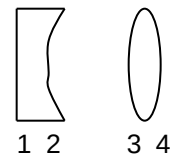
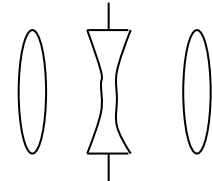




Triplet Design Following Geary's Procedure

(J. M. Geary, *Intro. To Lens Design with Practical Zemax Examples*, ch. 30, Willman-Bell, 2002)

- 1) For “**rear half**” = rear positive equi-convex element & plano-concave negative element, with the aperture stop located at the plano surface, Use equations from ch. 28 to calculate powers (half power for negative element) and lens separation.
- 2) Insert thin-lens solution into Zemax, add realistic thicknesses, and optimize with EFFL = desired EFL value and AXCL = 0 (variables on lens separation and curvatures of surface 2 & 3, with surface 4 slaved to 3).
- 3) Minimize spherical through lens bending. Let surfaces 2 and 3 vary (4 slaved to 3), but maintain the power of each element by holding EFLY equal to the initial value. Allow the airspace to vary over a reasonably limited range.
- 4) Add field angle (typically $\sim 5^\circ$) and aperture stop value. Add COMA and ASTI to the merit function editor, turn off the EFLYs (weight = 0), and vary curvatures 2, 3 and the airspace to minimize astigmatism (weight = 0 for COMA, weight = 1 for ASTI). Use FCGT once for each field angle. Leave COMA to be dealt with through symmetry.
- 5) Slave the back half to the “**front half**” = front positive equi-convex & concave-plano negative elements (AS between plano surfaces).
- 6) Run initial optimization using EFFL = target value and AXCL = 0. Activate TRAC, set variables on positive-element surfaces and separations, and optimize iteratively (increase field if needed).
- 7) Unslave front & back halves and optimize to obtain best performance (often move stop outside).

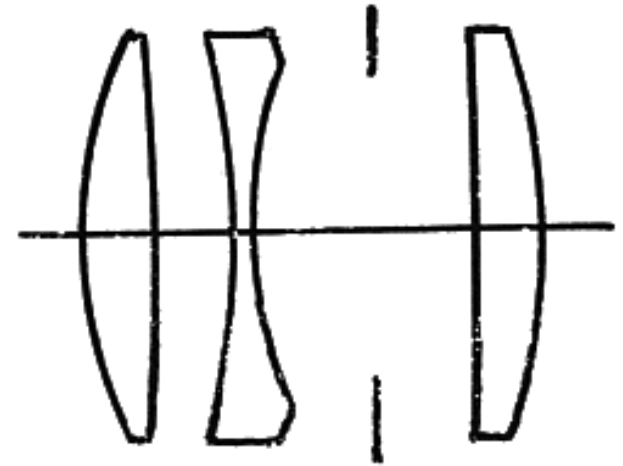


Cooke Triplet

Designed by H. Dennis Taylor in 1893 at Cooke of York as a portrait lens
[H. D. Taylor, "Optical designing as an art," *Trans. Opt. Soc.* **24**, 143 (1923)].

Design concept:

Equal-power thin positive and negative lenses in contact produce zero power and zero Petzval curvature. When separated, the system acquires positive power but maintains zero Petzval. To reduce the resulting large aberrations, split one element and place one half on each side...



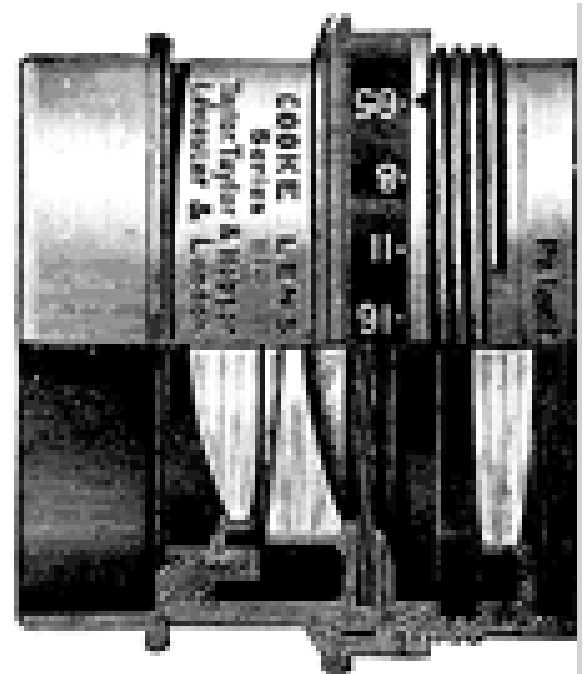
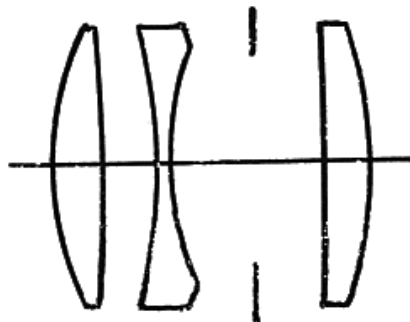


Cooke Triplet History

1893 f/4 (13°) Brit patent 22,607 U.S. patent 568,052 German patent 81,825

1895 f/7.7 (30°) Brit patent 15,107 U.S. patent 568,052 German patent 86,757
 f/5.6 (26°)

Cooke lenses famous for their harsh-weather capabilities. Cooke lenses used on almost all expeditions to Antarctica, Mt. Everest, etc.





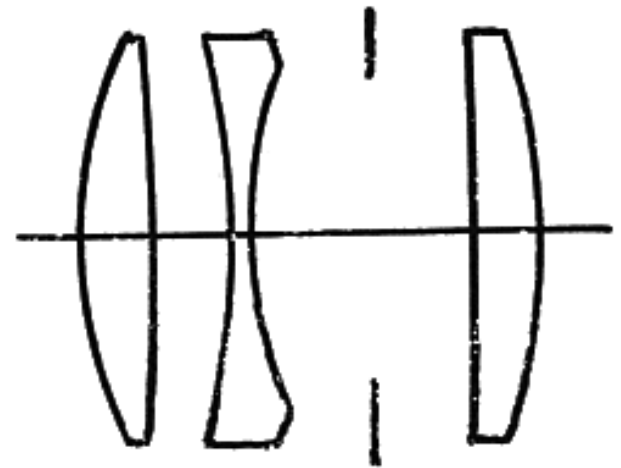
Cooke Triplet

Review of design technique:

3 lens powers + 2 airspaces used to control Axial and lateral color, Petzval curvature, focal length, and desired airspace ratio.

3 lens bendings used to correct spherical, coma, and astigmatism.

- no direct control over distortion other than glass choice ...



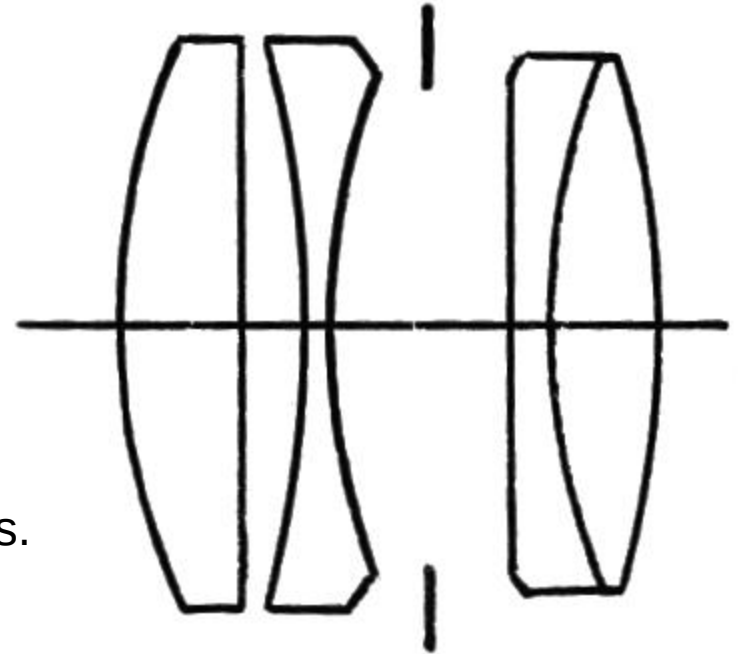


Tessar

Triplet modified by replacing back element with doublet (Tessar = Greek *four*)

Designed by Paul Rudolph in 1902
at Zeiss Optical in Germany.

- Front component has very little power; its main purpose is to correct aberrations from the achromatic doublet at the back.
- Cemented doublet interface in back element reduces zonal and oblique spherical aberration and reduces astigmatism at intermediate angles.
- Negative central element reduces Petzval sum ...



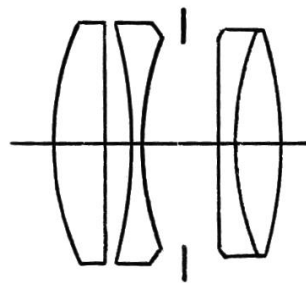


Tessar patent (1902)

“A spherically, chromatically, and astigmatically corrected objective consisting of four lenses separated by the diaphragm into two groups each of two lenses, of which groups one includes a pair of facing surfaces and the other a cemented surface, the power of the pair of facing surfaces being negative and that of the cemented surface positive.”

Later amendment:

The positive element of the separated lenses must be outside and the negative element inside toward the stop.





Tessar History

(www.zeiss.com)

1902	f/6.3	German patent 142,294	U.S. patent 721,240	Brit patent 13,061
1917	f/4.5			
1930	f/2.8	German patent 603,325	U.S. patent 1,849,681	Brit patent 369,833

Tessar-style lens used in early Leica cameras (1920):

1920 50-mm f/3.5 Elmar German patent 343,086

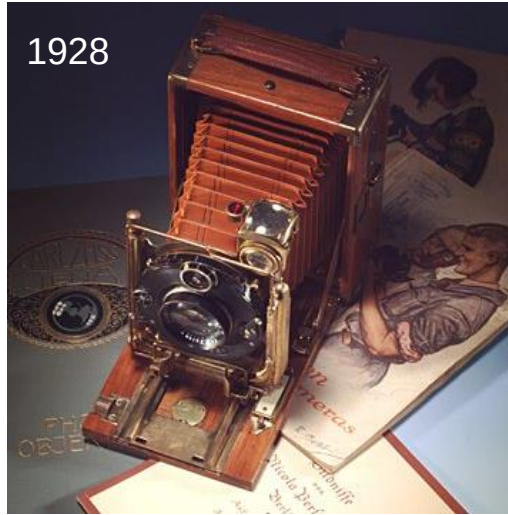


Tessar Legacy...

1913



1928



1950s



1970



2002



2015



(Vario-Tessar = zoom Tessar)



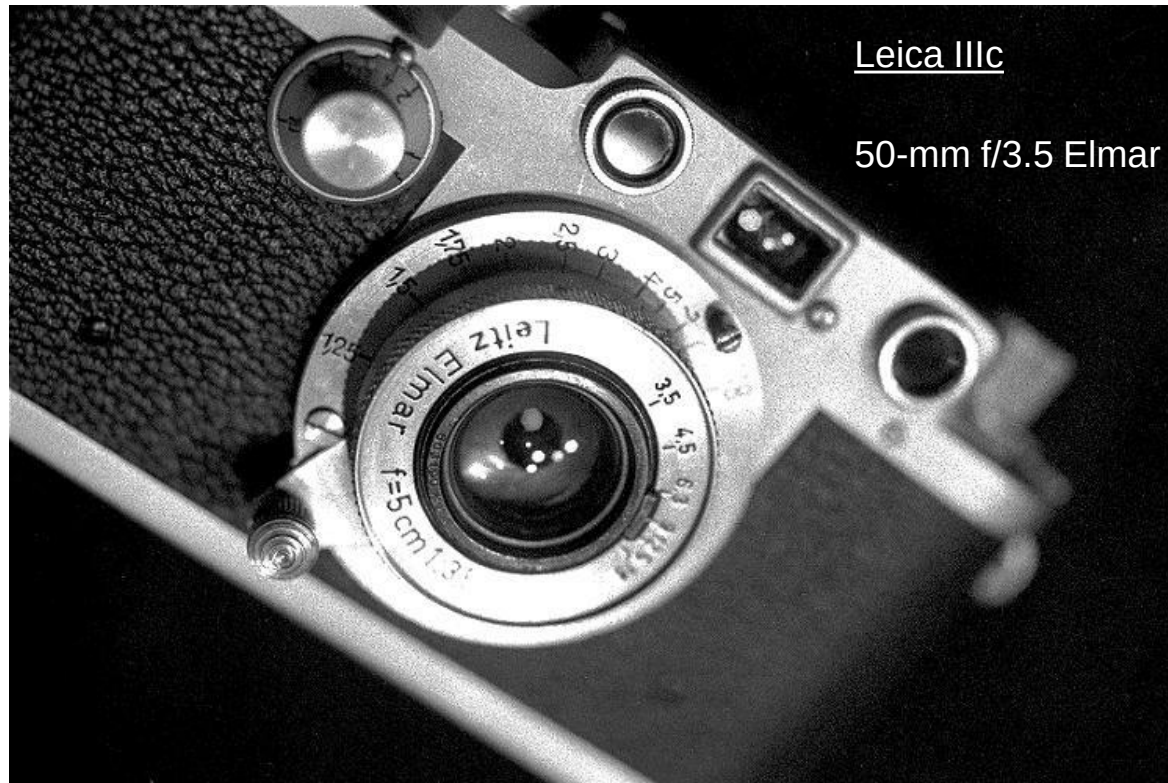
Non-Zeiss Tessar-Style Triplets

Over 400 types of Tessars have been made by nearly all lens manufacturers, in 100+ years.

Modern vario-Elmar
(16-18-21, f/4)
\$3895



Classic Leica IIIc with Leitz Elmar 50-mm f/3.5 lens ("Tessar" type)



Leica IIIc

50-mm f/3.5 Elmar