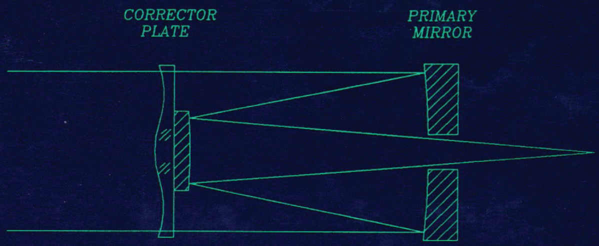
HANDBOOK OF LENS DESIGN



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HANDBOOK OF LENS DESIGN

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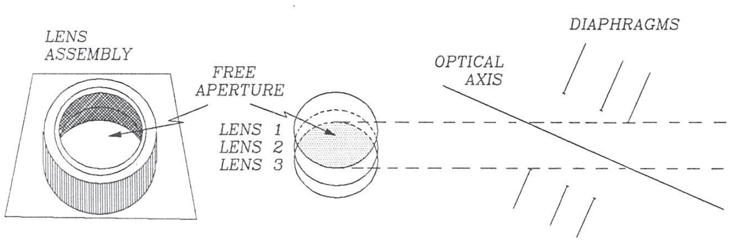

Figure 1.24.- Vignetting in a lens

If the light beam entering the system comes from a point object off-axis, as shown in Fig. 1.24, several surfaces may limit the transverse extension of the beam, producing an apparent aperture with a nearly elliptical shape. Then, the system is said to have *vignetting*. The vignetting effect appears only when the angle of incidence of the beam exceeds a certain limit. It is frequently desirable to avoid vignetting in a centered optical system, as shown in Fig. 1.25, to avoid excessive decreasing of the illuminance of the image at the edge of the field and, to have a better control of the image analysis during the design stage. Sometimes, however, vignetting is introduced on purpose, to eliminate some aberrations difficult to correct.

As shown in Fig. 1.23, of all meridional rays going from a point off-axis on the object plane, to the point on the image plane, only one passes through the center of the stop. This ray is the *principal ray*, or

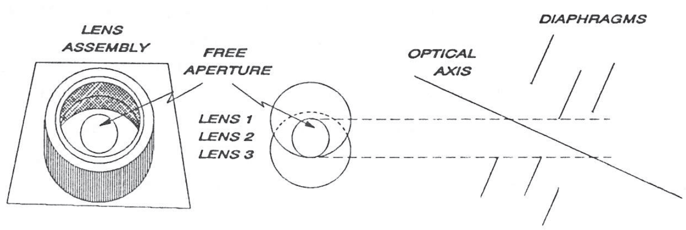

Figure 1.25.- Stop size to avoid vignetting in a lens for a given off-axis angle

ray that passes through the off-axi
The intersection of the extension
object space with the optical a
Similarly, the intersection of the
ray in the image space with the o
All quantities referring to the pri
top of the symbol, for example,
ray and $\bar{u}$ is its paraxial angle w
to see that $\bar{y}$ is equal to zero a
axial rays (meridional rays fro
without the bar.

The tangential and sagitta
may now be more formally defi
plane that contains the principa
sagittal plane is a plane perpe
contains the principal ray. As w
tangential plane for all media bet
a centered optical system. How
medium, because the principal ra

In order to trace the prin
must know its direction in the
such that the principal ray passes

1.6.1 Telecentric Systems

A *frontal telecentric* system
at infinity. Since the stop (diaphra
must be at a finite distance to avo
Let us consider the optical syster
is parallel to the optical axis, si
small defocusing by a small chan
system does not introduce any c
This property makes these syste
small defocusings do not introdu

A *rear telecentric* system h
(b). The stop is at the front focal

and

$$\frac{1}{f_3} = \frac{1}{F} \frac{V_3 [P_2 - P_1]}{\Delta} \tag{7.59}$$

where P_i are the partial dispersions and Δ is the determinant

$$\Delta = \begin{vmatrix} P_1 & V_1 & 1 \\ P_2 & V_2 & 1 \\ P_3 & V_3 & 1 \end{vmatrix} \tag{7.60}$$

We may see that the value of this determinant is the area of the triangle conecting the points representing the three glasses in a diagram of the partial dispersion P as a function of the Abbe number V. Thus, if this system of equations is to have a solution, this triangle must not have a zero area.

7.4 Magnification Chromatic Aberration

The magnification chromatic aberration, also frequently called lateral chromatic aberration or lateral color, appears when the images produced by different colors have different sizes on the observing plane. The effect of this aberration is a blurring of the image detail for points off-axis. The farther away from the axis, the greater the aberration (O'Connell, 1957).

To find an expression for the magnification chromatic aberration let us consider an optical system, as shown in Fig. 7.10. The paraxial

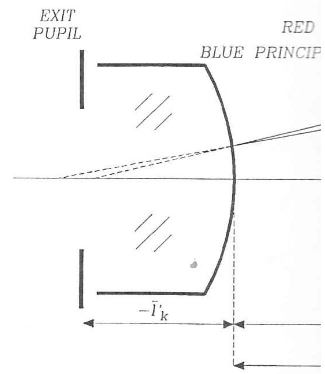

Figure 7.10.- Principal rays in
aberration

sagittal image for red light
The paraxial sagittal image
principal ray. The heights h
Lagrange theorem. As pointe
aberration arises because th
red and blue paraxial sag
aberration, these two images
chromatic aberration, repre
distance SQ from the blue p
ray (or viceversa, by the dis

Now, let us consider a
(*Chromatic Difference of*
assume in this figure that the
for colors C and F. This is n
in a first approximation, i
usually small distance betwe
Thus, we may write

$$QM = \left[\frac{l'_F - \cdots}{l'_C - \cdots}\right.$$

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