Petzval's portrait lens

Lens Design OPTI 517

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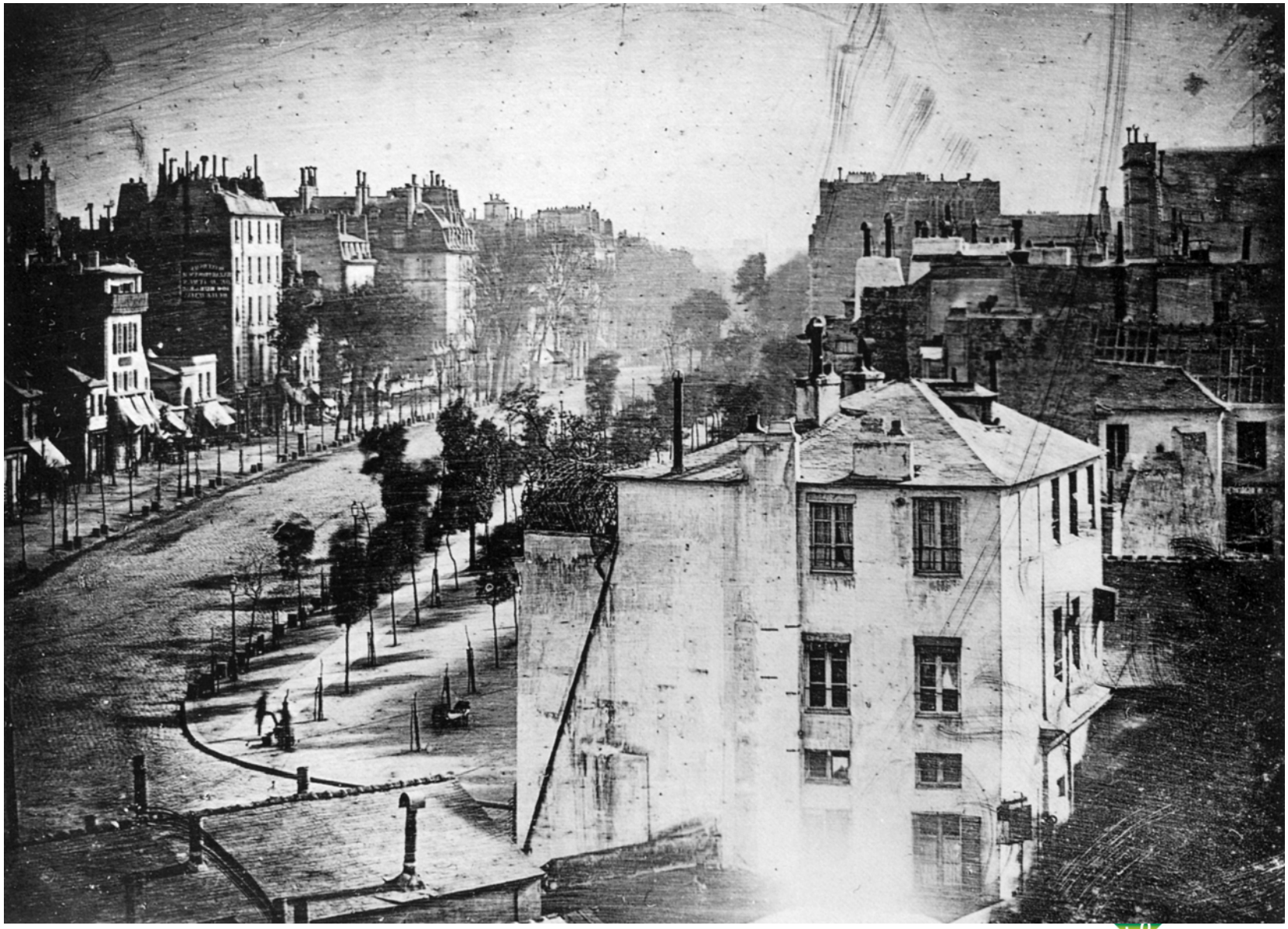

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Chronology

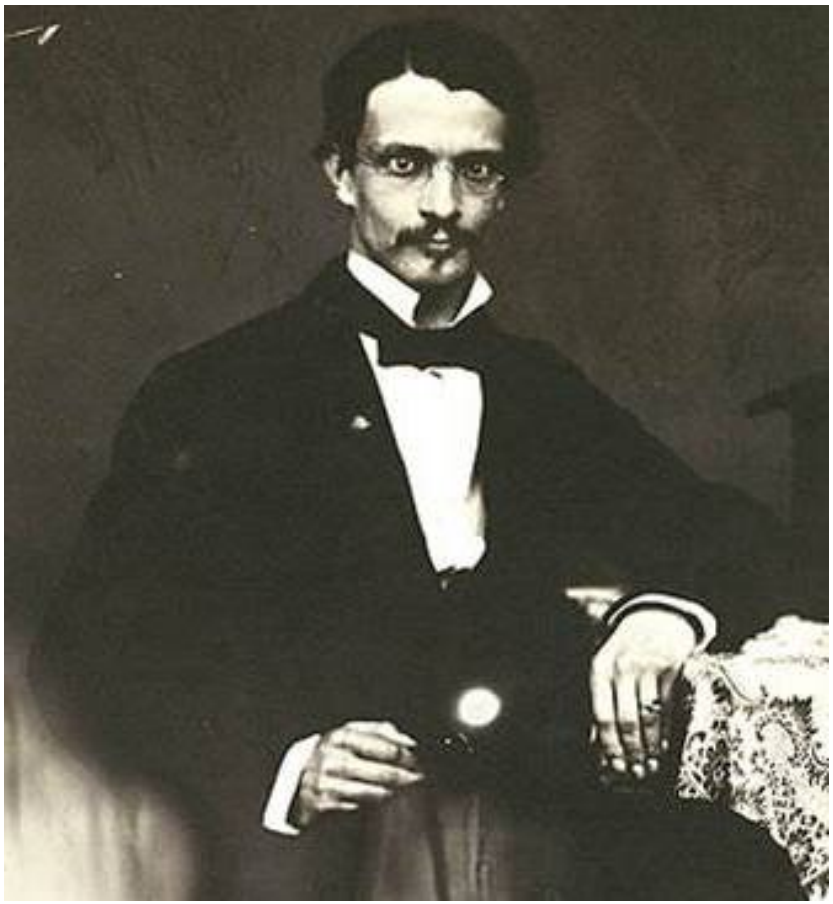
- Camera obscura; Leonardo da Vinci (1452-1519)

  provided the first known technical description
- The idea of capturing an image
- Lois Jacques Mande Daguerre (1787-1851) succeeded in finding a photographic process. This was announced in 1939

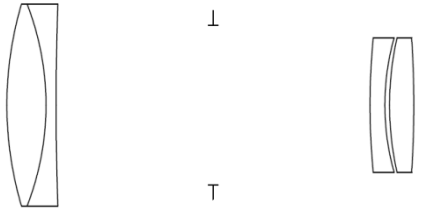
Time table

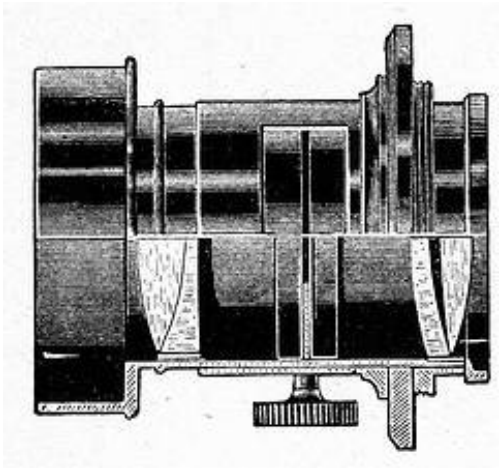
1812 W. Wollaston landscape lens; 30 deg @ f/15
1825 ~T. Young, G. Airy, J. Herschel, H. Coddington
1828 Hamilton's theory of systems of rays
1839 Photography was made a practical reality
1839 Chevalier lens
1840 Petzval (Hungarian) portrait lens; 15 deg @ f/3.6
1841 Gauss's cardinal points, focal and principal
1856 Seidel theory

Joseph Petzval
1807-1891



Specification





R +52.9	-41.4	+436.2	+104.8	+36.8	45.5	-149.5
		N-crown=1.517; N-flint=1.576				
T	5.8	1.5	23.3/23.3	2.2	0.7	3.6

F=100 mm

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Petzval portrait lens could actually take photographs of people. This likely contributed to its success. It made photography a practical reality.

Fig. 48. „Sekundenbild", Daguerreotyp,
auf Jodchlorplatten aufgenommen von den Gebrüdern Natterer in Wien 1841.

Petzval Portrait lens
vs
Wollanston landscape lens

- F/3.6
- Field +/- 15 degrees
- Artificially flattened field
- 1840
- Photography process announced in 1839

- F/15
- Field +/- 30 degrees
- Artificially flattened field
- 1812
- Applied to camera obscura

Petzval portrait lens could actually take photographs of people. This likely contributed to its success. It made photography a practical reality.

Images

Object

Image

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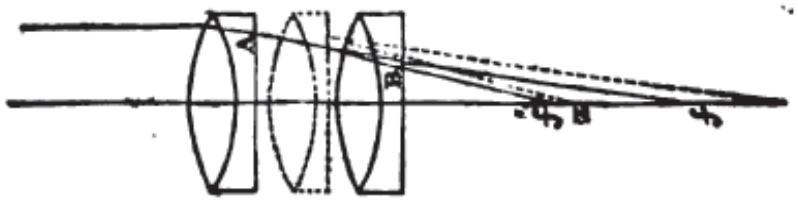
The state of the art

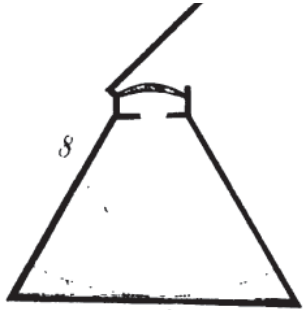
- Telescope doublets: Chromatic aberration and spherical aberration
- Periscopic lenses in the camera obscura
- Airy's study of the periscopic lens exhibiting the trade of between astigmatism and field curvature.
- H. Coddington treatise in optics
- Microscopes
- J.J. Lister microscope which was aplanatic 1830

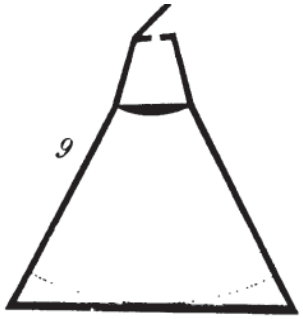
State of the art in finite field lens design

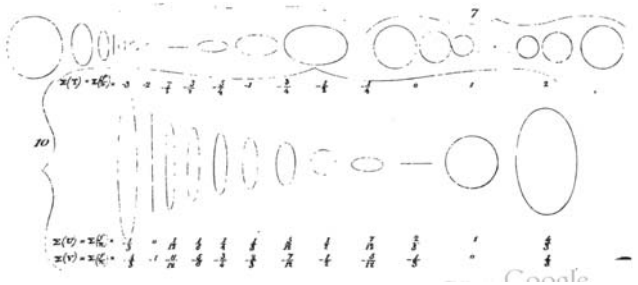


XIII. *On some properties in achromatic object-glasses applicable to the improvement of the microscope.* By JOSEPH JACKSON LISTER, *Esq.* *Communicated by Dr.* ROGET, *Secretary.*

Read January 21, 1830.







I. *On the Spherical Aberration of the Eye-pieces of Telescopes.*

By GEORGE BIDDELL AIRY, M. A.

FELLOW OF TRINITY COLLEGE, AND OF THE CAMBRIDGE PHILOSOPHICAL SOCIETY, AND LUCASIAN PROFESSOR OF MATHEMATICS IN THE UNIVERSITY OF CAMBRIDGE.

[Read *May* 14 and *May* 21, 1827.]

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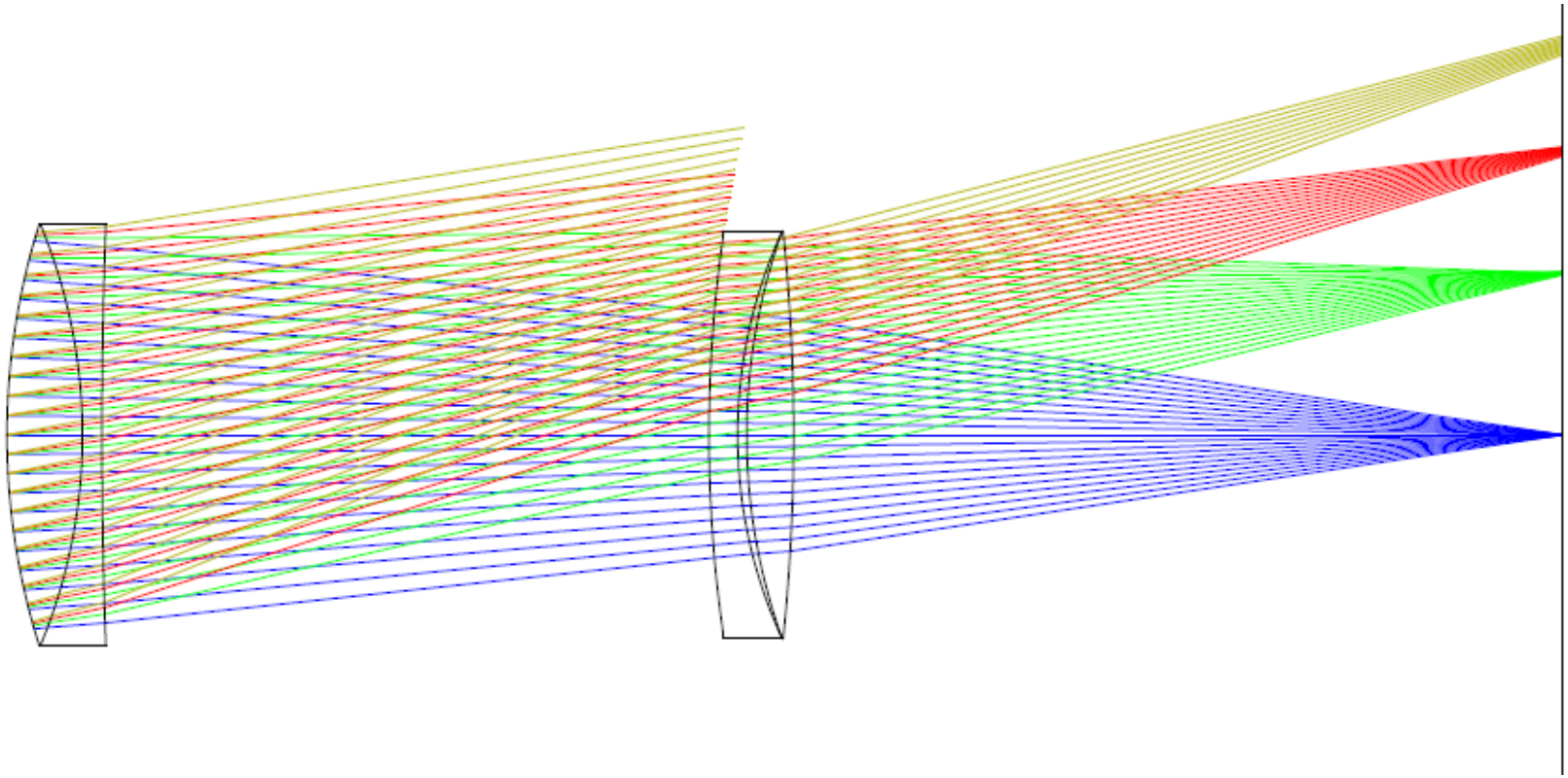
How was designed and how it works?

- First calculated camera lens
- It required the control of several aberrations, light vignetting, fabrication, and understanding of the application plus familiarly with optical hardware
- A fast lens was needed.
- Start with the available f/5 achromatic doublet

Petzval lens stop at first lens



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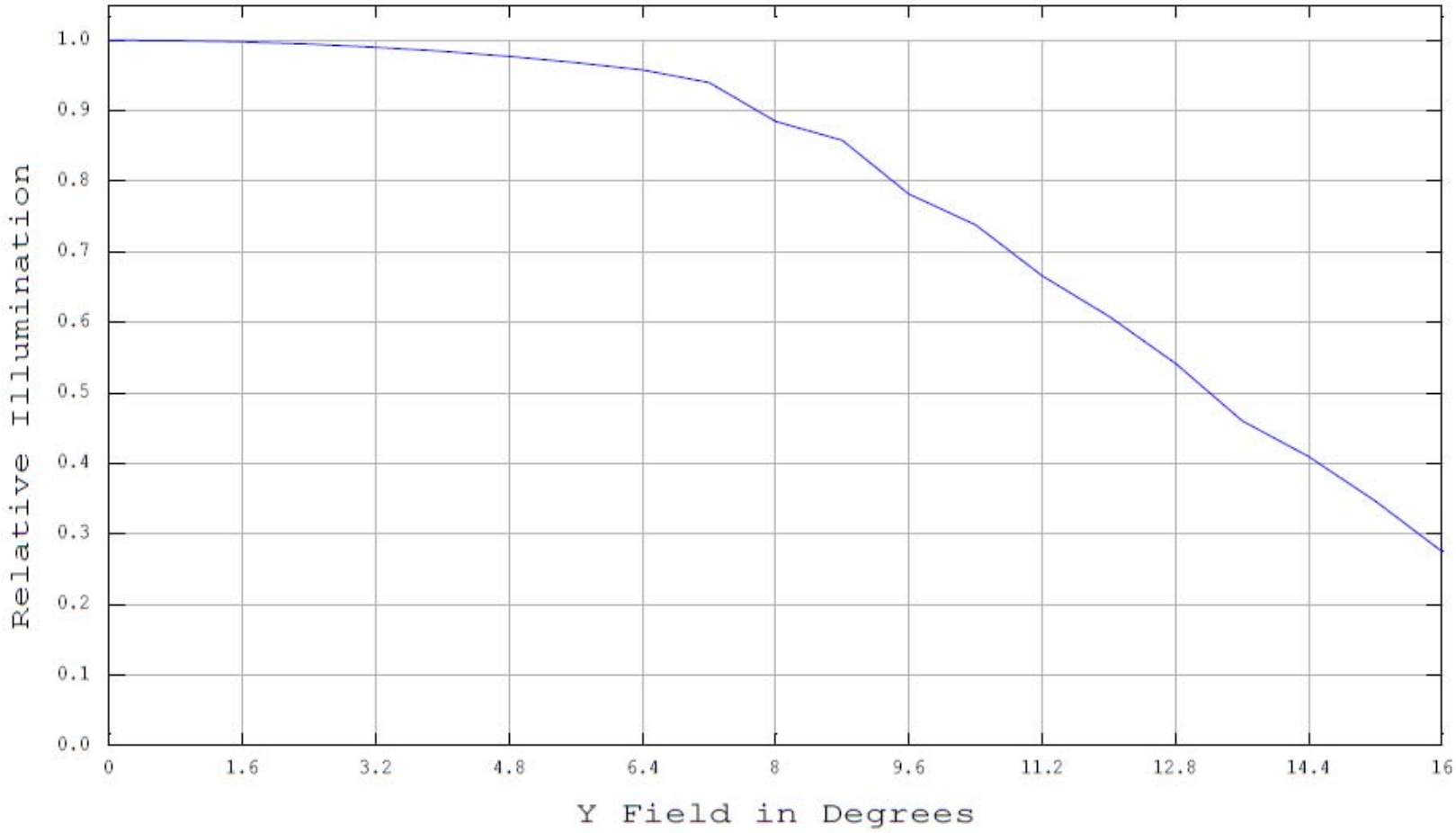
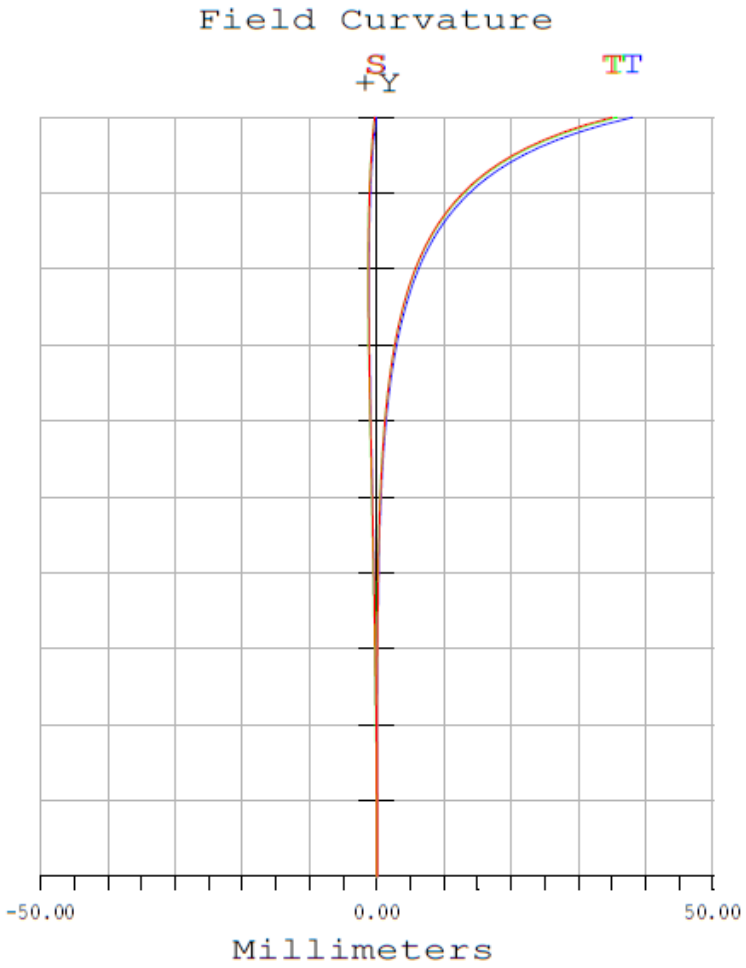
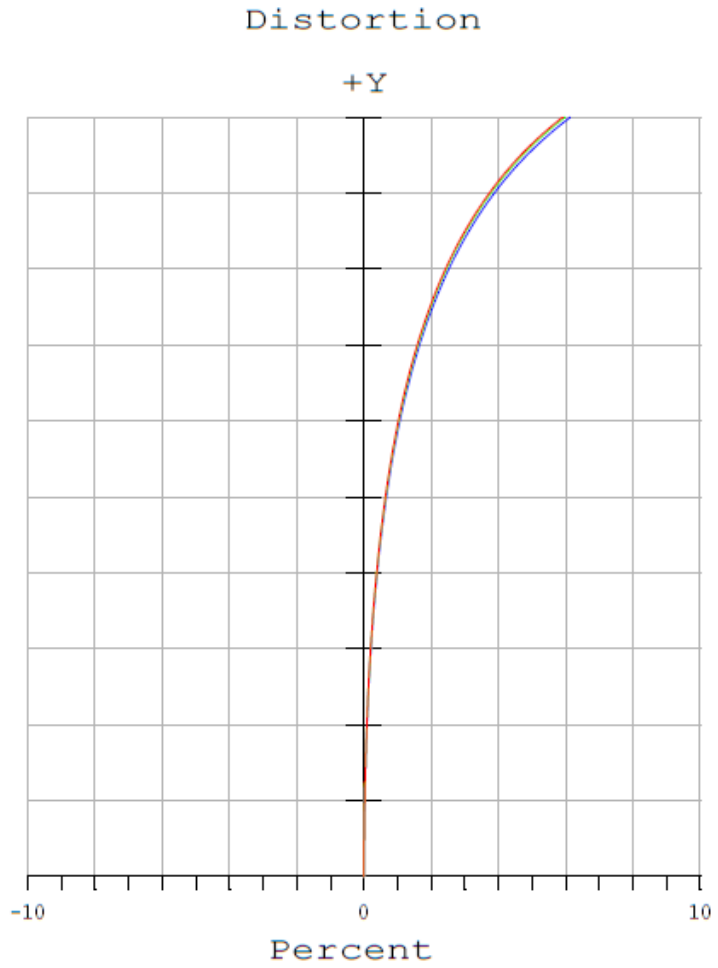
Relative illumination



Field curves





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Likely design concept

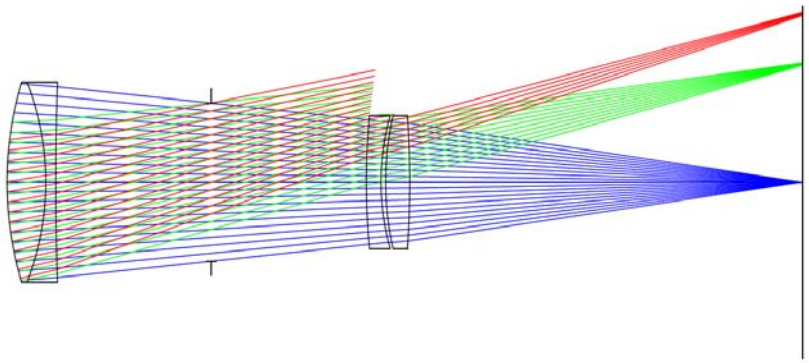
•Specs ~F/3.6, +/- 15 degrees (note aggressive improvement on optical speed)
•Use an available f/5 doublet
•Add a second doublet to increase optical speed and to flatten the field
•Spherical aberration is about individually corrected by each doublet
•Lens splitting for reduced aberrations
•Chromatic change of focus individually by each doublet.
•Chromatic change of magnification, by individual correction
•Astigmatism is made negative by second doublet to artificially flatten the field

•Stop was at first lens
•Later the stop was located at the middle and Waterhouse stops used ~1858.

Other insights

- Use of the alternate form for the second doublet
- Air-spaced doublet allows for control of astigmatism and allows ‘soft focus’

Light vignetting



Light is limited by the physical apertures of the lenses.
This reduces aberration and improves image quality at the expense of light and illumination uniformity.

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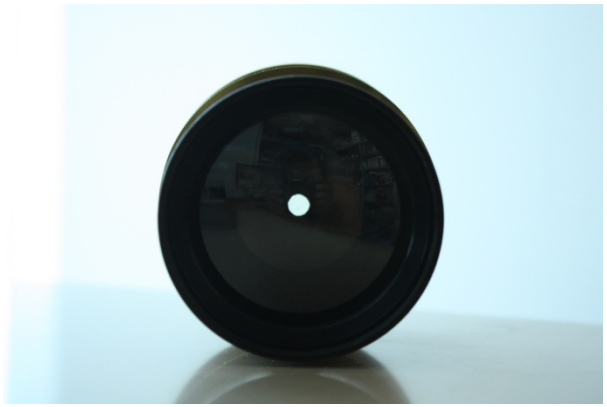
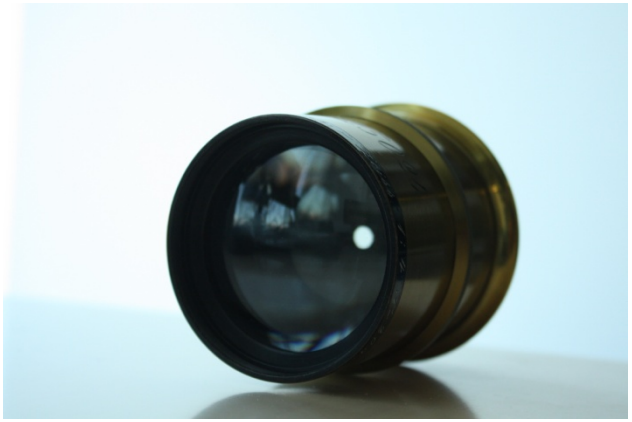
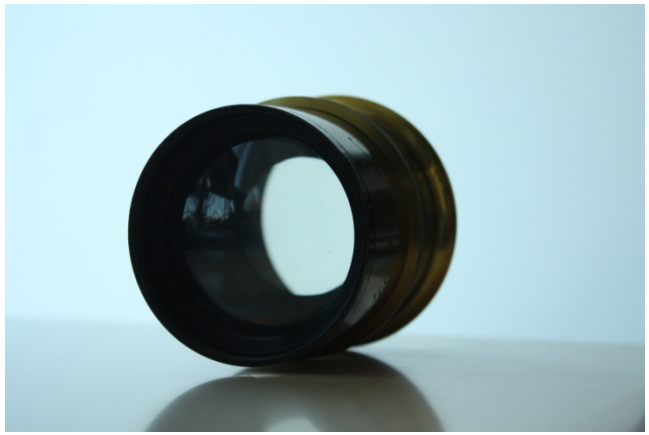
Light vignetting







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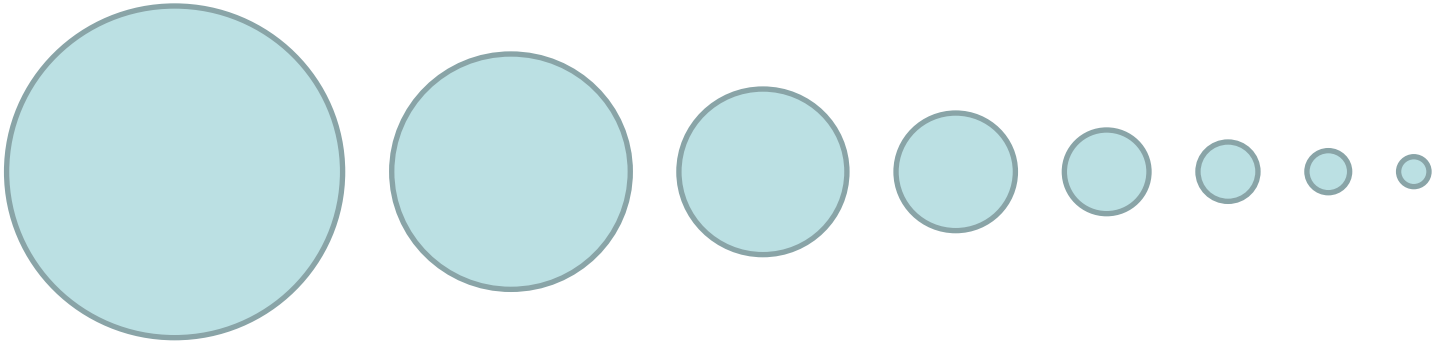
F-stops



F/1.4	F/2	F/2.8	F/4	F/5.6	F/8	F/16	F/22
1 sec.	2 sec.	4 sec.	8 sec.	16 sec.	32 sec.	64 sec.	128 sec.

One F-stop step doubles the exposure time

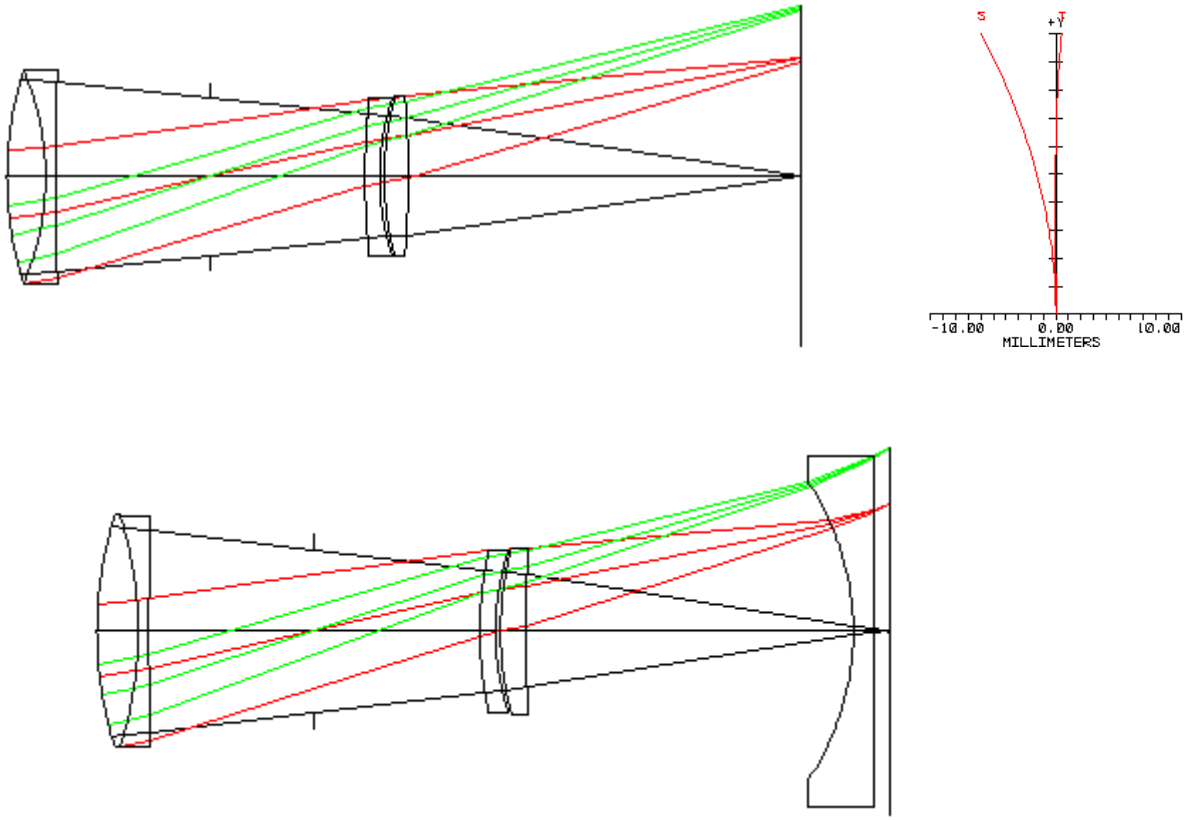
How much vignetting?

0.0%, 50% 75% 87.5%

It does depend on application.

One F-stop might be acceptable in photography

Field flattener lens



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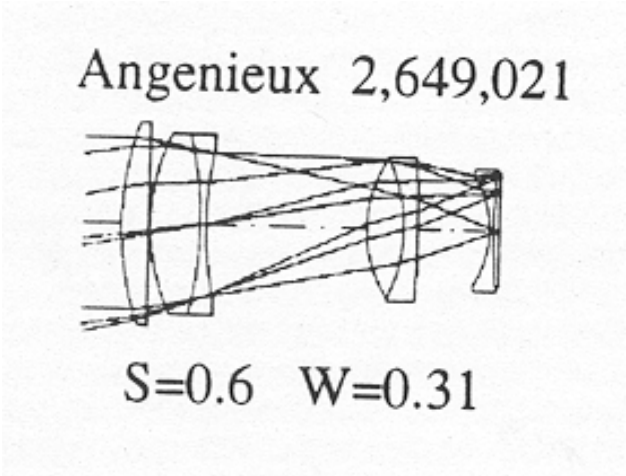
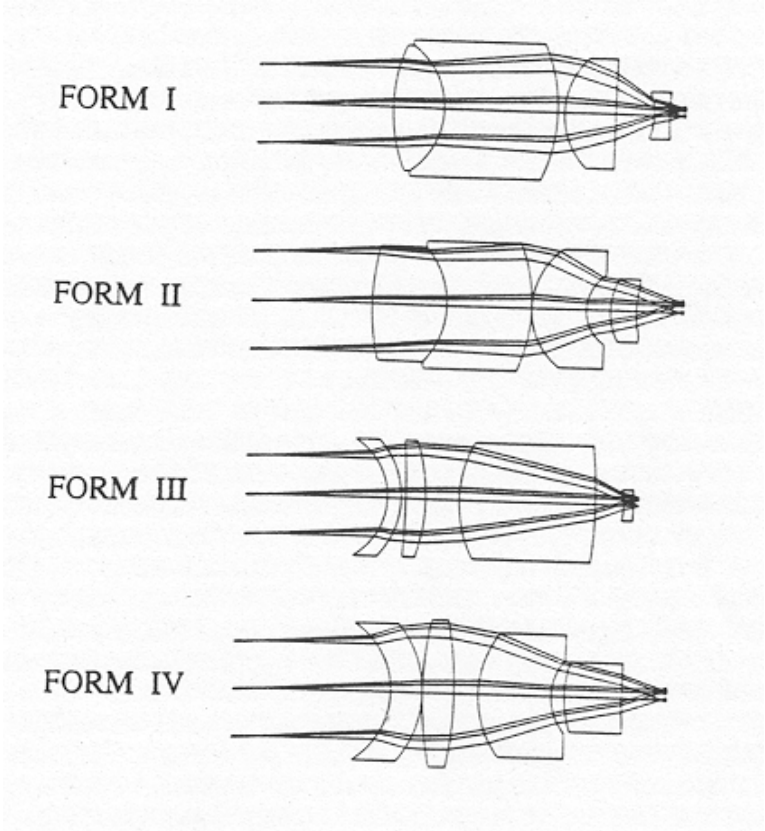
Other lenses based on the Petzval lens





Lens forms

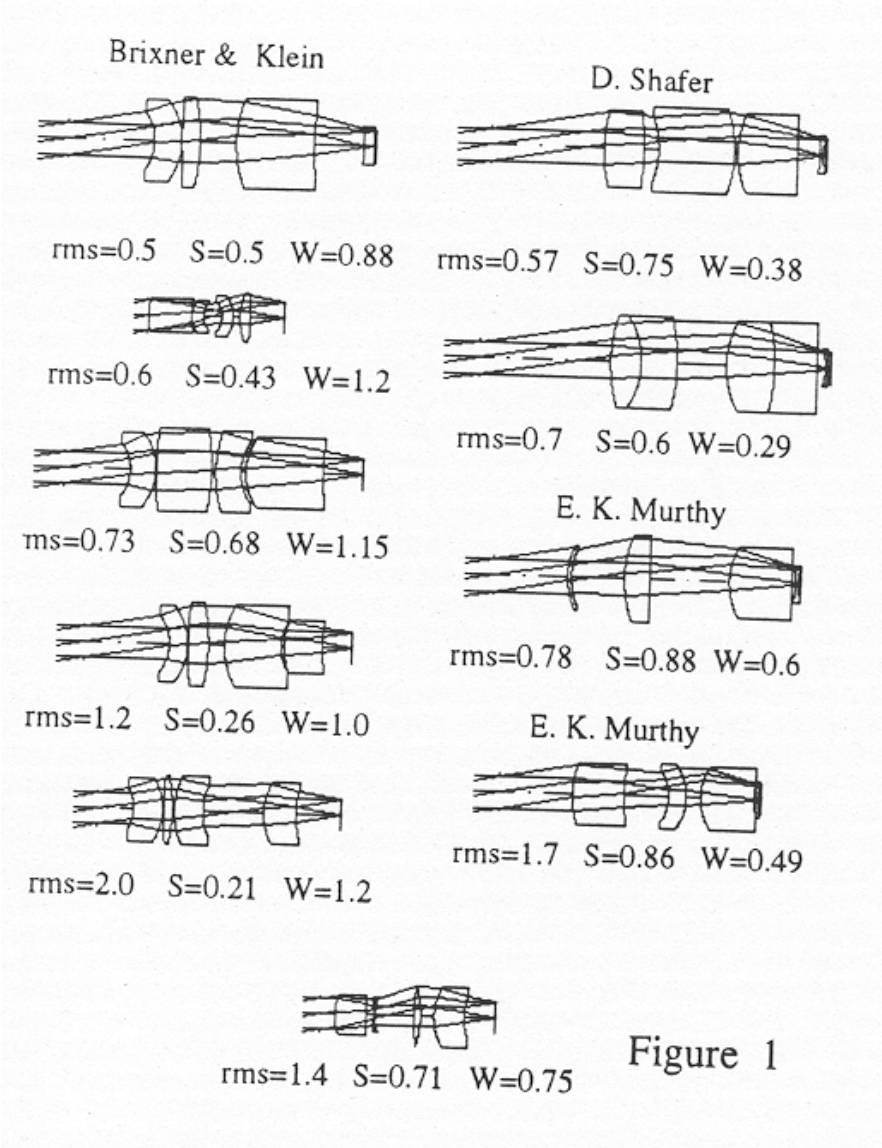


Figure 1

Using a Petzval lens

- If I can use a Petzval type lens I will do it!
- It is a relaxed lens in that the optical power of the parts contributes to the total power.
- The individual doublet lens optical power efficiently contributes to the total power.