Photographic Objective Lenses: A Schematic Guide

Simple Meniscus Lens
The Simple Meniscus lens is almost universally used in inexpensive cameras. To get an image of good quality it must be used with a separate aperture stop, reducing the aperture of the lens and the aberrations and their effects. The stop also selects the pencil of off-axis rays that passes through the lens: this controls astigmatism and eliminates coma. Spherical and chromatic aberrations and field curvature are totally uncorrected, but are rendered tolerable by the low speed—about f/15. Distortion is uncorrected. The stop may be before or behind the lens, although it is always on the concave side. If the meniscus lens is compounded, chromatic aberration can be corrected and spherical reduced slightly, but this is not an economical solution.

Double Meniscus System
The arrangement of the two simple meniscus lenses on either side of the aperture stop is called a Periscopic lens. Symmetrical about the stop, it has greatly reduced coma, lateral color and distortion. Spherical aberration is slightly better than in the single meniscus, but axial color and field curvature are slightly worse.

If the two menisci are achromatized, the chromatic aberration is eliminated and the spherical is somewhat reduced. However, the remaining spherical aberration and the field curvature limit the lens to a speed of about f/8. Known as the Rapid Rectilinear, this was once a very popular lens for medium-priced cameras.

Meniscus Anastigmats
The first true anastigmas used a thick meniscus construction to achieve the wide separation of convex and concave surfaces necessary to flatten the field. Correction of chromatic and spherical aberration was accomplished by the cemented surfaces. Although limited to speeds of f/8 to f/4.5 by heavy residual spherical aberration, these anastigmats are still useful as moderately wide-angle lenses, and are capable of excellent definition when stopped a bit below their full aperture.

Retrofocus
The Retrofocus, or Reversed Telephoto lens, is usually composed of an ordinary objective with a negative component near its front focal point. Because of its relatively large back-focus and size, it is most useful for short-focal-length, wide-angle applications. In its early form the rear member was a standard objective, but modern versions tend to be designed as a unit and are difficult to classify.

A new class of wide-angle lens has evolved from this form, as the bending of ray bundles outward by the negative member lends itself to this application. In a wide-angle configuration there is usually a fairly complex positive member closely enveloping the stop with symmetrically arranged negative elements on either side.

Dogmar/Aviar
Historically known as the Celor, this lens was derived from the Dagor, although it can be regarded as a
Lenses

Triplet with a split flint element. It is an excellent general-purpose photographic lens and can be designed with a wider-than-normal field. This design form is also used extensively in high-quality commercial process lenses.

Cooke Triplet

The Cooke Triplet Anastigmat is the simplest lens in which all the primary aberrations may be corrected. Consisting of two positive crown elements on either side of, and spaced away from, a negative flint element, this lens gives the designer the necessary freedom (shapes, powers and spacings) to do a reasonably complete correction job. As a result it is a popular and economical choice for a wide range of applications. At f/5.6, compact triplets can cover fields up to 60°. At the other extreme, high-index crown glasses make speeds above f/2 feasible for short-focal-length, narrow-angle applications. The Cooke Triplet is probably the most widely used photographic lens, either in its original form or in one of its many derivatives.

Double Gauss

This is one of the most powerful design forms and is the basis of most high-speed (over f/2) camera lenses. Derived from the Gauss form of telescope objective, which consisted of a meniscus crown and a meniscus flint, both convex to the long conjugate, the Double Gauss retains the excellent spherical correction of its ancestor. Perhaps the most serious defect in this design is oblique spherical aberration, which is usually kept in check by carefully vignetting the oblique pencils. Many modifications of this design exist: the outer crowns have been split and compounded and the doublets have been air-spaced and made into triplets.

Petzval Lens

Because of its relatively high speed (f/3) and narrow field of good definition, the Petzval lens was originally used in 19th century portrait photography. In its modern form the order of the elements in the rear achromat is reversed and the elements are cemented together. Useful for motion picture projection, the lens has been increased in speed to about f/1.6, but angular coverage is limited by field curvature to about 10 degrees.

Split-Crown Triplets

These descendants of the Cooke Triplet were created by splitting one of the crown elements into two to reduce the aberrations. The improvement has primarily increased the speed of the lens. For example, with ordinary dense barium crown glass, the Cooke Triplet is limited to speeds of about f/3.5. With a split crown element the aperture is approximately doubled, although the field coverage is reduced.

Tessar

Although it is externally very similar to the Cooke Triplet, the Tessar was actually derived from the Protar, a totally different form of lens. While its applications, coverages and speeds are similar to those of the triplet anastigmat, the Tessar is a significantly better lens, usually showing somewhat better coverage, definition or versatility. Most good enlarging lenses and medium-speed “normal” camera lenses are of the Tessar type.