Astronomy 80 B: Light

Lecture 10: Aberrations, photography

1 May 2003

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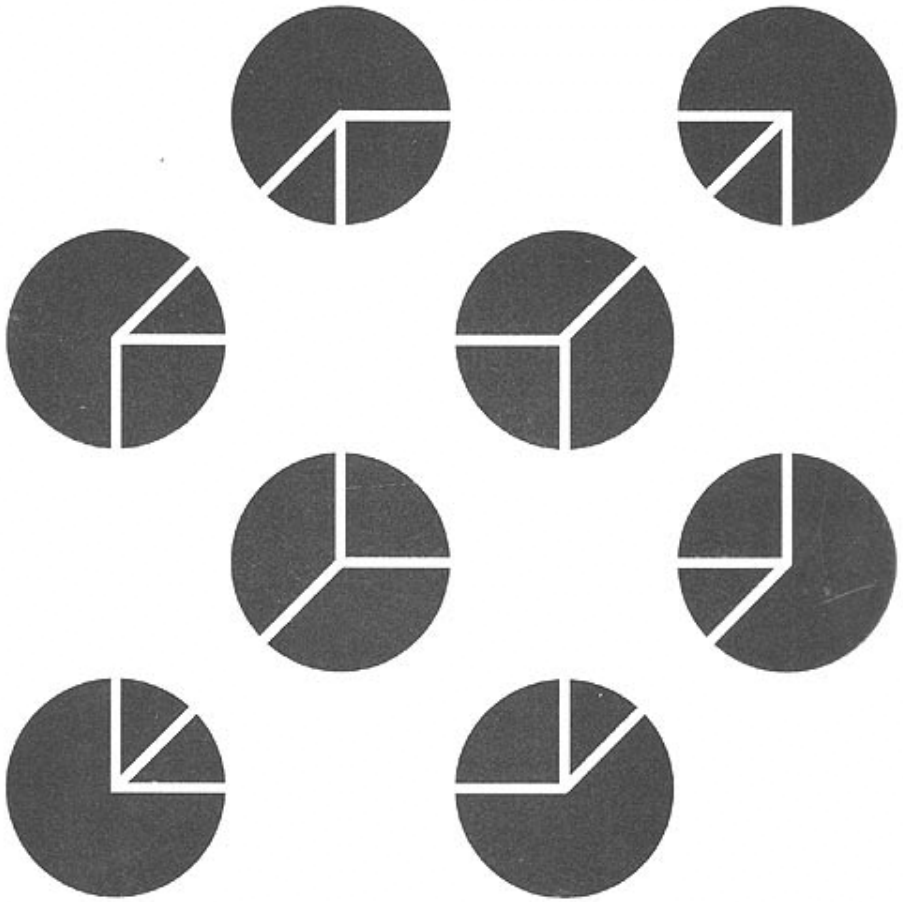
Topics for Today

- Optical illusion
- Pretty picture
- Fresnel Lenses
- Aberrations
- Cameras
- Quiz

Figure 5.11, page 182

Illusory cube



Based on "Organizational Determinants of Subjective Contour: The Subjective Necker Cube," by D. R. Bradley and H. M. Petry, 1977, *American Journal of Psychology, 90*, pp. 253-262. American Psychological Association.

Fresnel lens principle

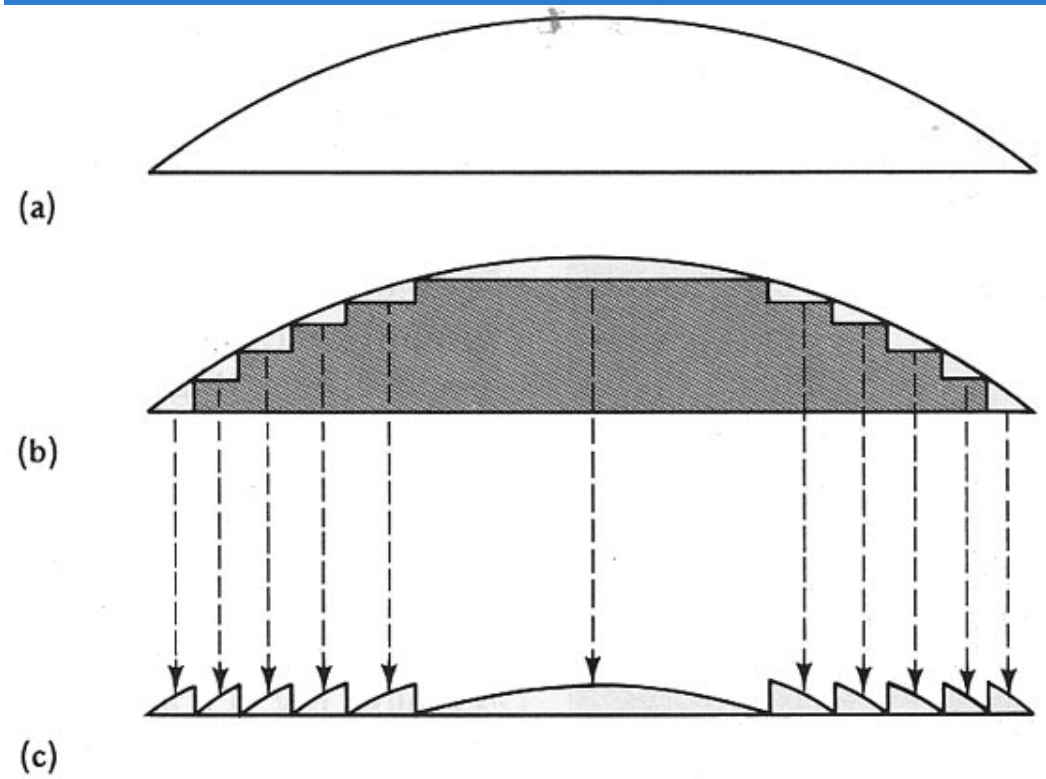
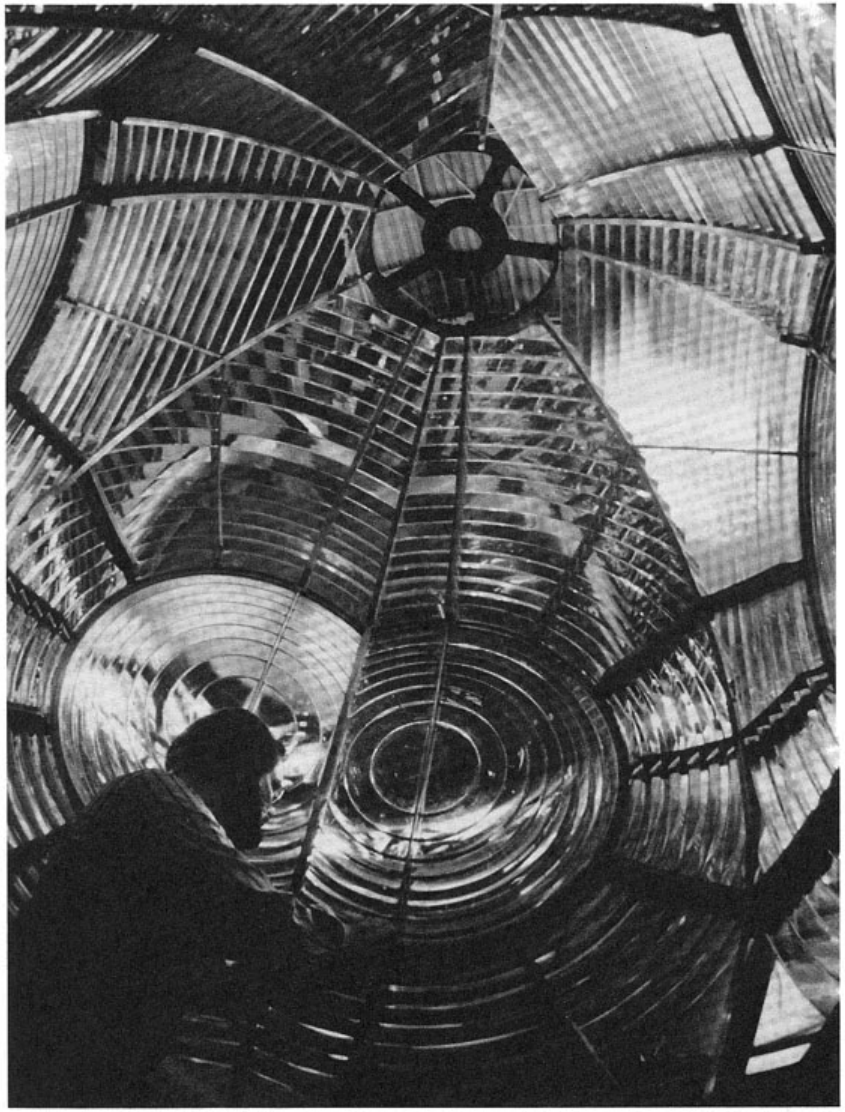


FIGURE 3.29

(a) A thick, converging lens (with one flat side). **(b)** Parts of the glass of this lens that have no essential effect on the bending of light (shown shaded). Remember that these sections are really rings oriented perpendicular to the paper. **(c)** After removing the nonessential glass and rearranging the lens, you get a Fresnel lens.

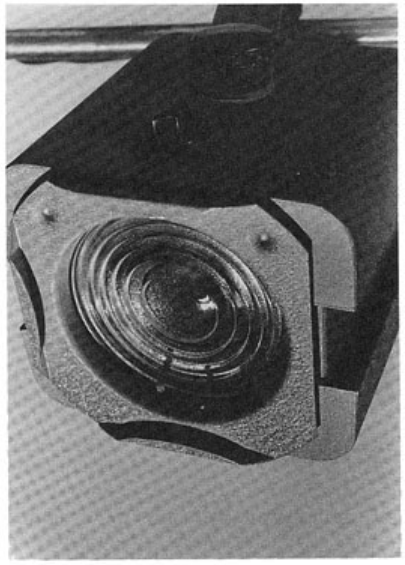
Fresnel lens applications



(a)

FIGURE 3.30

(a) Photograph of a Fresnel lens designed for use where Fresnel first intended: in a lighthouse. **(b)** Photograph of a Fresnel spotlight.



(b)

Traffic light

- Fresnel lens images scene onto ground glass screen at ~ focal distance
- Light source illuminates ground glass
- Mask the screen to block light that would go to undesired locations

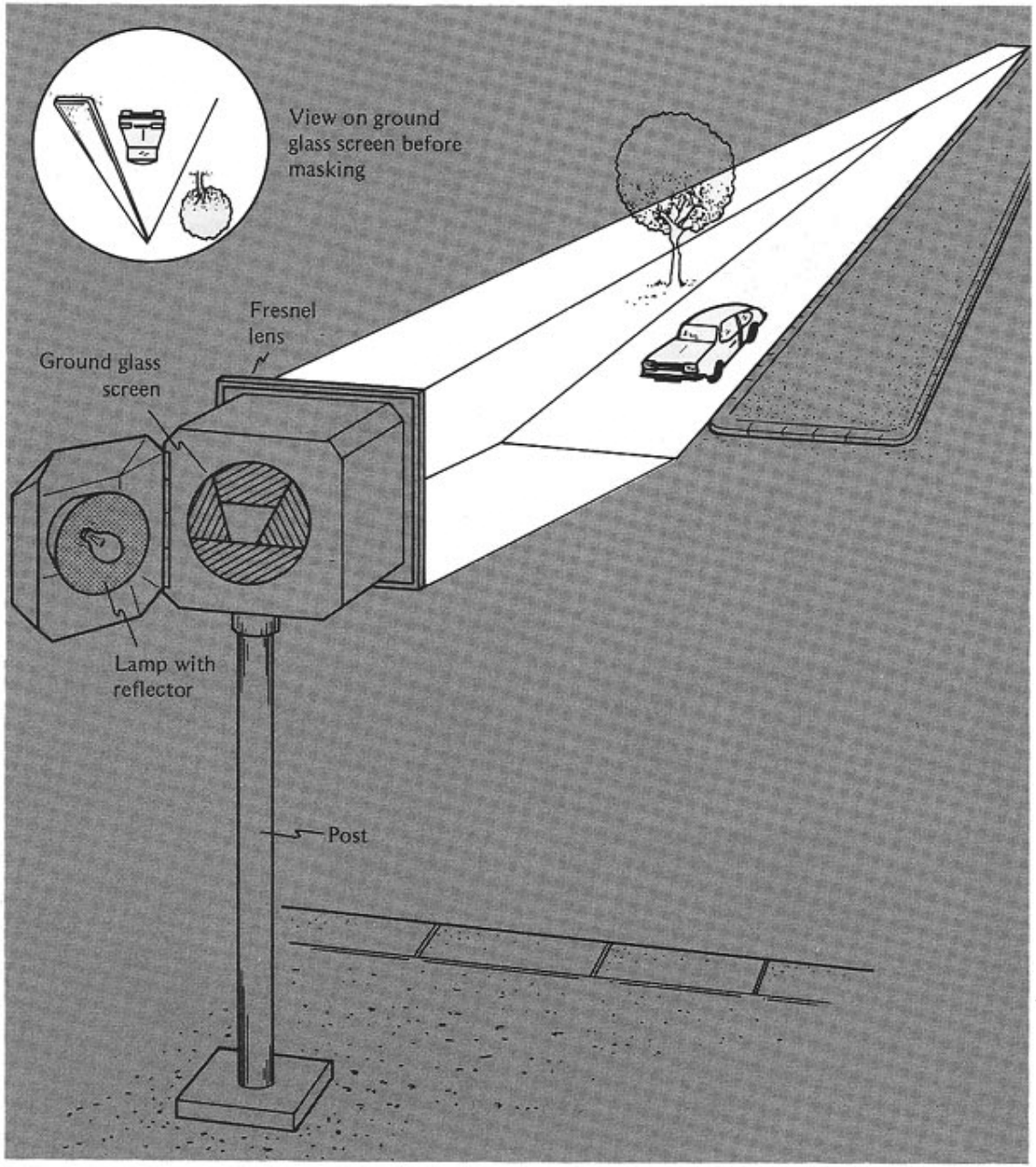


FIGURE 3.31

An "optically programmed" traffic light.

Aberrations

- **Chromatic Aberration**
- **Spherical Aberration**
- **Field angle effects (off-axis aberrations)**
  - Field curvature
  - Coma
  - Astigmatism
  - Distortion

Chromatic aberration and doublets

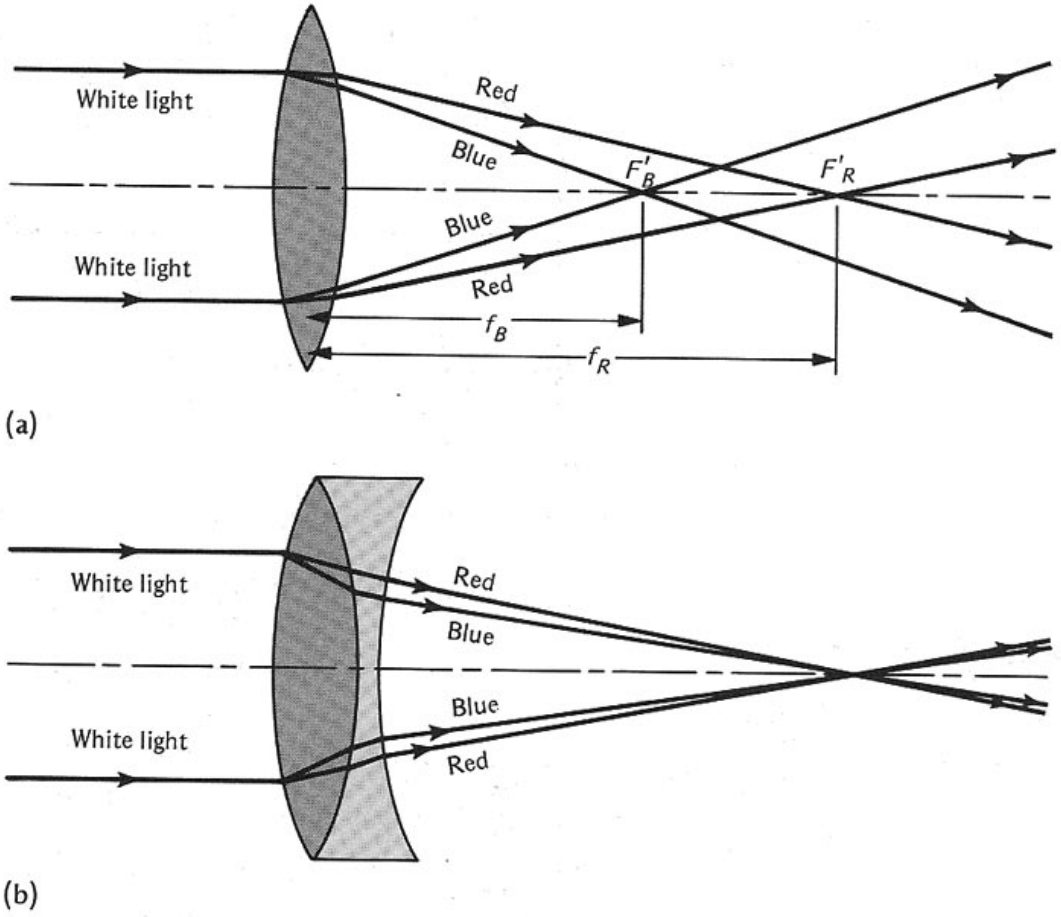


FIGURE 3.33

(a) Chromatic aberration of a converging lens. **(b)** Elimination of this aberration by an achromatic doublet.

Spherical aberration from a lens

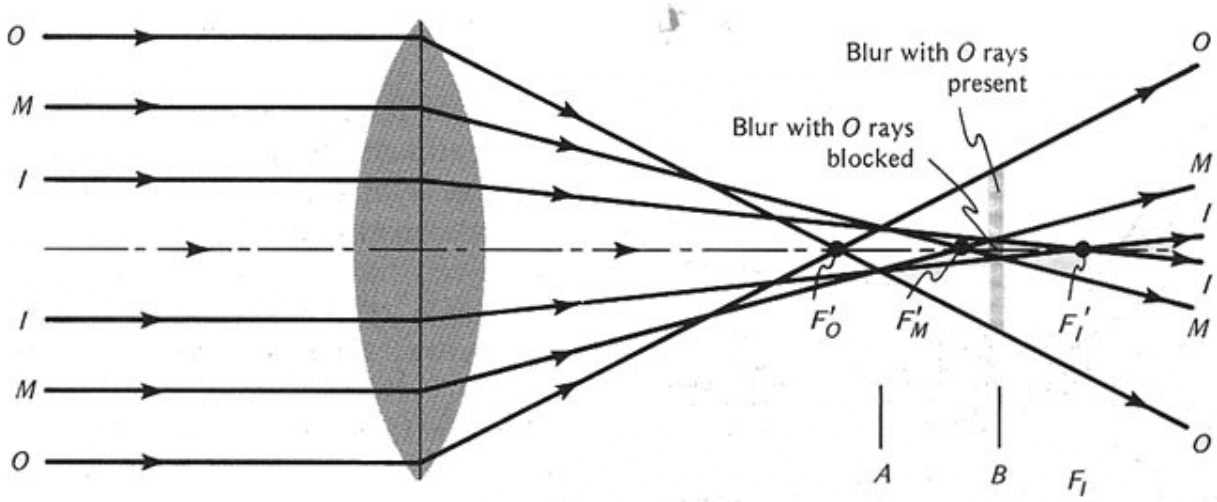


FIGURE 3.34

Spherical aberration in a converging lens. The inner rays, *I*, closest to the axis, have the farthest focal point, F_I'. The outer rays, *O*, are bent most, so they have the nearest focal point, F_O'. The rays in the middle, *M*, are focused between these extremes, at F_M'.

Spherical aberration from a concave mirror

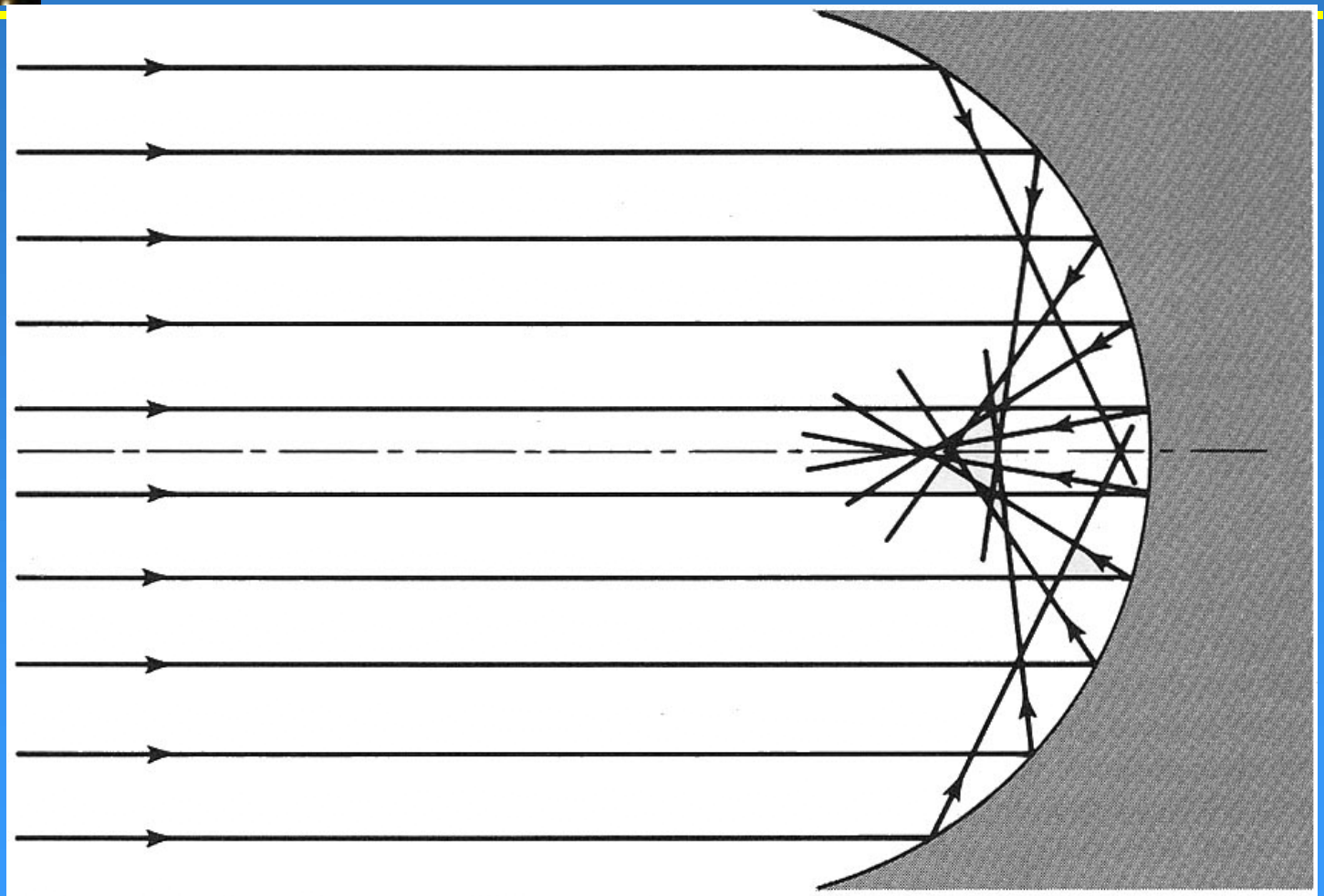


FIGURE 3.35

Spherical aberration in a concave mirror.

Parabolic mirrors have no spherical aberration (on axis)

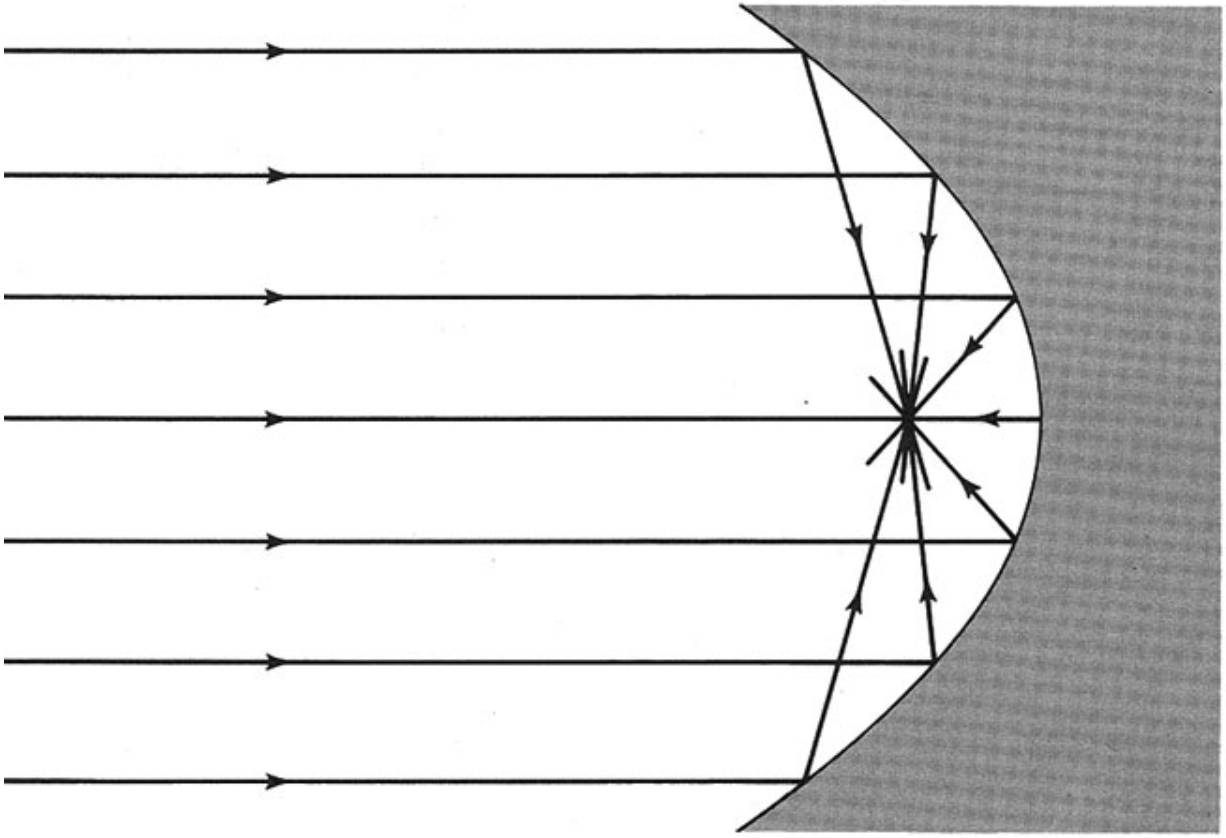


FIGURE 3.36

A parabolic reflector has no aberrations if the object is on the axis and very far away.

Ellipsoidal reflector

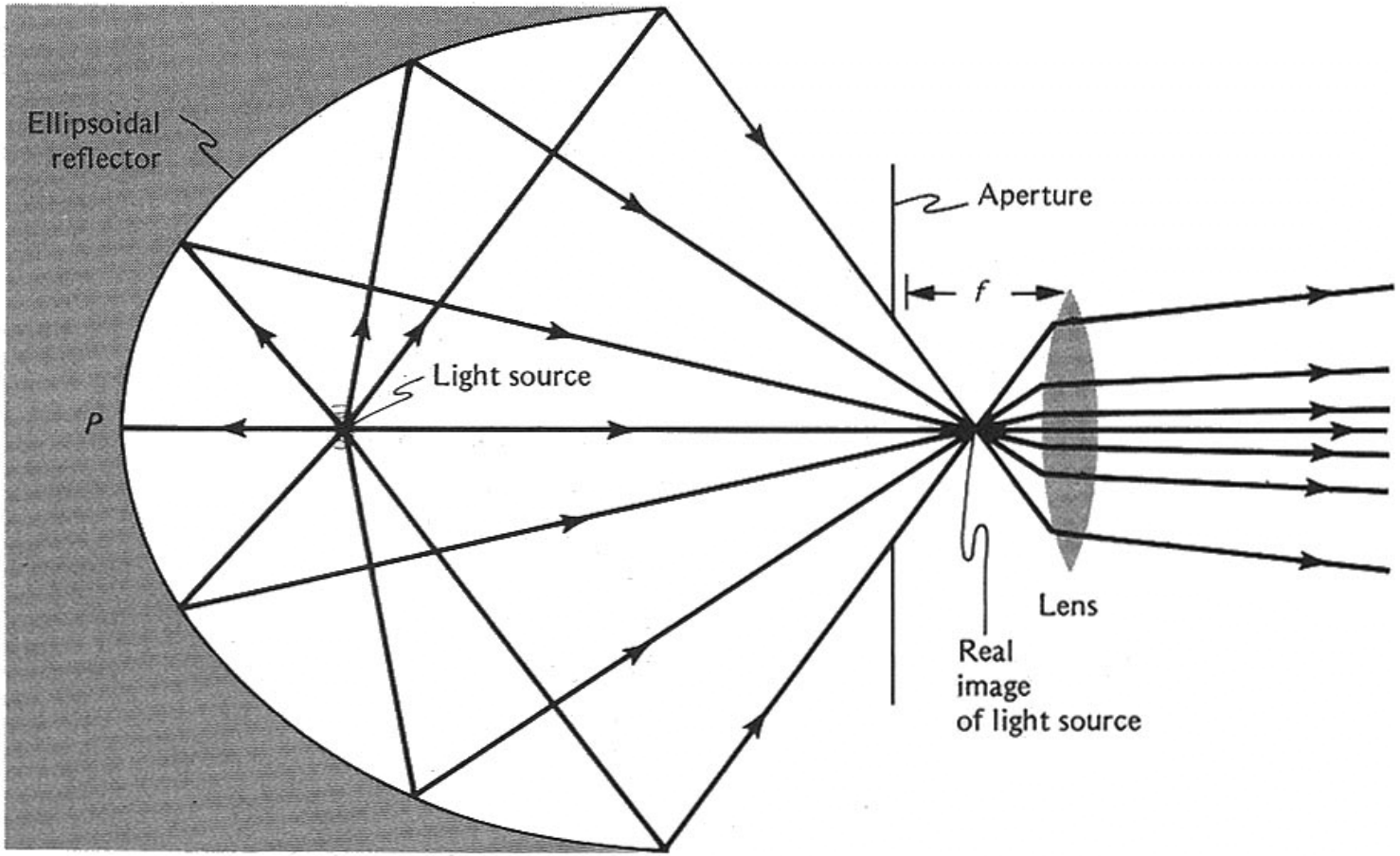


FIGURE 3.37

An ellipsoidal spotlight.

Spherical aberration in glass of water

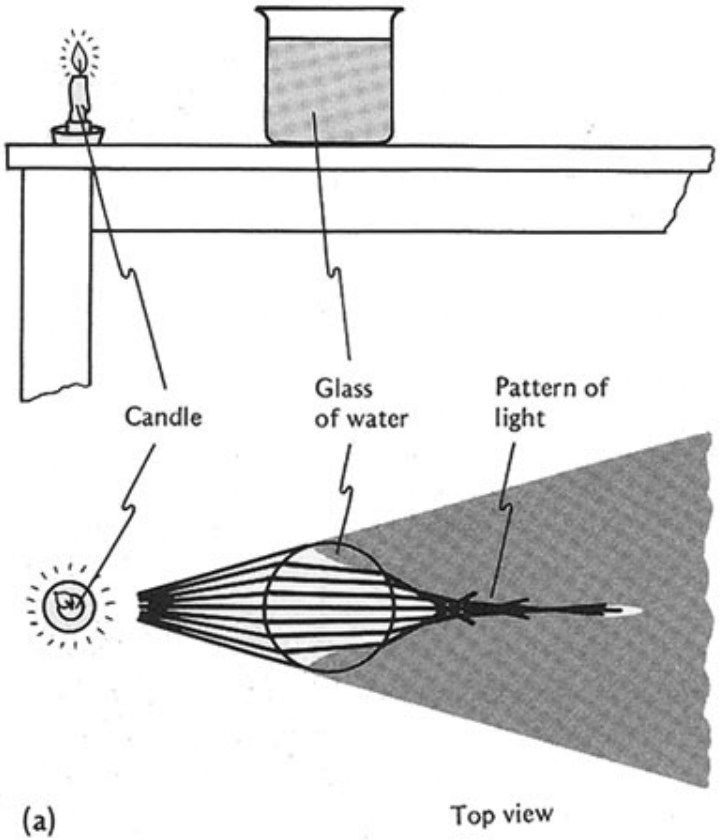


FIGURE 3.38

(a) Spherical aberration in a water glass lens (side and top views). **(b)** Photograph of spherical aberration pattern in a teacup reflector.

Field curvature from lens

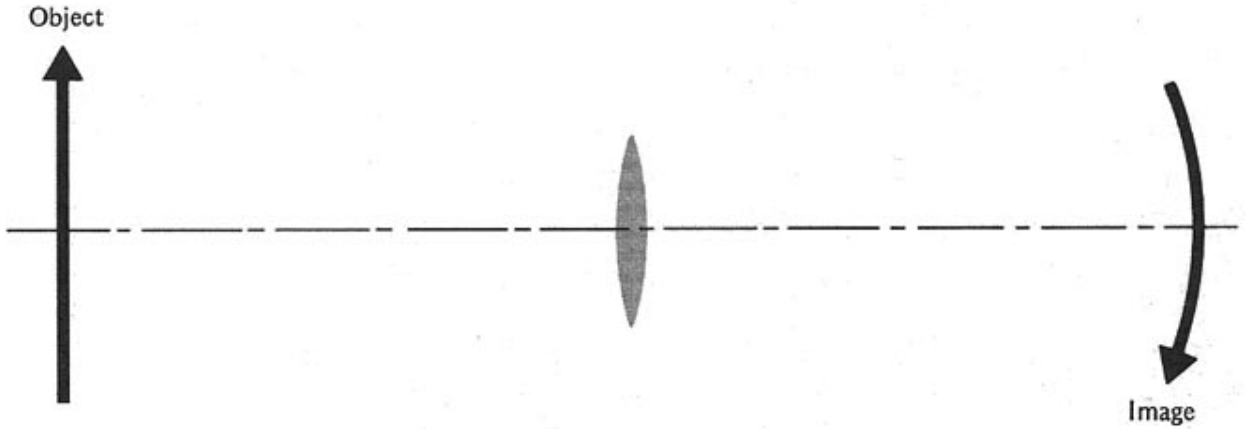


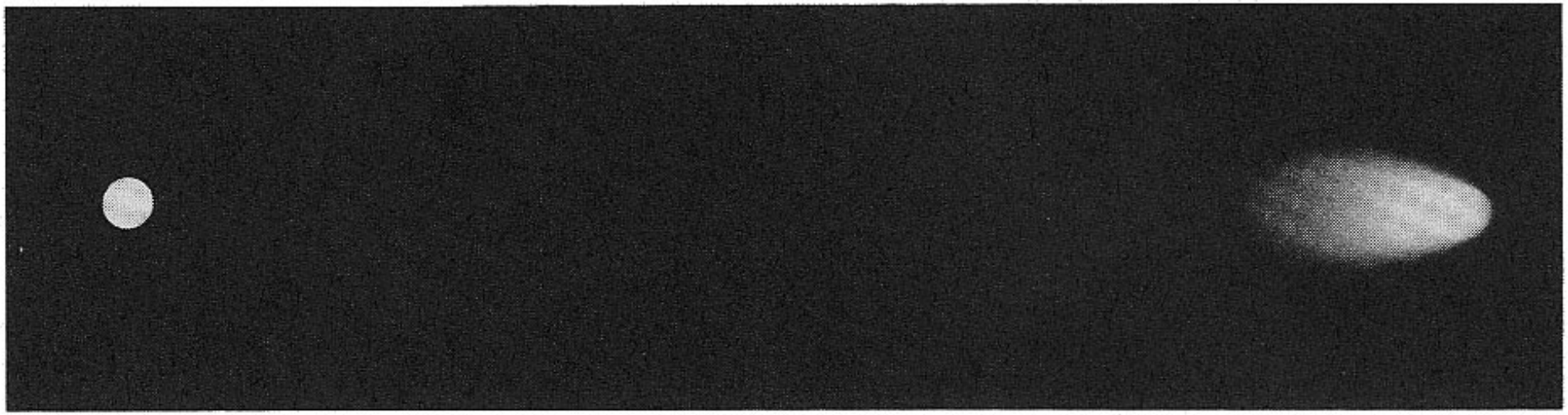
FIGURE 3.39

Curvature of field of a converging lens.

Comatic aberration

FIGURE 3.40

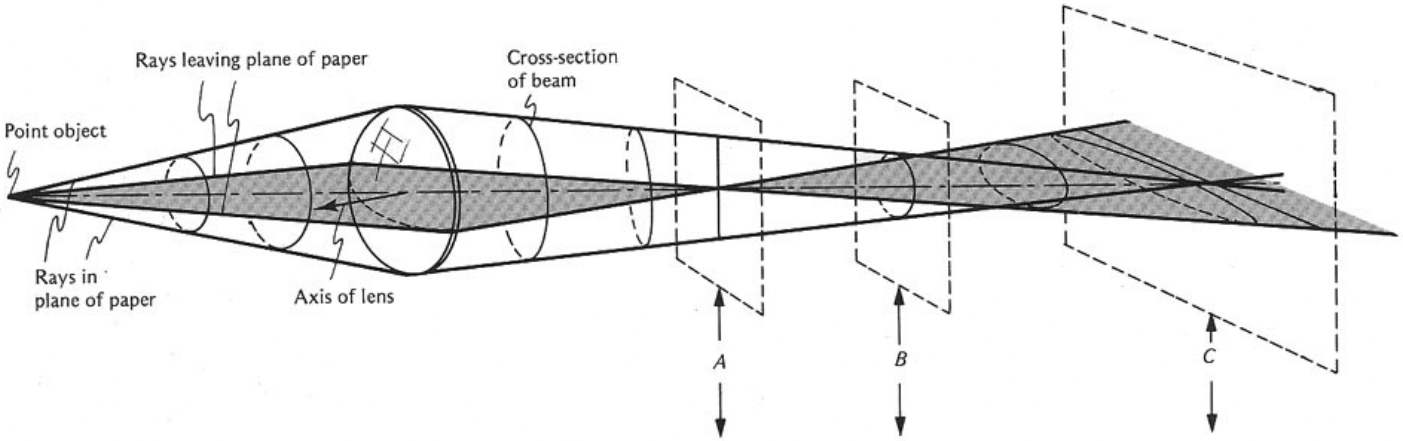
A small circular spot of light *on the axis* is projected by a lens to form the faithful image on the left (no coma). An identical *off-axis* spot of light produces the image with coma, on the right.

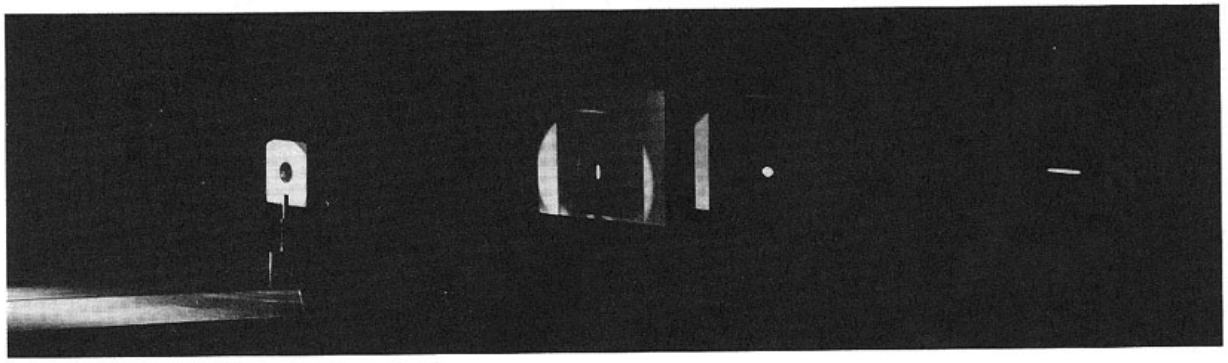


Astigmatism aberration

FIGURE 3.41

The astigmatic image of a point object in three planes, perpendicular to the axis. When the screen is at *A*, the image is a vertical line, and it is a horizontal line when the screen is at *C*. A screen at *B* gives the smallest circular image. (The photograph was taken by triple exposure, changing the position of a single screen between exposures.)





Distortion

- Upper image shows barrel distortions
- Lower image shows pincushion distortion

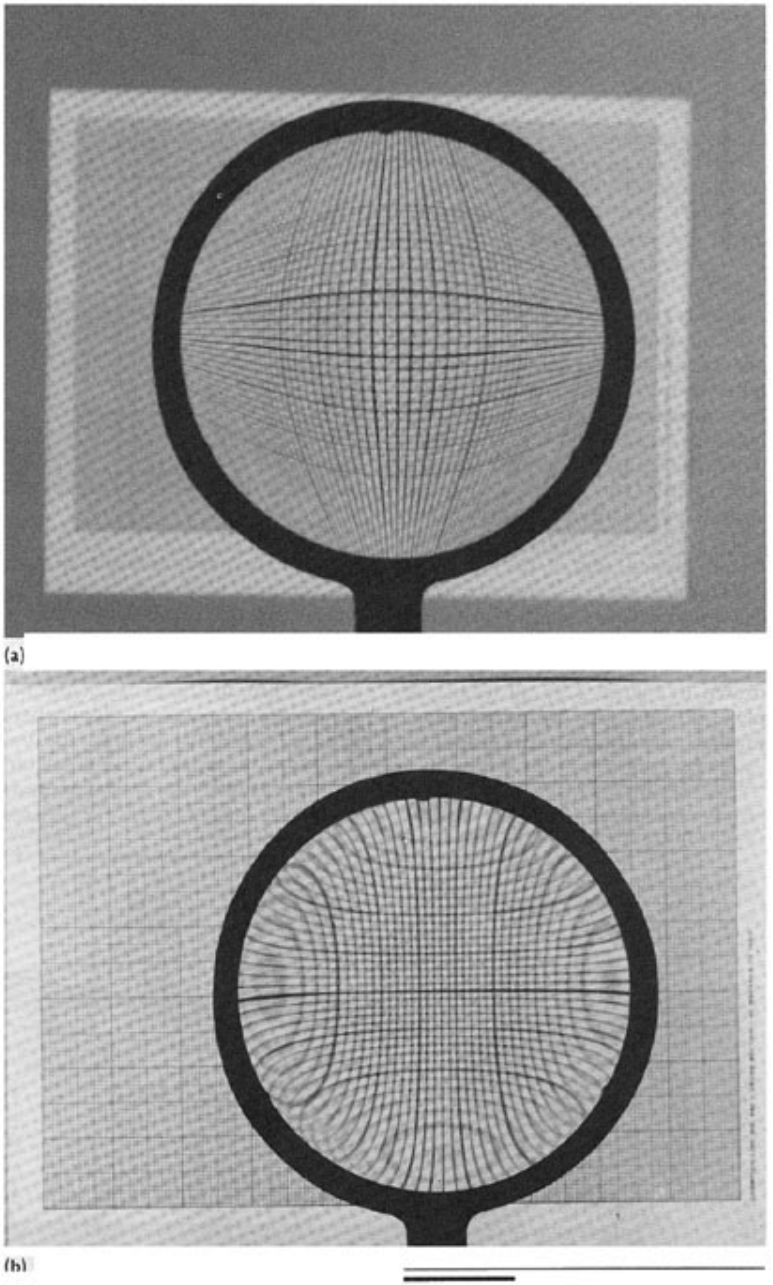


FIGURE 3.42

Graph paper with square rulings as seen through a lens that exhibits distortion. (Photographs taken by method described in the TRY IT.) **(a) Barrel distortion. (b) Pincushion distortion.**

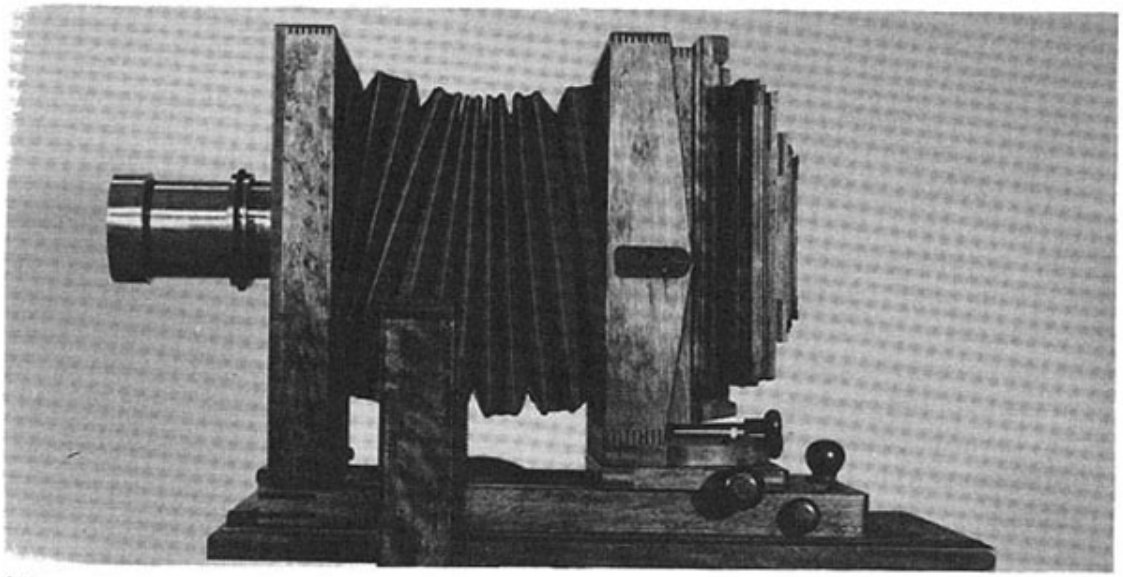
Camera

- **Key components of a camera**

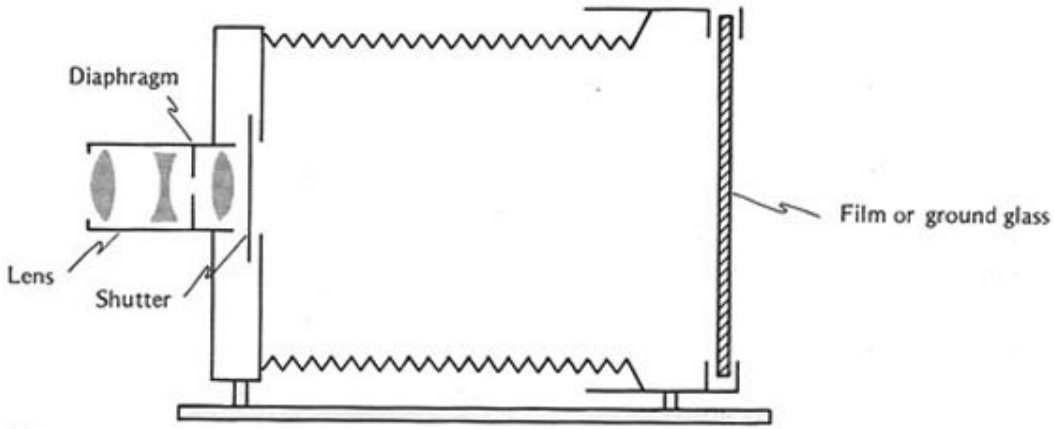
2003 May 1

FIGURE 4.1

(a) Photograph of a large-format camera. The brass cylinder contains the lens. The back of this camera can carry either a ground glass screen for viewing or a film holder. **(b)** The essential parts of this camera.



(a)



(b)

What is a camera?

- light tight box: This keeps out stray light so only the desired light gets to the film
- lens: This gathers the incident light and focuses it onto the film
- viewfinder: This allows the person to see what they are taking a picture of and compose and focus the image properly
- focus mechanism: This allows the focal position of the camera to be adjusted so the image of the desired object ends up on the film plane. As distance to object varies, focus changes.
- diaphragm: This adjustable device controls the amount of light that gets into the camera and hence to the film
- shutter: This controls the length of the exposure; how much time light is admitted to the film
- film plane / focal plane: Where the film must be accurately placed to match the in focus image the camera lens has made
- Film: The light sensitive material used to record the image. Commonly film, but more recently other solid state detectors replace film

- **Depth of focus**
- **Depth of field**

FIGURE 4.2

(a) Depth of focus. For the range of film positions shown, the image of the fixed object will be acceptably in focus. **(b)** Depth of field. Objects within the range shown are acceptably in focus for the particular lens-film distance chosen.

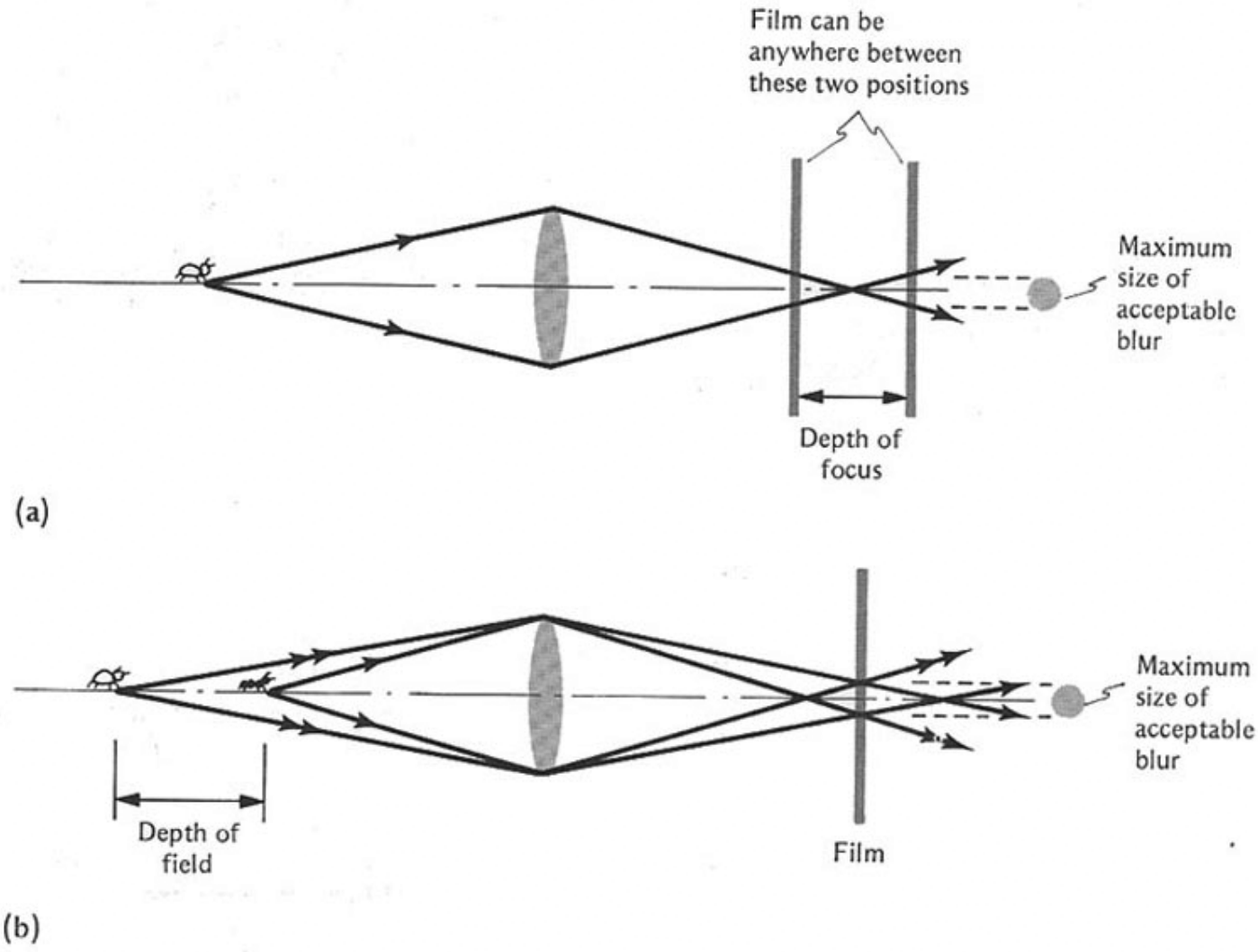
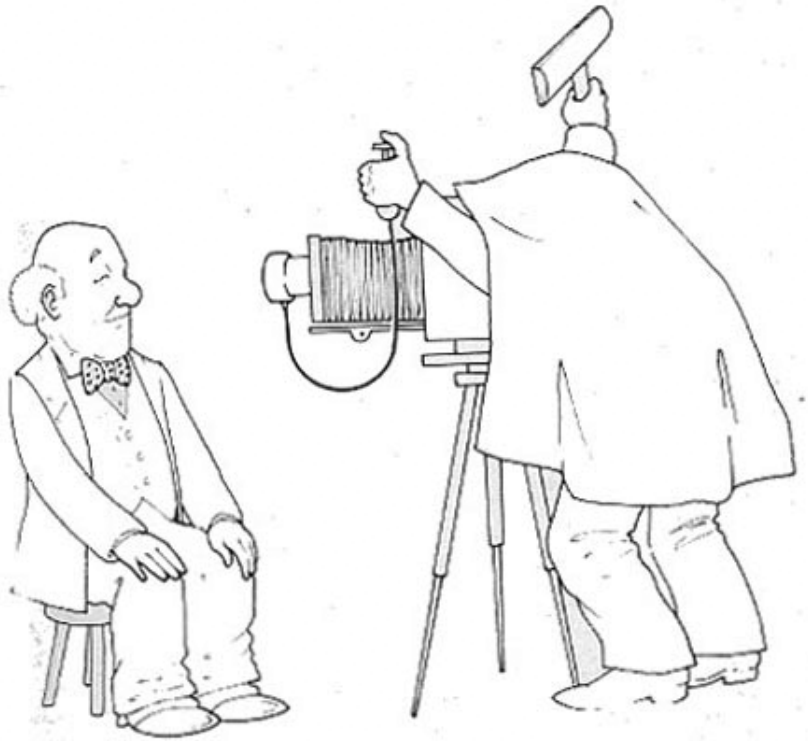
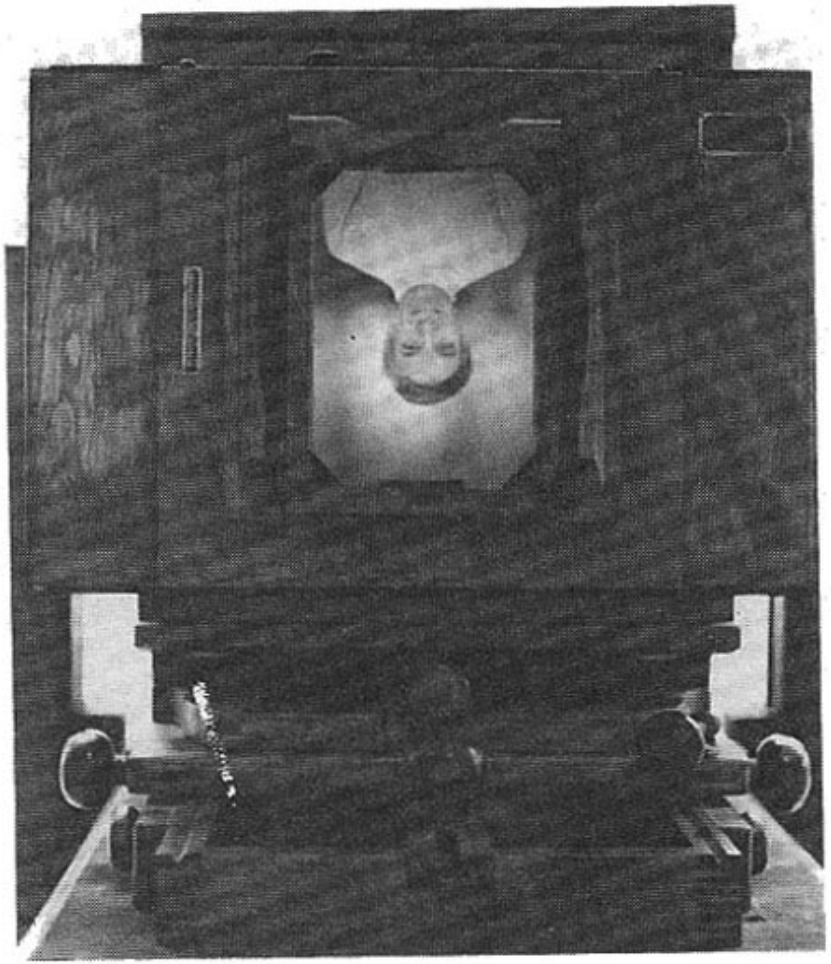


FIGURE 4.3

(a) The traditional view of a traditional photographer looking into the back of the camera, with a black cloth thrown over his head to exclude stray light so he can see the screen. **(b)** The actual view that the photographer may have as he looks into the back of his view camera.



(a)



(b)

Single lens reflex camera

- **Key components of an SLR**

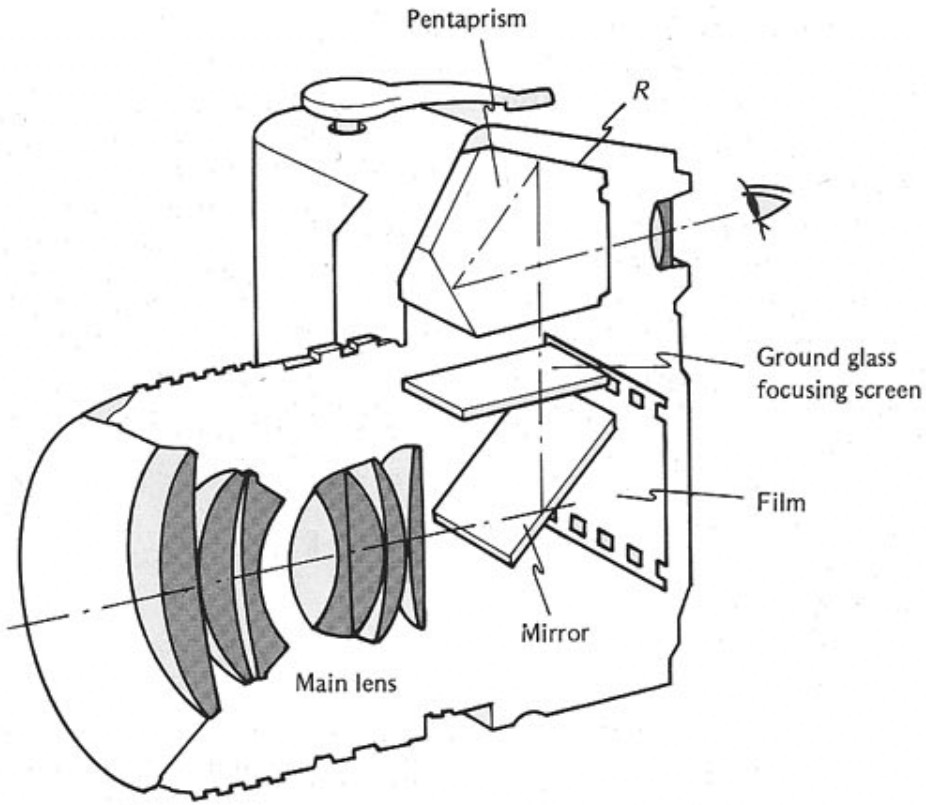


FIGURE 4.4

The main parts of a modern single-lens reflex camera. The distance of the light path from the lens to the film is the same as from the lens to the focusing screen by way of the mirror. The pentaprism inverts the image on the focusing screen before the photographer sees it. The roof *R* of the pentaprism consists of two faces that provide extra reflections perpendicular to the plane of the figure in order to reverse the image in that direction as well.

Focusing onto a screen

- **Biprisms will shift an out of focus image, opposite directions for each prism, by an amount proportional to the defocus**