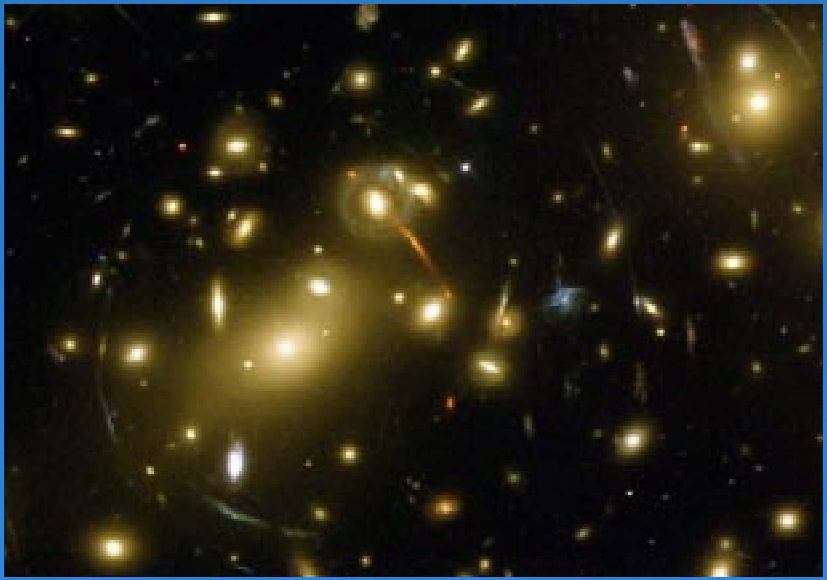

Astronomy 80 B: Light

Lecture 16: instruments, binocular vision, quiz #3

22 May 2003

Jerry Nelson

Topics for Today

- Research paper is due on or BEFORE 5 June
- Optical illusion
- Atmospheric picture
- Optical instruments
- Binocular vision
- Quiz


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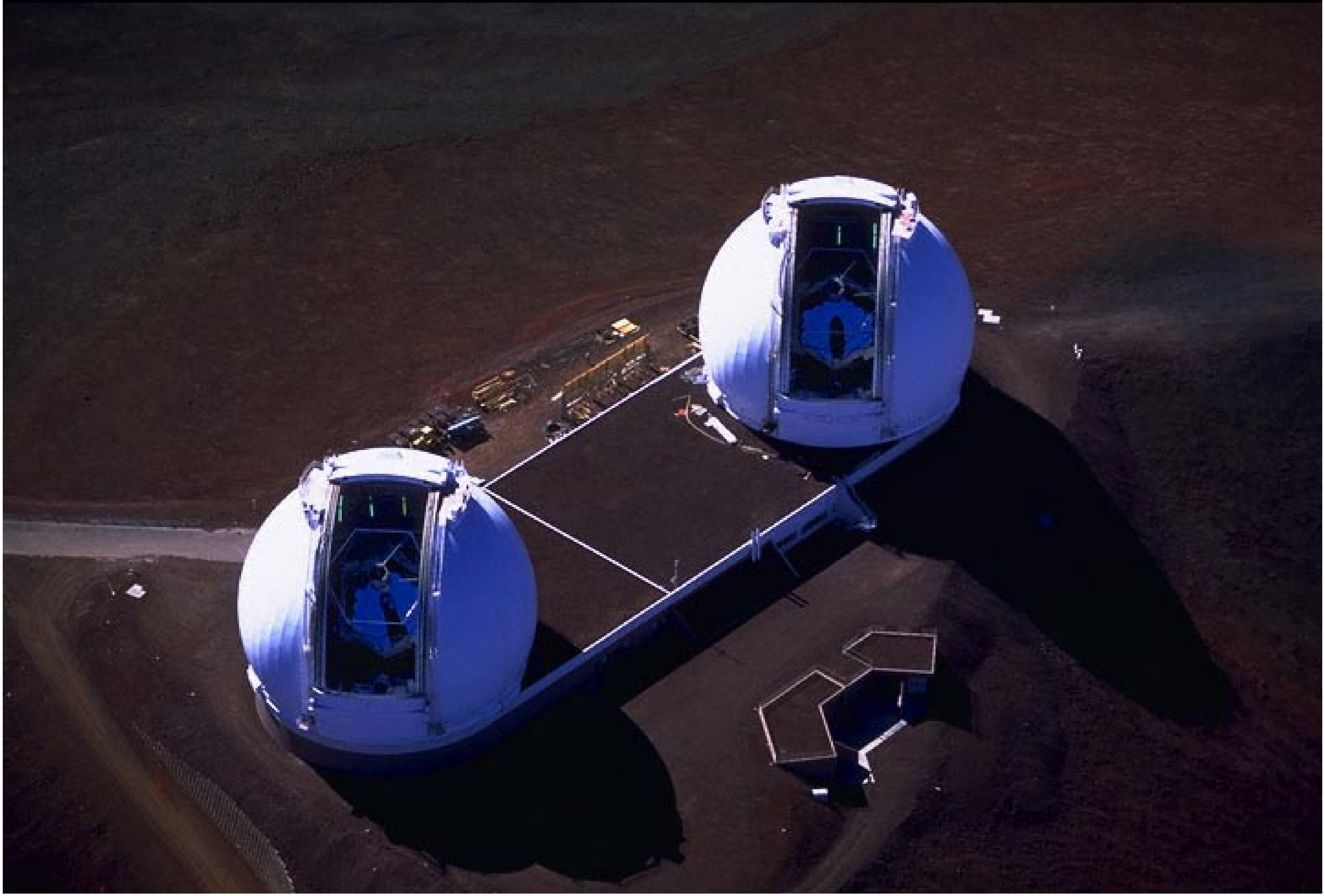
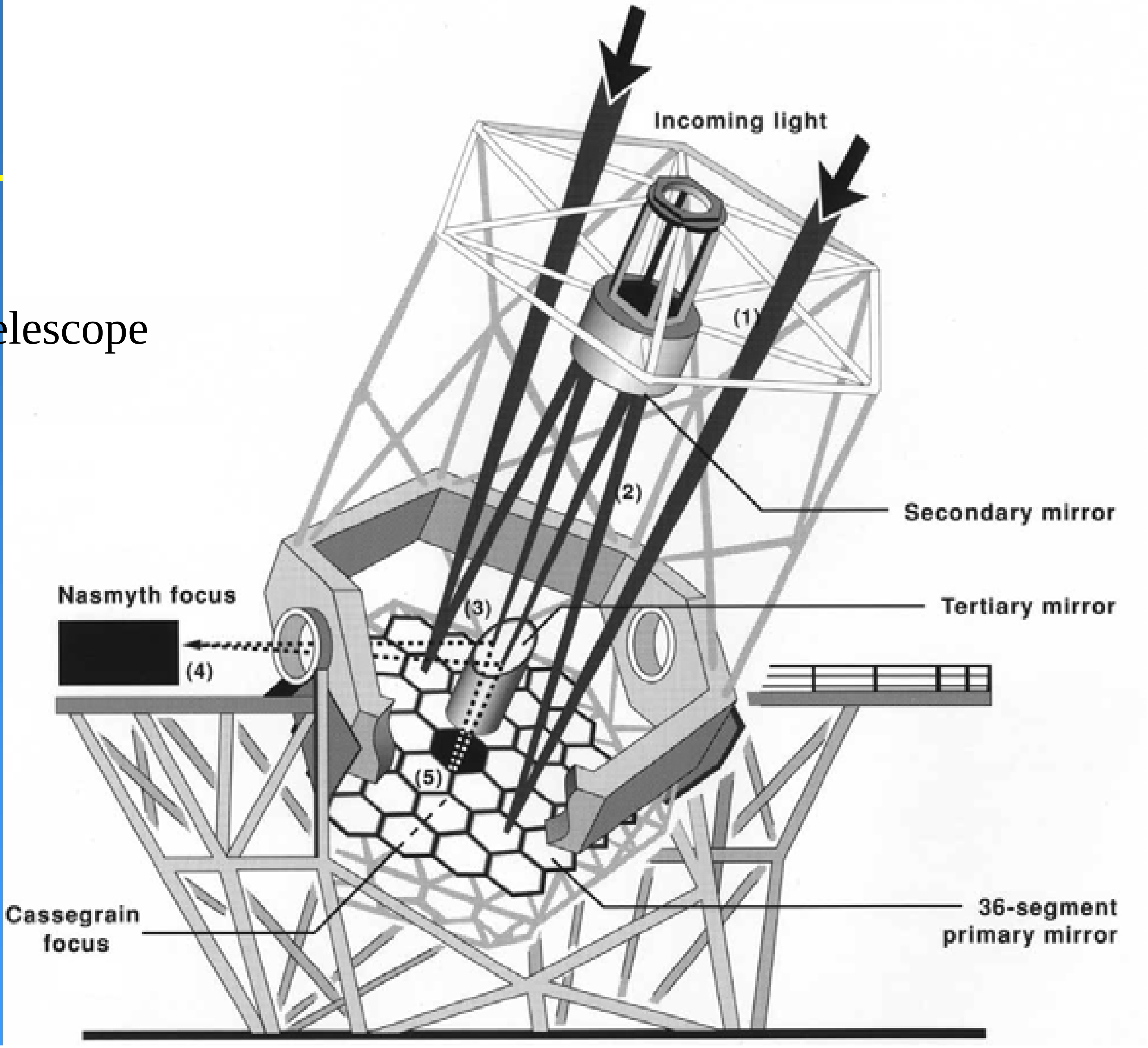
The Keck Telescopes



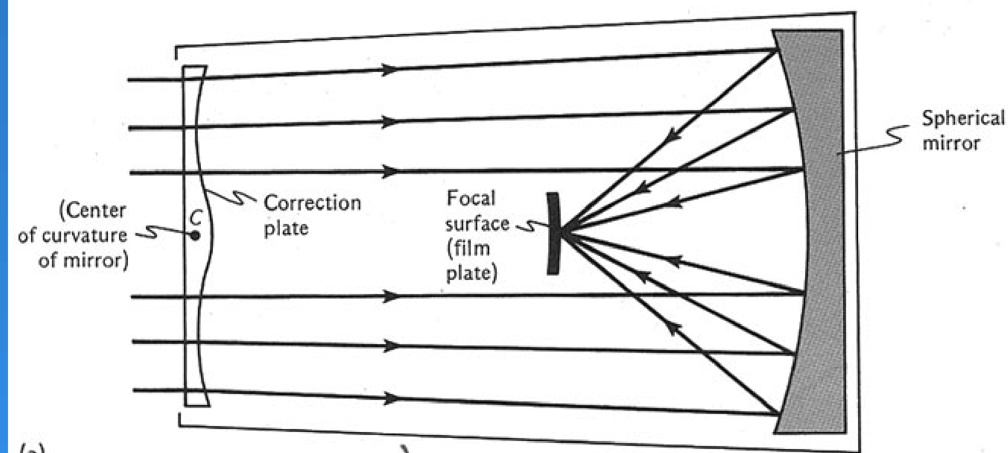
Keck Telescope



Keck 10-m telescope

Schmidt telescope

- **Wide field telescope**
  - Transmissive element
    - Correction plate
    - No power
    - Located at center of curvature of mirror
  - Spherical mirror
  - Curved focal surface



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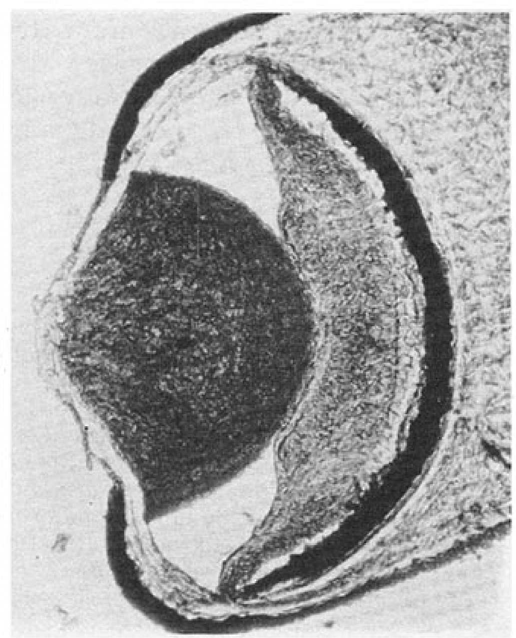


(b)

FIGURE 6.18

(a) The Schmidt telescope, and **(b)** a scallop's eye.

Schlieren photograph

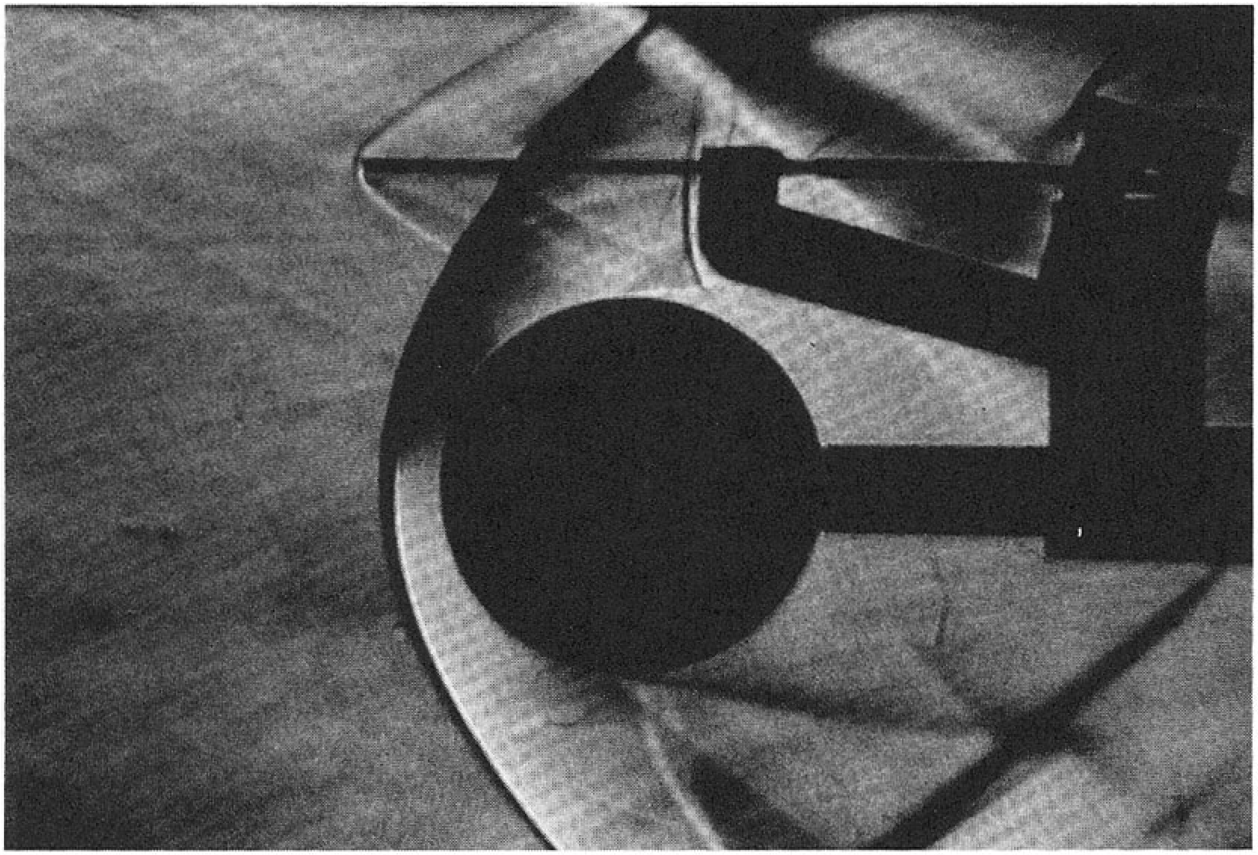


FIGURE 6.19

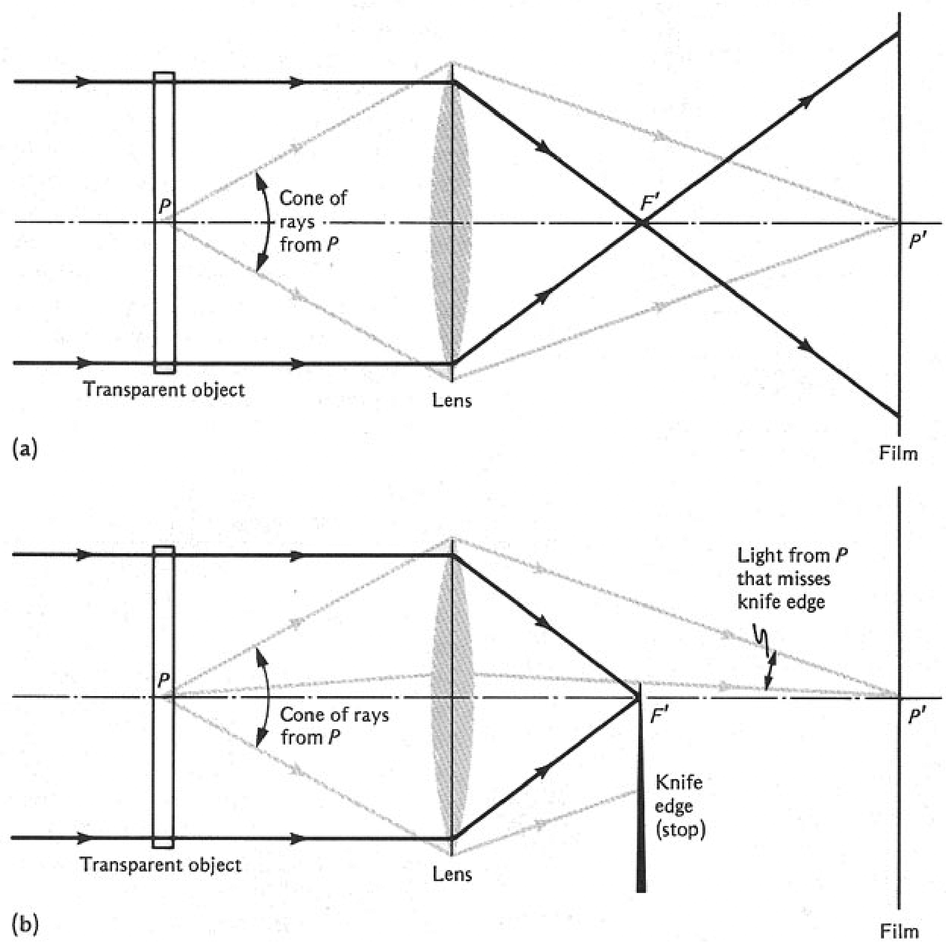
Schlieren photograph of shock waves in air that moves at supersonic speed past a sphere. The horizontal rod above the sphere measures the pressure.

Principle of Schlieren photography

- **Basic idea is to block the unscattered light, allowing only scattered light to get to final image of the scattering object**
- **Done by putting an opaque object in the light source image plane (a knife edge)**

FIGURE 6.20

Principle of schlieren photography of a transparent object: **(a)** without knife edge, **(b)** with knife edge.



Principle of field lens

- **Location of field lens is at the image of the field**
- **Purpose is to increase and make more uniform the illumination (reduce vignettng)**
- **Images one lens onto another**
- **Doesn’t change location of image**

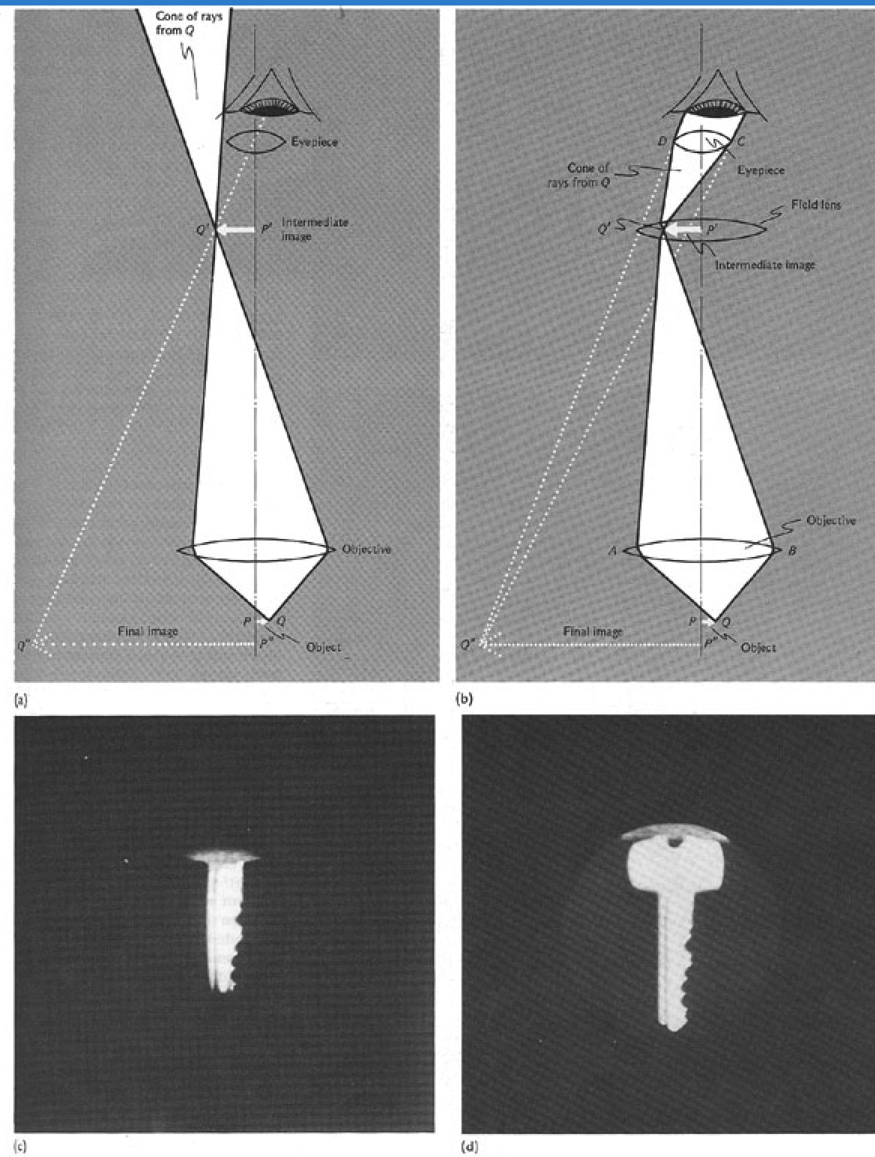


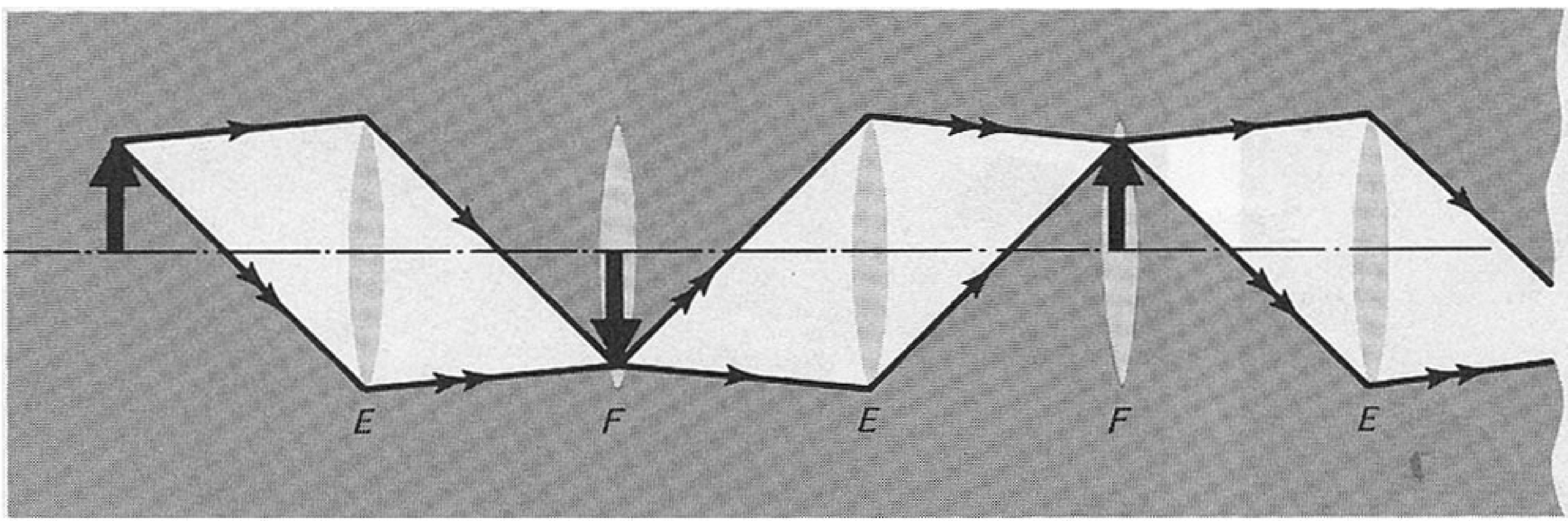
FIGURE 6.21

Principle of the field lens. **(a)** Without field lens the final image is vignetted, only the heavy part of the arrow P"Q" is significantly illuminated, the intensity falling to zero at Q". (See this effect in Fig. 4.5c). **(b)** With a field lens the entire field is well illuminated, because the field lens bends the entire cone of rays *AQ'B* into *CQ'D*, so they can reach the eyepiece and the eye. **(c)** and **(d)** Photographs of the eye's view in the two cases, respectively.

Erectng lenses and field lenses

FIGURE 6.22

Erecting lenses *(E)* and field lenses *(F)* that may be part of a long string of lenses in a cystoscope or a periscope. Note that the full cone of rays striking the first lens emerges from the system.



Where do field lenses go?

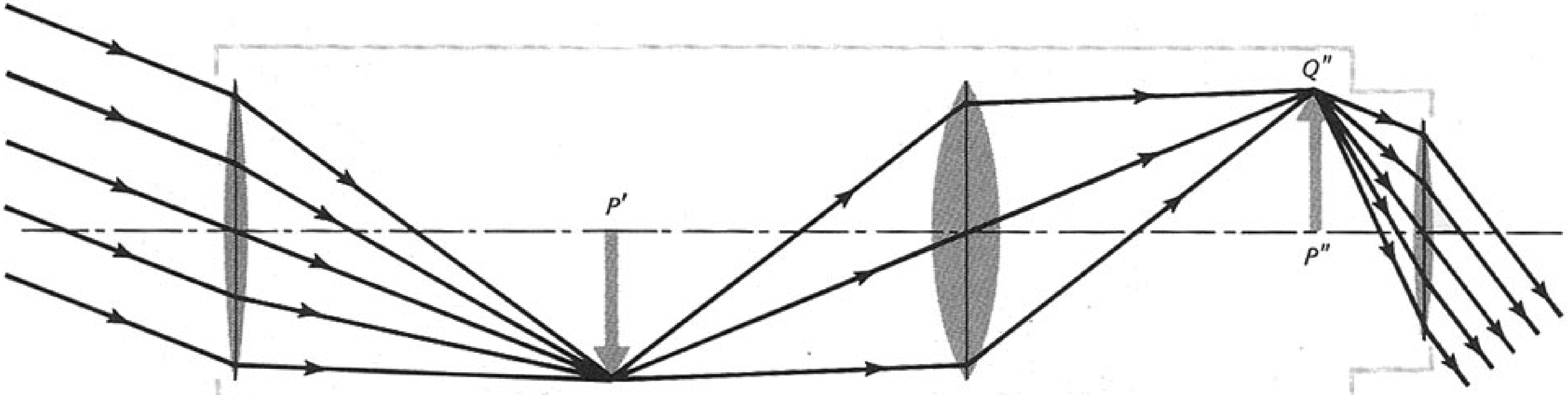


FIGURE 6.14

Principle of a terrestrial telescope, which uses an erecting system. This figure uses our ray tracing convention (see caption Fig. 6.9) whereby the intermediate image serves as a source of new rays, not necessarily extensions of the rays converging to it.

Projector lens

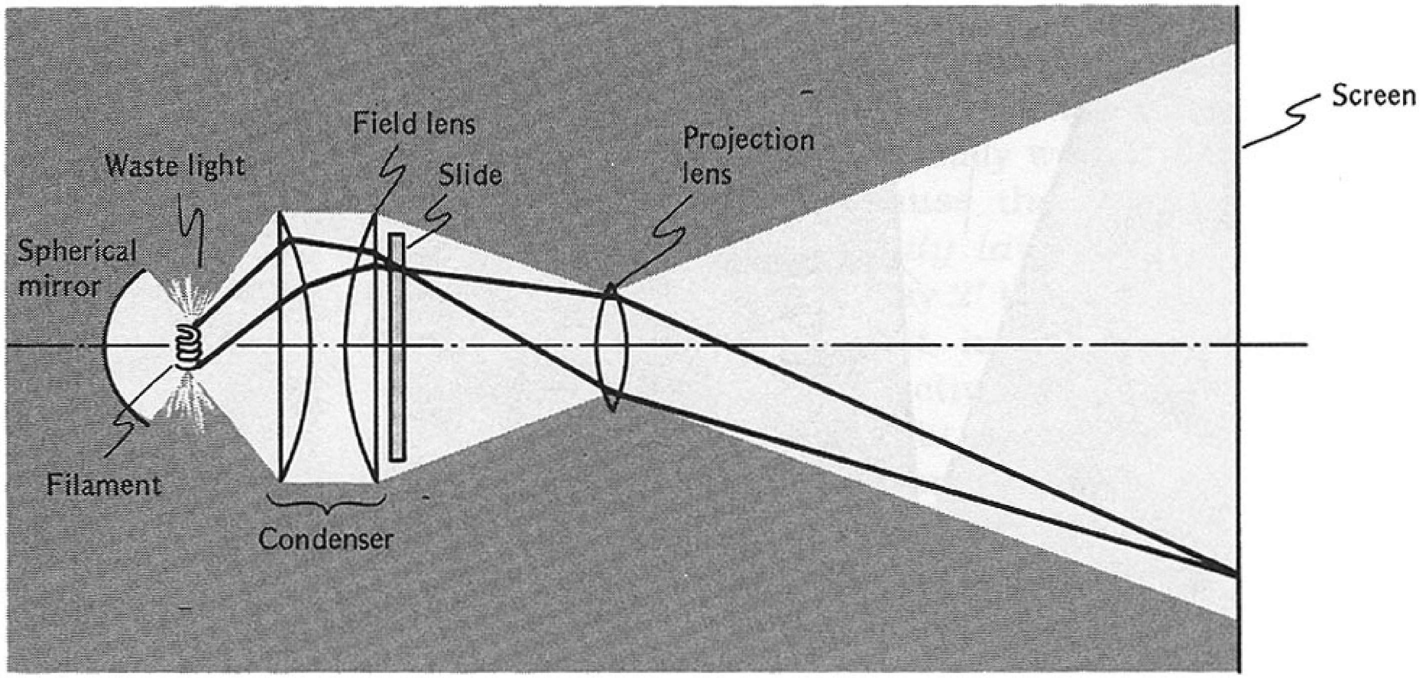


FIGURE 6.23

Projector with illuminating system. Solid outline shows a cone of rays from one point on the slide, defined by the imaging system. White region shows the cone of rays defined by the illuminating system.

Projector lens

- **Image made by projector**
- **Image without field lens**
- **Image without condenser**

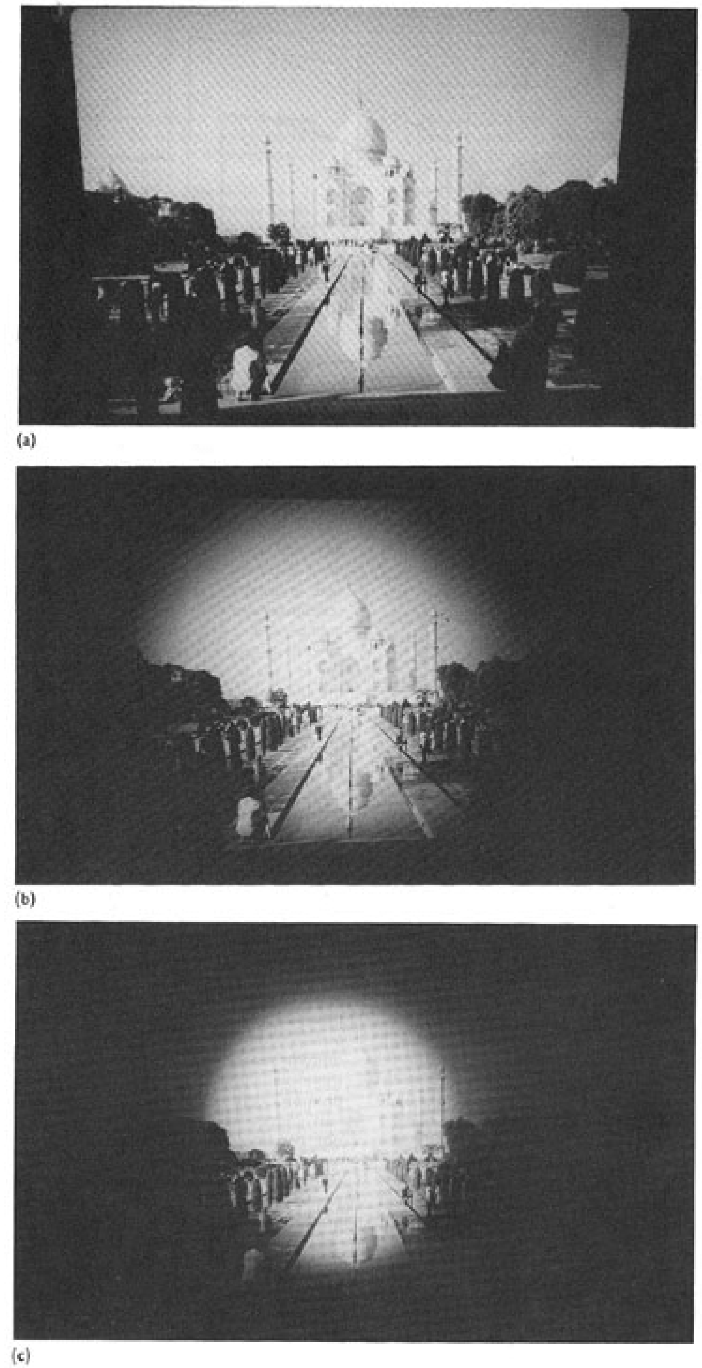


FIGURE 6.24

Image thrown by projector (a) with all lenses in place, (b) with the field lens removed, and (c) with the entire condenser removed. Note the "keystoning" of the image.

Geometry of zoom projection lens

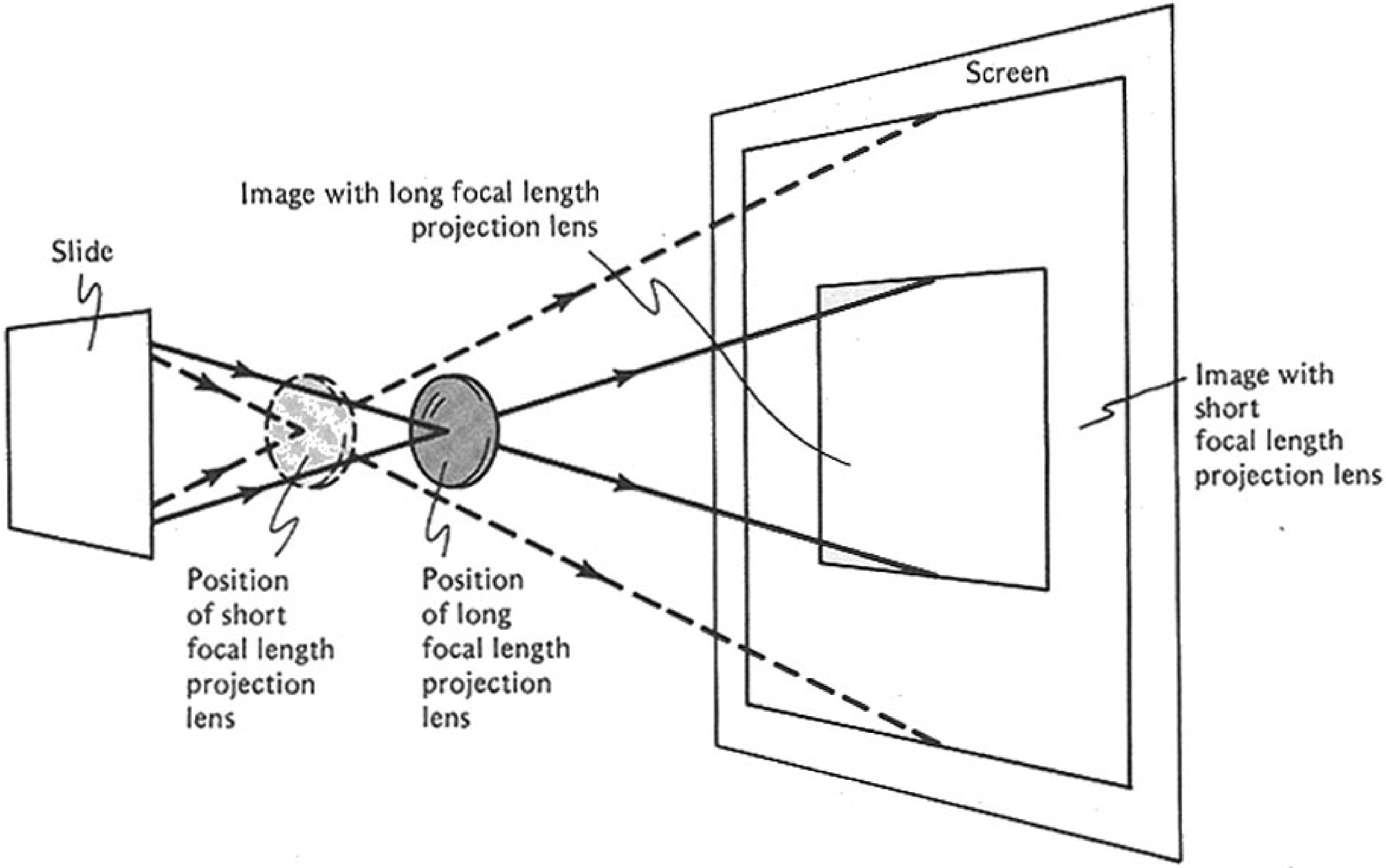


FIGURE 6.25

Zoom projection lens.

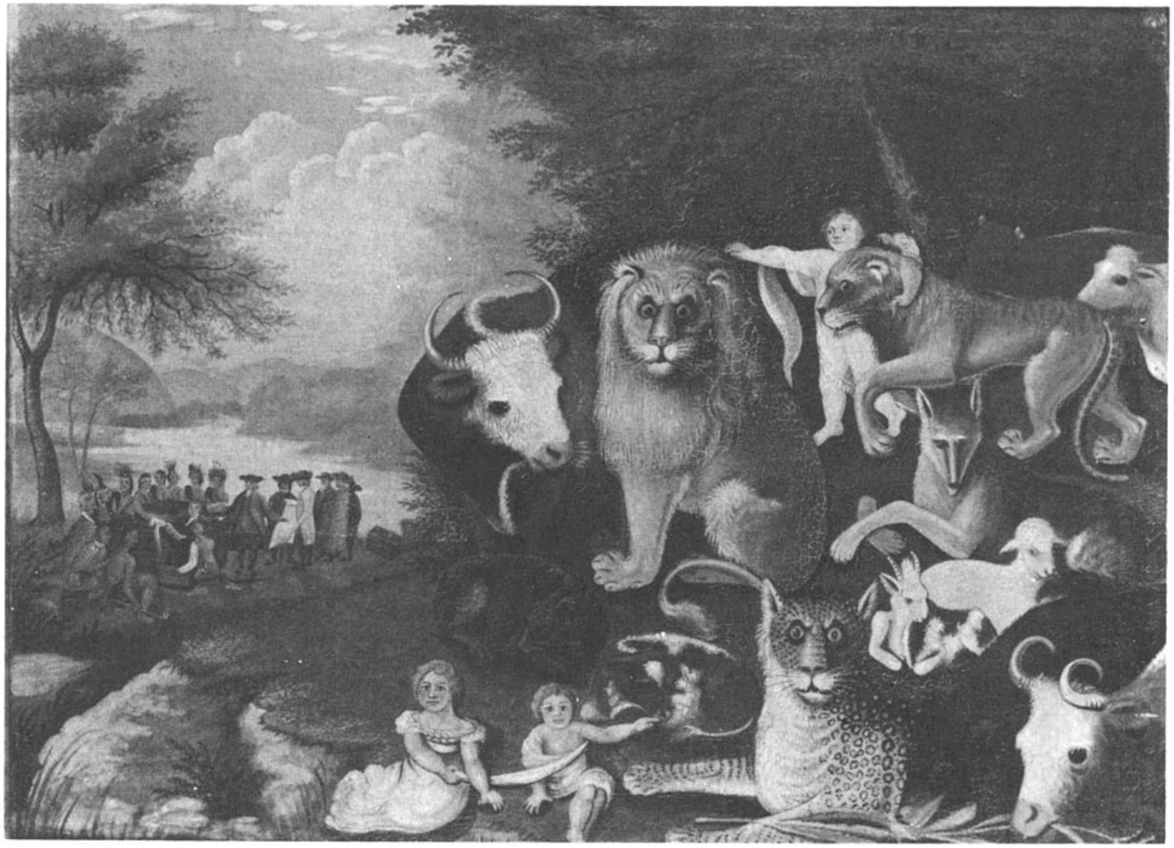
Binocular vision and depth perception

- **We have two eyes- why?**
  - – Increased field of view (really important for prey)
  - – The fields of view of our eyes greatly overlap
    - Each eye 208°, overlap, 130°
  - – Our brain receives two distinct images that arent the same
    - Put your thumb at arms length and look at it with one eye at a time- notice the background moves
    - Put your finger close to your face and focus on distant object. Notice your finger becomes transparent
  - – The brain cleverly processes and combines both images
  - – The image differences contain depth information that we use

Eyes of predators and prey

FIGURE 8.1

Edward Hicks' "The Peaceable Kingdom" shows both predators and prey. They are easily distinguishable by the location of their eyes.



Techniques for measuring depth or distance

- **Accommodation**
  - Your eye focuses to make images sharp
  - The amount of focus added by your lens contains distance information
  - Used extensively by some animals
  - Only useful to humans for close objects
- **Convergence**
  - To view a nearby object, the angles between the optical axes of our eyes must change from zero (distant). This is called the angle of convergence.
  - Focus on your finger at arms length and bring your finger up to your nose
  - Useful for close objects

Angle of convergence

*Greek *parallaxis*, change.

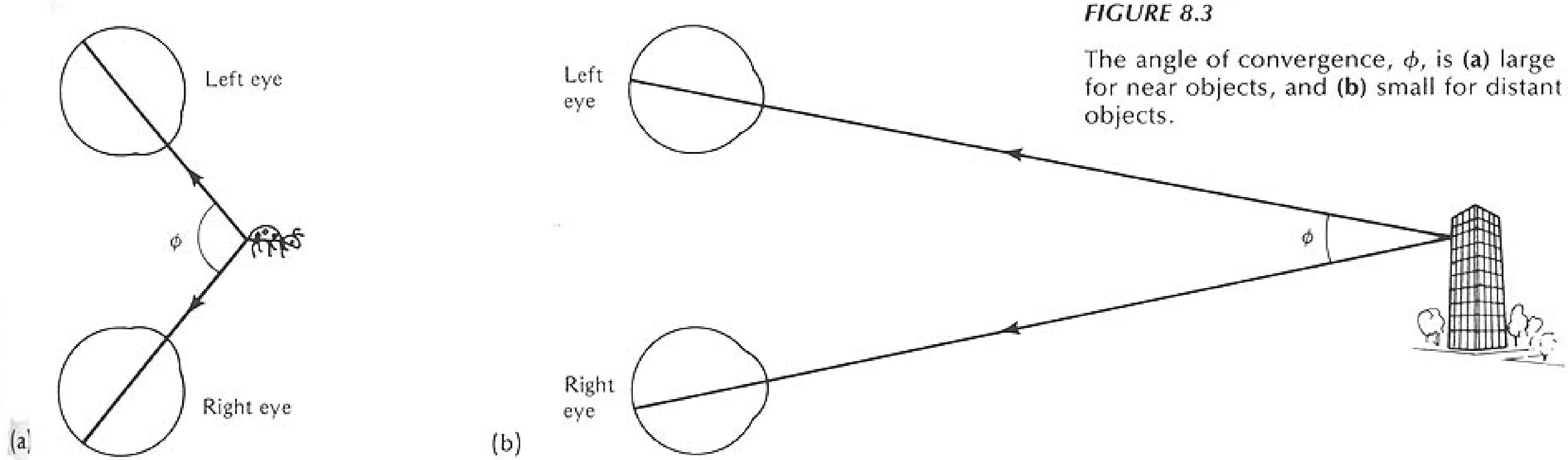


FIGURE 8.3

The angle of convergence, ϕ, is **(a)** large for near objects, and **(b)** small for distant objects.

Techniques for measuring depth or distance-2

- **Parallax**
  - The differences in the two views is most important to humans. The view changes resulting from different positions produces parallax
  - look at a piece of paper and put your finger near it. Move your head around and notice you can then see what your finger otherwise blocked.
  - Different views might be from two eyes or from views changing with time
  - Movies generally look flat because our eyes see no parallax
  - 3-D movies give our eyes two different scenes and thus we perceive depth, using parallax

parallax

- **Different views of each eye**
- **Parallax and binocular disparity**

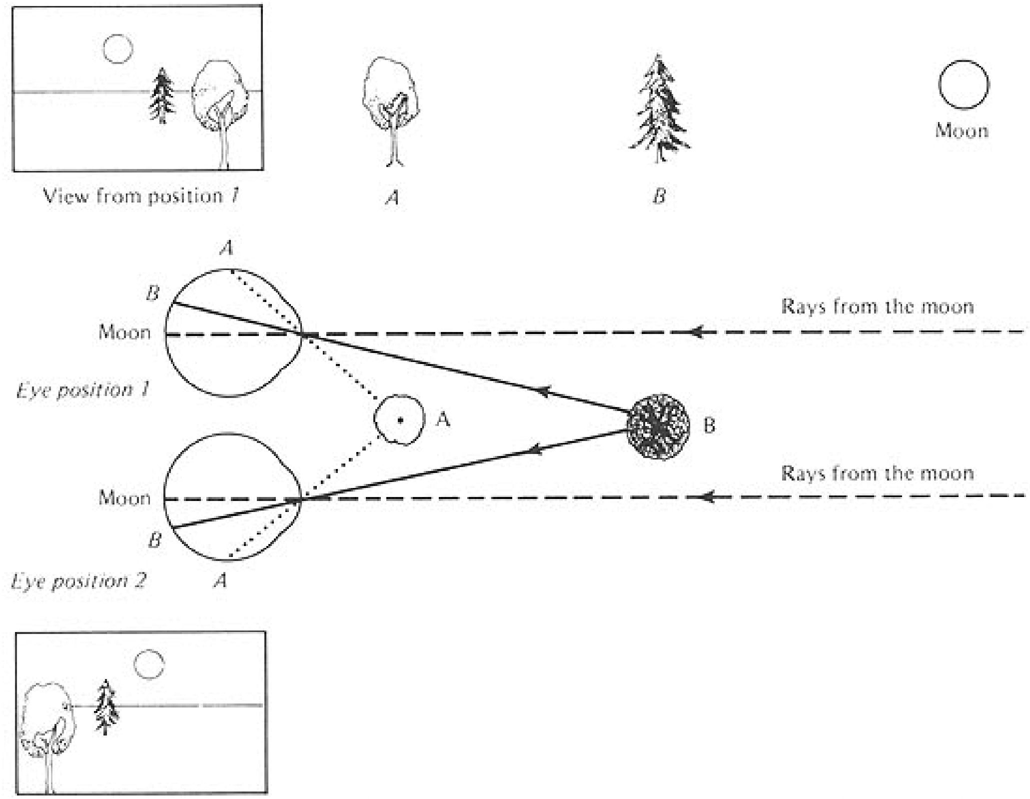


FIGURE 8.4

The locations of the images on the retina change as the eye moves from position *1* to position *2*. The location of the retinal image of the nearest object, *A*, changes the most—from one extreme to the other. The image of a more distant object, *B*, moves less, while the parallel rays of the very distant moon are always imaged on the same place on the retina. This is why the moon seems to follow you as you look at it, say, from the window of a moving car. The closer the object is to you, the more it appears to move in the direction opposite to your motion.

Binocular disparity

- **Two distinct views generated by the separation of our eyes is called binocular disparity. This is just a form of parallax**
  - Eyes are separated by about 6.5 cm
  - Generally our brain fuses the images together and we perceive a single image

Binocular disparity

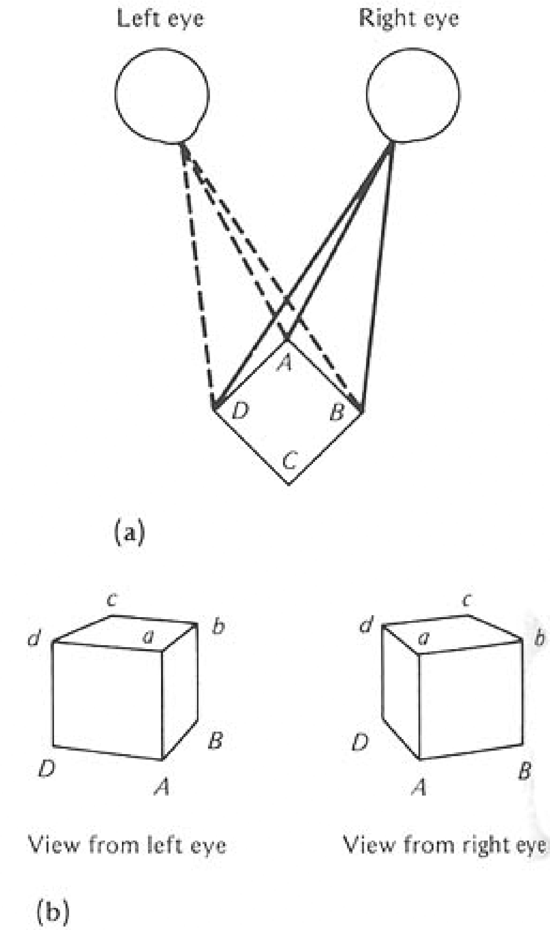


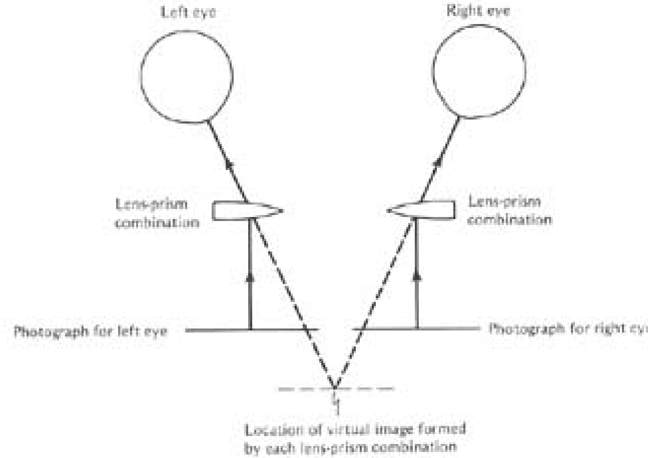
FIGURE 8.6

The two eyes looking at a cube see slightly different views of the cube. **(a)** View of eyes and cube. **(b)** Views seen by each eye. Note that the edge *da* subtends a smaller angle for the *right* eye than does *ab*, and consequently that eye sees *da* as shorter than *ab*. For the left eye, the situation is reversed.

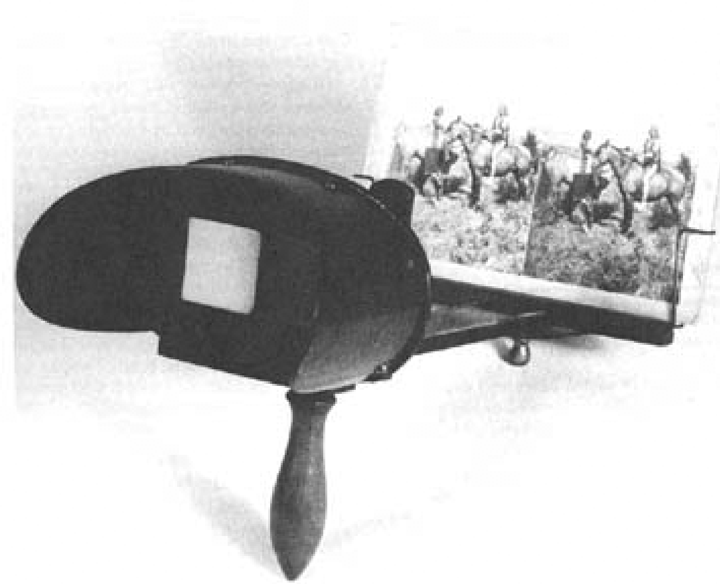
Binocular disparity-2

- **We can adjust the apparent separation of two images and thus change the binocular disparity**
  - Often pairs of aerial photographs are used to measure height changes on the ground. The separation of the camera locations for the two images determines the amount of disparity
- **Stereoscope is a simple optical instrument that gives us three dimensional images**
  - Each eye is allowed to only see a single image
- **Polarized light and different polarized filters can allow each eye to see different images (if movie projection system allows it)**
- **Color filters placed in front of each eye can allow each eye to see different images (if the movie scene is designed for it)**

stereograms



(a)



(b)

FIGURE 8.7

(a) The principle of the stereoscope. The amount of depth perceived depends on the disparity between the two photographs. **(b)** A stereoscope from the 1880s viewing a stereo pair of photographs of Indians.

Stereo photograph

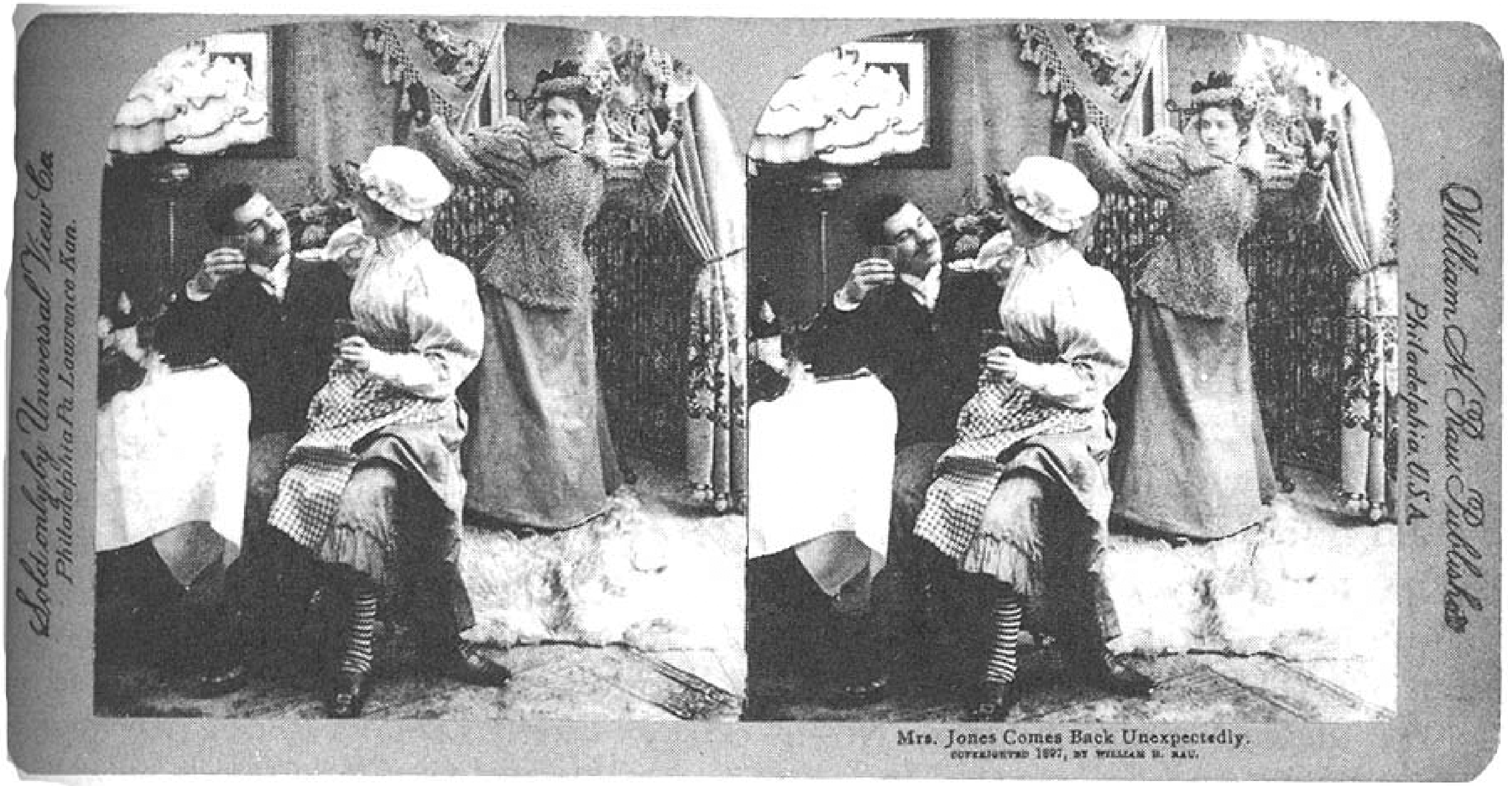


FIGURE 8.8

Stereoscopic photograph: "Mrs. Jones Comes Back Unexpectedly" (1897).

- **Effects of stereo vision**
- **What is in front, whats in back**

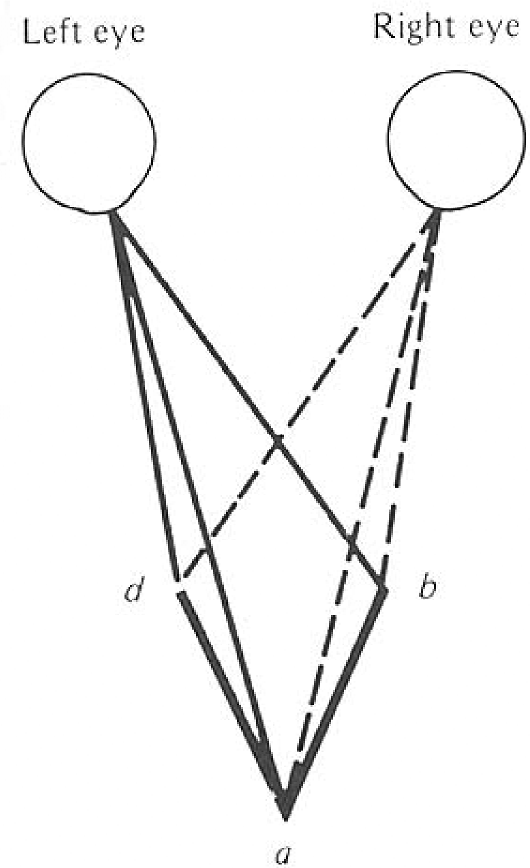


FIGURE 8.9

The two eyes looking at this object would have views corresponding to those shown in Figure 8.6b, but with the views interchanged. The edge *da* now subtends a smaller angle for the *left* eye, so that eye sees *da* as shorter than *ab*.

Stereograms

- **You can view stereo pairs in several ways**
  - Use an optical instrument to allow your relaxed eyes to see two images
  - If images are separated by your eye spacing (~ 6cm) you can bring your face close to the pair of images and look "through" the images (no convergence) and focus each eye on its image (accommodate)
    - We have brought convergence and accommodation into conflict
  - Cross your eyes so each eye sees the two images and the their separation is such that the "central" pair of images fuse together. Thus only 3 images are seen.
    - When this fusion occurs, adjust the focus of your eyes so the images are sharply focused
    - We have brought convergence and accommodation into conflict