Tessar and Dagor lenses

Lens Design OPTI 517

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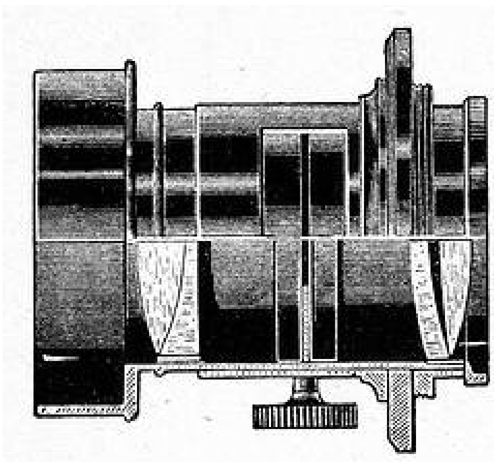
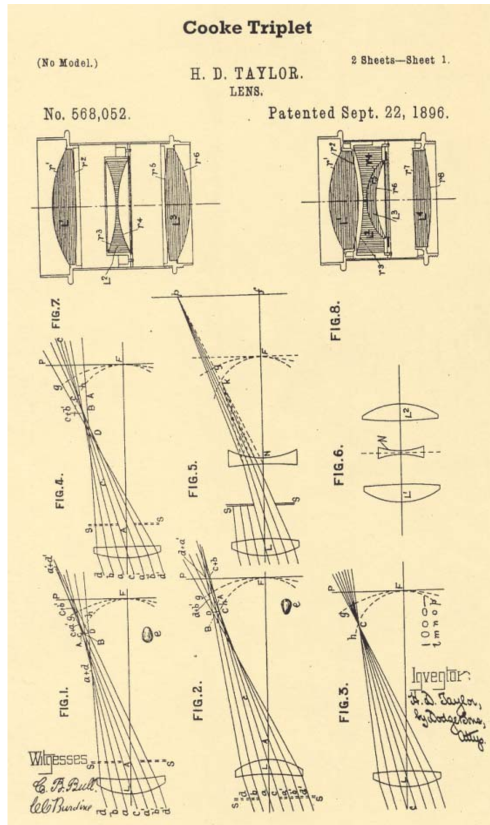
The University of Arizona®

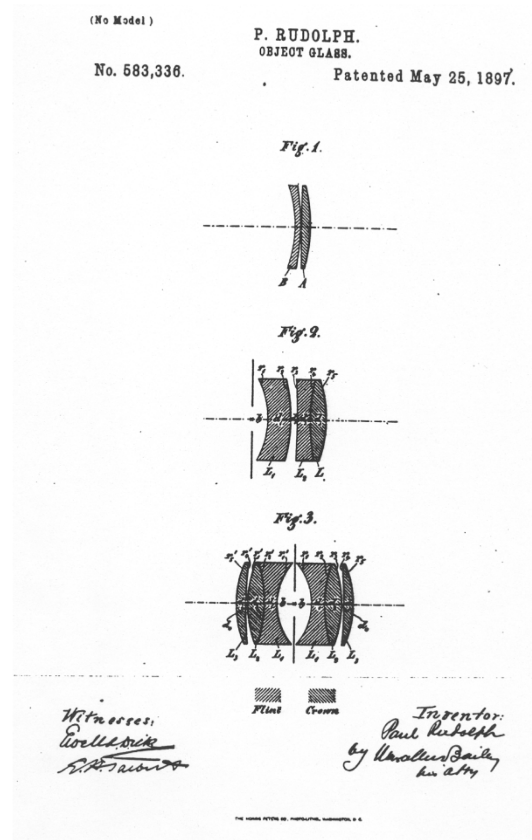
Important basic lens forms



Petzval
little stress



Cooke Triplet
Stressed with
high high-order
aberrations



DB Gauss
Stressed with
Low high-order
aberrations

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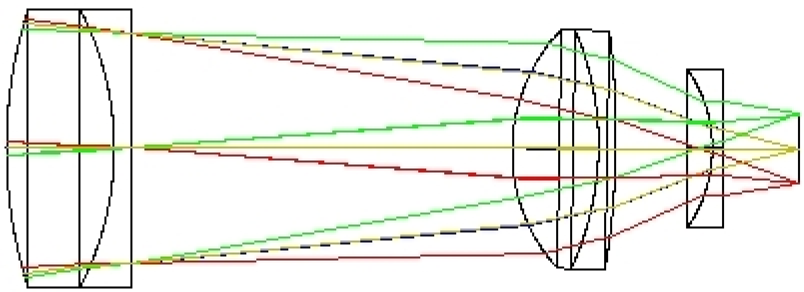
Measuring lens sensitivity to surface tilts

$$W_{131} = -\frac{1}{2} AB\Delta\left\{\frac{u}{n}\right\} y \qquad W_{222} = -\frac{1}{2} B^2\Delta\left\{\frac{u}{n}\right\} y$$

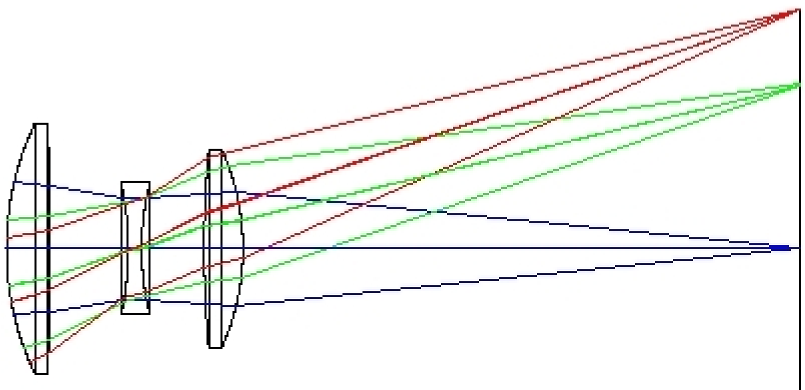
$$cs = \left(\frac{1}{1-m}\right)^2 \frac{1}{y_{stop}} \left(\frac{1}{n'u'}\right)^2 A\Delta\left\{\frac{u}{n}\right\} y \qquad as = \frac{1}{1-m}\frac{1}{B_{stop}}\frac{1}{y_{stop}}\frac{1}{n'u'} B\Delta\left\{\frac{u}{n}\right\} y$$

$$CS = \sqrt{\sum_j cs^2} \qquad AS = \sqrt{\sum_j as^2}$$

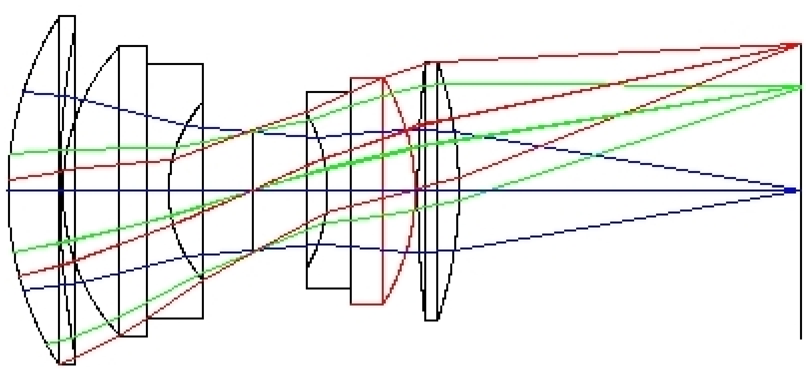
Lens sensitivity comparison



Coma sensitivity 0.32
Astigmatism sensitivity 0.27



Coma sensitivity 2.87
Astigmatism sensitivity 0.92

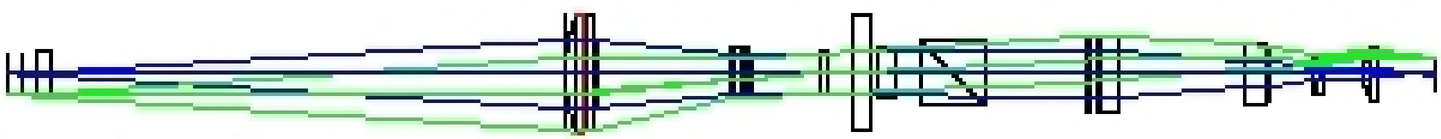


Coma sensitivity 0.99
Astigmatism sensitivity 0.18

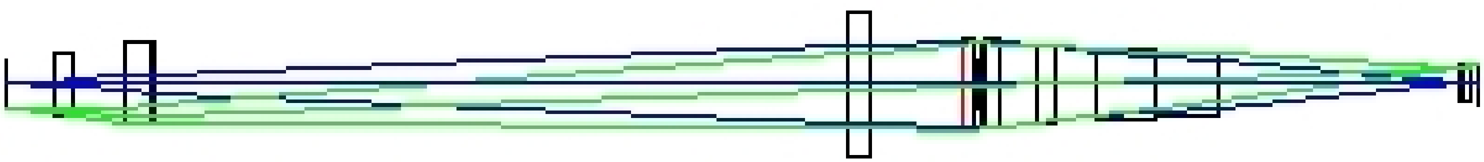
Actual tough and easy to align designs

Off-the-shelf relay at F/6

Coma sensitivity 0.54
Astigmatism sensitivity 0.78



Coma sensitivity 0.14
Astigmatism sensitivity 0.21



Improper opto-mechanics leads to tough alignment

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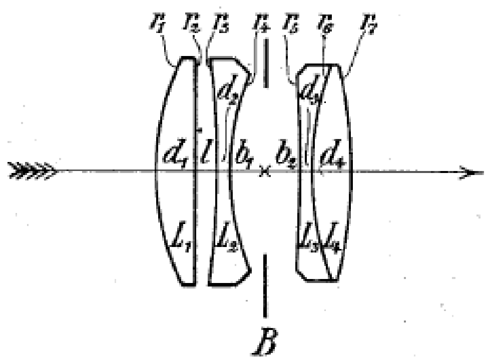
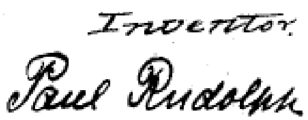
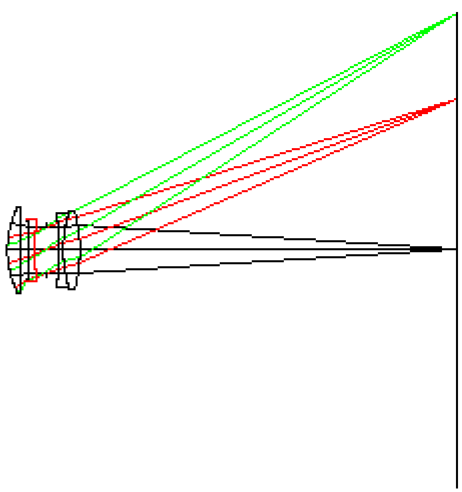
Tessar lens





- More degrees of freedom
- Can be thought of as a re-optimization of the PROTAR
- Sharper than Cooke triplet (low index)
- Compactness
- Tessar, greek, four
- 1902, Paul Rudolph
- New achromat reduces lens stress



Radii:	*Thicknesses and Distances:*
$r^1 = +0.215$	$d^1 = 0.033$
$r^2 = \pm \infty$	$l = 0.019$
$r^3 = -0.743$	$d^2 = 0.011$
$r^4 = +0.208$	$b^1 = 0.030$
$r^5 = -1.113$	$b^2 = 0.030$
$r^6 = +0.253$	$d^3 = 0.011$
$r^7 = -0.367$	$d^4 = 0.030$

Glasses used:

	L^1.	L^2.	L^3.	L^4.
n_D	1.61132	1.60457	1.52110	1.61132
n_F	1.61870	1.61436	1.52830	1.61895
$n_{G'}$	1.62463	1.62252	1.53397	1.62514

P

Tessar

- The front component has very little power and acts as a corrector of the rear component new achromat
- The cemented interface of the new achromat: 1) reduces zonal spherical aberration, 2) reduces oblique spherical aberration, 3) reduces zonal astigmatism
- It is a compact lens

Merte’s Patent of 1932

Faster Tessar lens F/5.6

March 15, 1932. W. MERTÉ ET AL 1,849,681

PHOTOGRAPHIC THREE-LENS OBJECTIVE

Filed July 10, 1931

Focal length: 100

Radii:		Thicknesses and distances:	
r_1	= + 23.4	d_I	= 4.3
r_2	= ∞	l	= 2.3
r_3	= − 81.3	d_{II}	= 2.5
r_4	= + 22.4	b_1	= 4.2
r_5	= − 322.0	b_2	= 1.3
r_6	= + 27.6	d_{III}	= 0.6
r_7	= − 48.3	d_{IV}	= 4.7

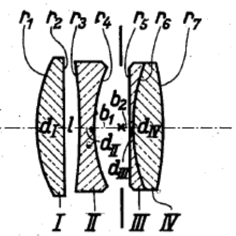


Fig. 1

Radii:		Thicknesses and distances:	
r_1	= + 24.2	d_I	= 4.1
r_2	= − 555.0	l	= 2.2
r_3	= − 96.0	d_{II}	= 3.1
r_4	= + 21.0	b_1	= 3.4
r_5	= − 166.0	b_2	= 2.6
r_6	= + 21.0	d_{III}	= 0.7
r_7	= − 45.2	d_{IV}	= 4.4

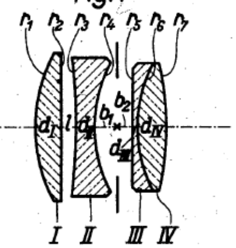


Fig. 2

Kinds of glass:

		I	II and III	IV
Fig. 1	n_d =	1.58315	1.58215	1.67110
	ν =	59.3	42.0	47.3

		I and IV	II	III
Fig. 2	n_d =	1.67110	1.62004	1.58215
	ν =	47.3	36.3	42.0

Inventors:

Dr. Willy Merté

[illegible]

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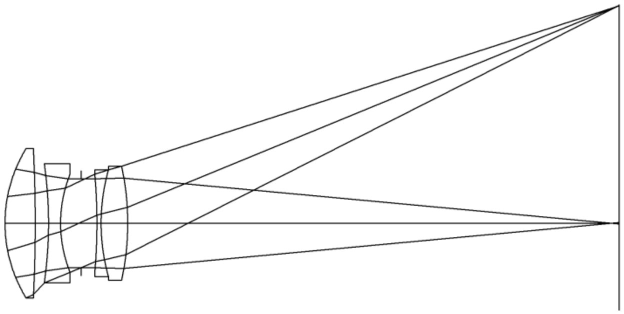
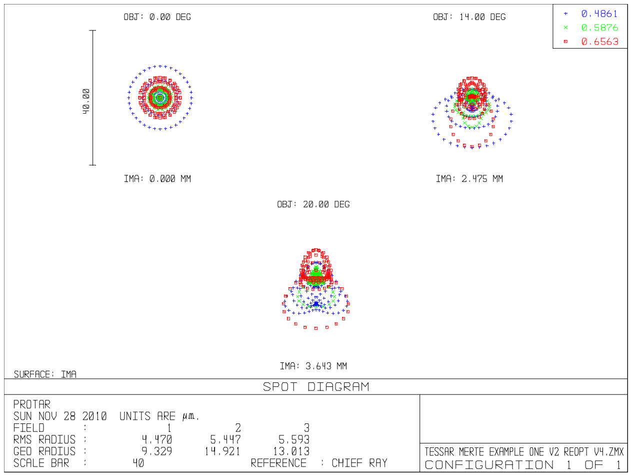
Re-optimized Merte's example two

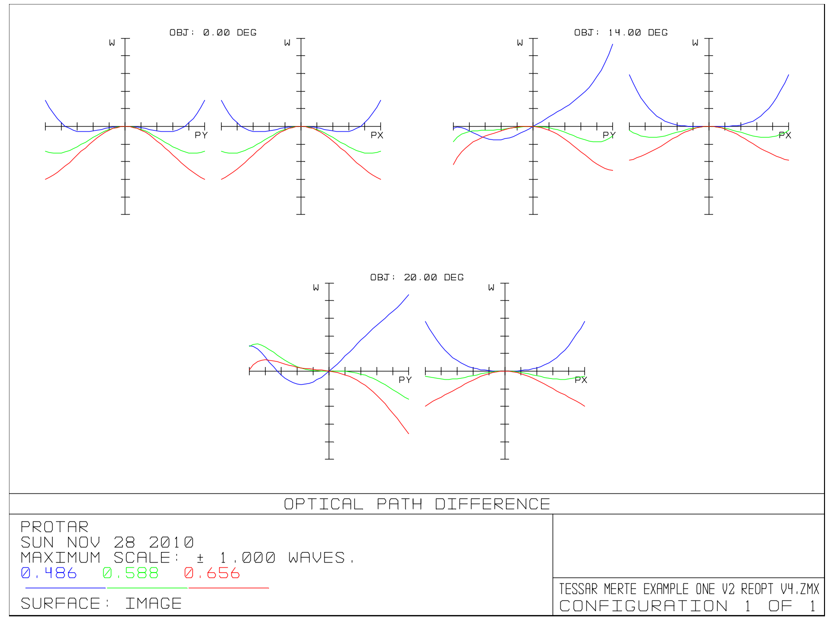


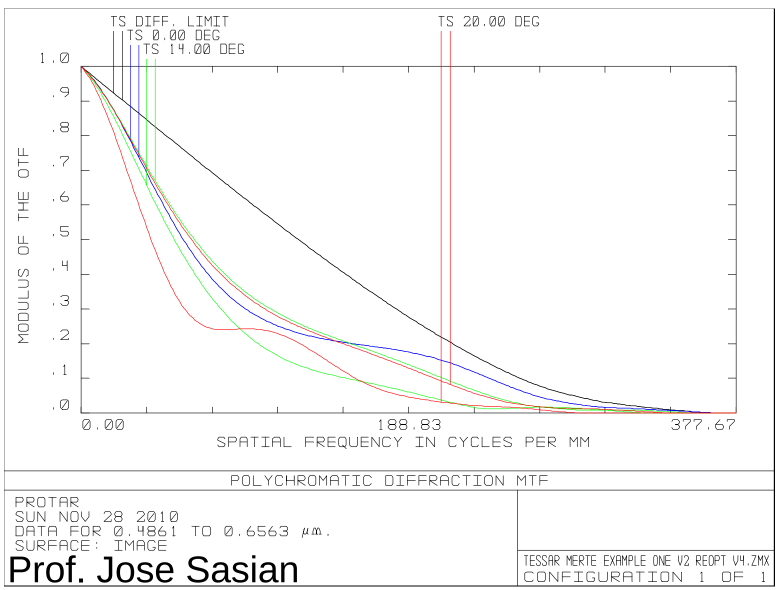
F=10 mm
F/5.6
+/- 20 deg

OSC Crowd 2007

Performance







Scales are 0.04mm
1 wave
And 377 c/mm

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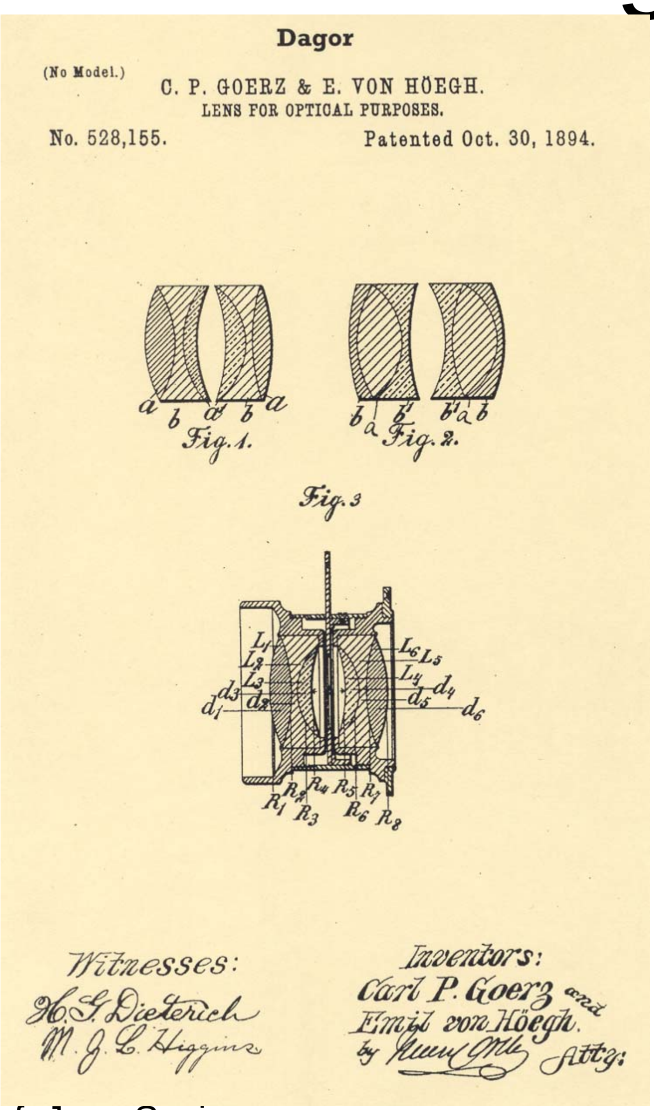
Dagor Lens



- A different solution based on a thick meniscus
- Use of cemented surfaces
- Use of the symmetry principle
- 1894
- Emil Von Hoegh
- Double Anastigmatic GoeRz

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Hoegh suggestions

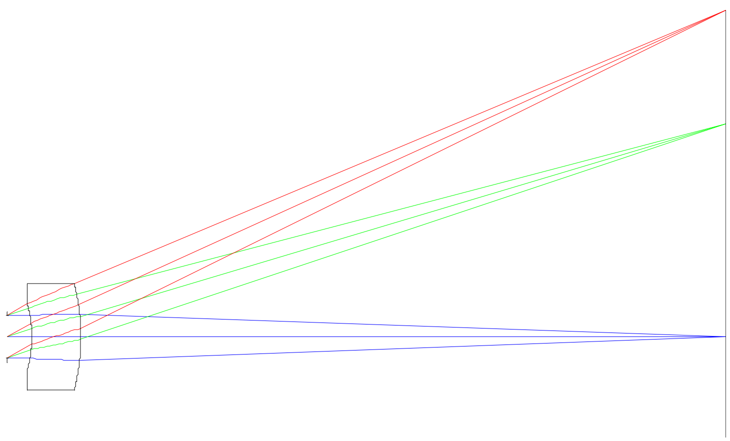
(From R. Kingslake)

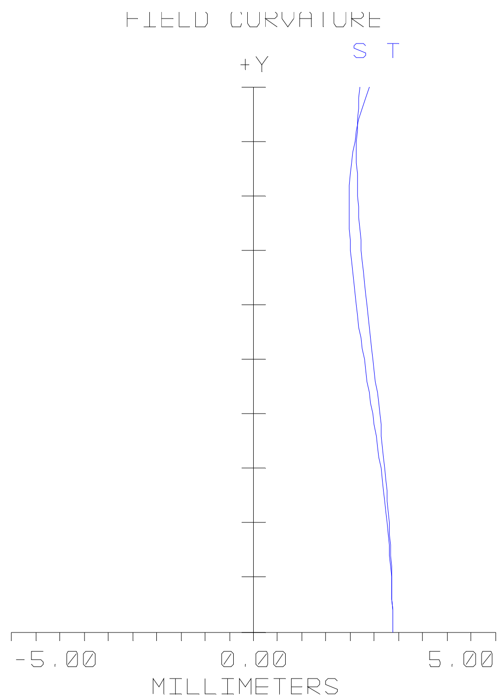
1 Insert a collective interface convex to the stop in the flint element of the rapid rectilinear, thus turning the half-system from a doublet into a triplet

2 Use progressively increasing refractive indices outward from the stop

3 Use almost equal outside radii of curvature and to thicken the lens sufficiently to give the desired focal length and Petzval sum

Using radial gradient index





$$n = n_0 + A_2 r^2 + A_4 r^4$$

Four classical ways to correct for field curvature
A different way is by using radial index glass

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From the landscape lens to the Planar lens summary
(Variations in the landscape lens theme or the variations in the doublet lens theme)

- Wollanston meniscus and Chevalier achromatic lens ~1812
- Petzval portrait lens ~1839
- Periscopic lens ~1865
- New glasses ~1885
- New achromat doublet
- Rapid rectilinear ~1866
- Ross concentric (Schroeder) lens ~1890
- Protar ~1890
- Cooke (D. Taylor) triplet ~1896
- Planar (double Gauss) ~1897
- Tessar ~1902
- Dagor ~1894