values below $k_v \leq 0.8$, and figure 9.14 suggests that roughly half of the population might be susceptible to this phenomenon.

With the static binocular, the globe effect remains invisible, for the same reason why the barrel distortion of the visual field remains unnoticed by the observer: Though straight edges of objects are bending outward, this distortion occurs in the peripheral part of the visual field and is virtually invisible. Its presence is verified, however, with the help of Helmholtz-checkerboards (figure 9.13). In daily life situations, the image formed in the visual cortex is a superposition of numerous patches which are taken during saccadic scans of the environment, during which predominantly central retinal areas, which are free of distortion, are employed. As a result, the static image appears distortion free, and only the moving image, which rolls in front of the eye, reveals the global barrel distortion of the visual field.

The question then arises why such a distortion remains invisible when turning the head. This is so because during motions of the head, the eyes remain fixated onto a certain motive for a short time, just to jump onto the next motive, and in this way, no continuous motion, which could reveal any curvature of the visual field, is perceived. When observing through a binocular, then the speed of the moving image is increased by a factor of the magnification m, and in these conditions the fixation of the line of view on individual motives is easily overcome, the image is flowing continuously, and the optical flow of figure 10.20 is turning visible.

How is the globe effect avoided? The short answer is: When the optical instrument generates a small amount of pincushion distortion, which precisely compensates for the individual amount of visual barrel distortion, then the globe effect is eliminated. Unfortunately, figure 9.14 proves that barrel distortion is not a universal feature of human perception, but individually different. Yet, reasonable average values exist which should effectively reduce the globe effect to such an extent that it remains unnoticed by the vast majority of binocular users. Apart from that, a complete compensation may not even be the optimum solution for every application. The following section is going discuss a couple of technical details that are of relevance when seeking for the right quantity of pincushion distortion in optical instruments. It may be conveniently skipped by the casual reader who has low ambition to dive deeper into these matters.

10.11 The search for the ideal distortion curve

The globe effect can be eliminated with the help of a pincushion distortion, which is deliberately implemented into the binocular. To prove that claim, we start with the generalized distortion relation (9.10),

$$\tan(ka) = m \tan(kA) , \qquad (10.44)$$

and solve for the half-angle in image space,

$$a = \frac{1}{k} \arctan\left[m \cdot \tan(kA)\right] . \qquad (10.45)$$

Once again, $k \in [0, 1]$ is a parameter of the quantity of pincushion distortion, $k = 1$ yielding the tangent condition which is free of distortion. Now we include the visual space of human perception (section 9.6): In visual space, the image point is no longer perceived at an angle a to the center of field, but has to be computed using equation (9.12), yielding

$$y = \frac{1}{k_v} \tan\left\{\frac{k_v}{k} \arctan\left[m \tan(kA)\right]\right\} . \qquad (10.46)$$

It is easily verified that in the special case of $k = k_v$, i.e. equality of instrumental pincushion distortion