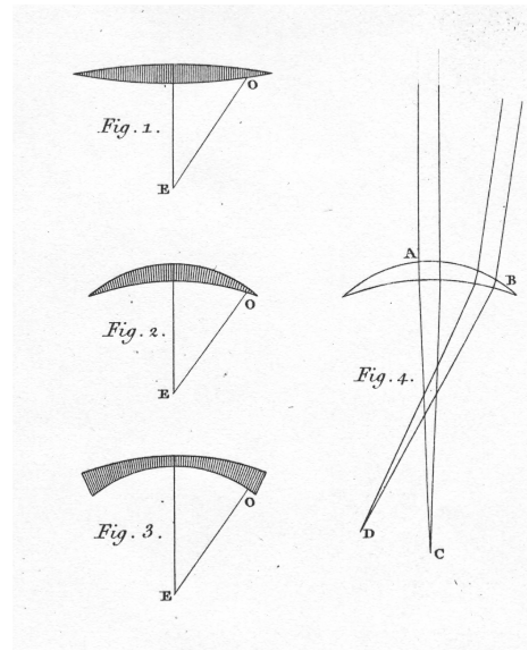
“Periscopic lenses”

Periscopic from the Greek *periskopeein* “to look around”



W. H. Wollaston
1766-1828





“The opportunity afforded by these glasses of *looking round* at various objects, it is thought may not improperly be expressed by the name of *Periscopic Spectacles*.”

1812

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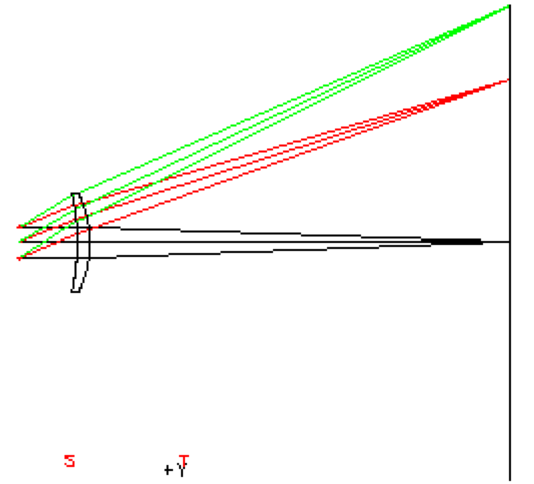
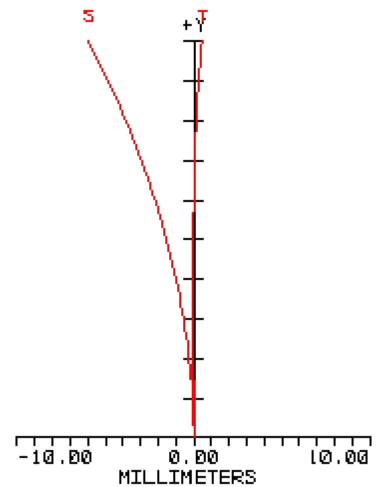
Wollaston meniscus (or landscape lens)

- Flattening the tangential field (for best image on a flat surface)
- The degrees of freedom are the lens bending and the stop position
- Aperture stop diameter, F/16, makes spherical aberration negligible
- Alternate solution, stop in back
- Limiting aberrations are spherical aberration and astigmatism
- Spherical aberration
- It has about 5% barrel distortion





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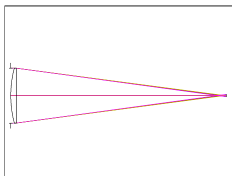
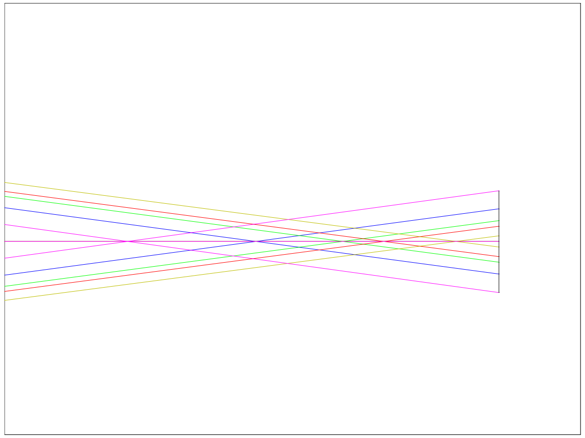
Depth of focus enhancement

- **Phase**
- Axial Chromatic Aberration
- Axicons
- Scatter
- Diffractive
- Wavefront coding; cubic phase plate
- **Amplitude**
- Entrance pupil apodization



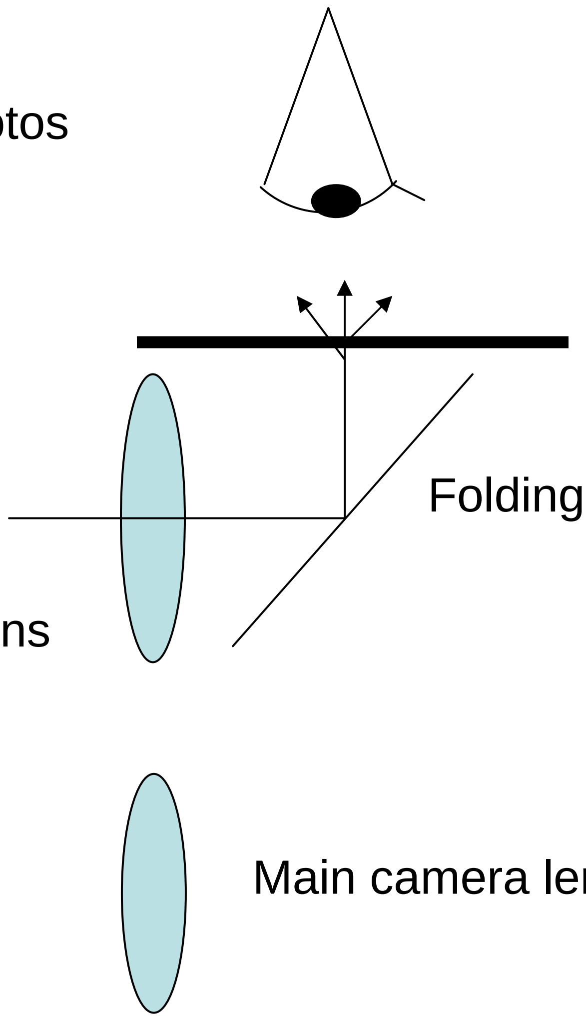


•"Spherical and chromatic aberrations tend to increase the depth of field" Kingslake p.268 Optical System Design

•Trade-off between DOF and resolution

Opaque finder

One for Portrait photos
One for Landscape photos



Parallax

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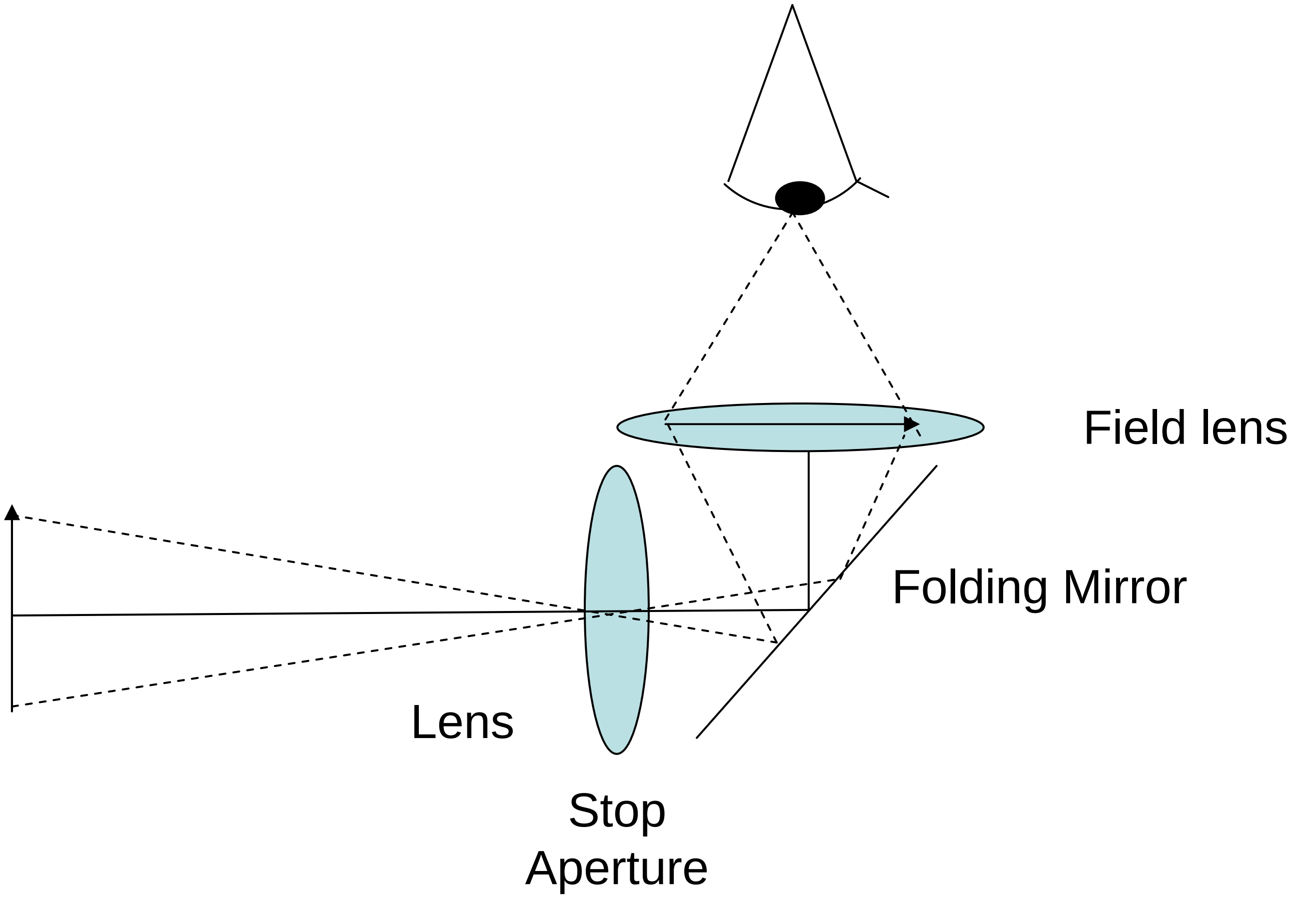
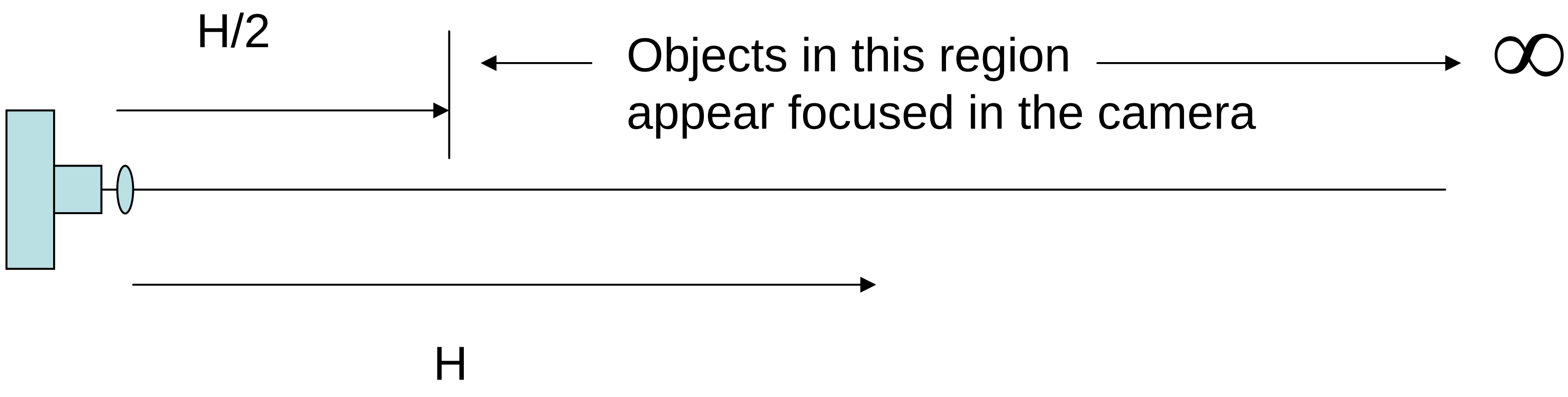
Brilliant finder



Hyperfocal distance



Objects beyond half the hyper-focal distance H appear in focus.

$$H = \frac{f^2}{f/\#}\frac{1}{c}$$

c is the diameter of the minimum spot size allowed

Hyperfocal distance H

~in focus

In this lecture

- Wollaston landscape lens
- The concept of artificially flattening the field
- The Brownie camera