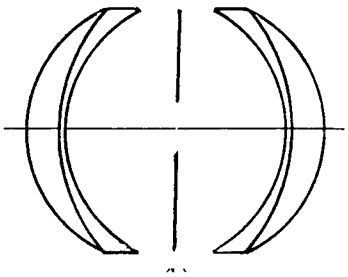
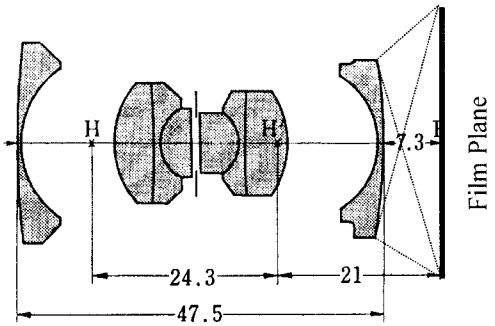
PHOTOGRAPHIC OBJECTIVES #3: WIDE ANGLE LENSES

The normal lens has the shortest focal length which just fills the image format without vignetting. A lens with a shorter than normal focal length will project an image whose diameter will be smaller and the magnification is less.

The advantage to a lesser magnification is that more objects can be fit into the film format since their images are smaller for a wider field of view. But the diameter of the projected image diminishes also as the focal length decreases, and too short of a focal length might not have enough image area to cover the full film format. The trick to designing a wide angle lens revolves around projecting a real image whose diameter is larger than the lens's focal length.

Nineteenth century wide angle lenses used radically curved achromatic doublets in a symmetrical arrangement. They could have fields of view as wide as 80 degrees, but at really small openings, like f/30! This has been the basic design philosophy for wide angle lenses, with the major improvement of adding more elements to gain speed and combat aberrations.





Optical Formula for 21 mm f/4

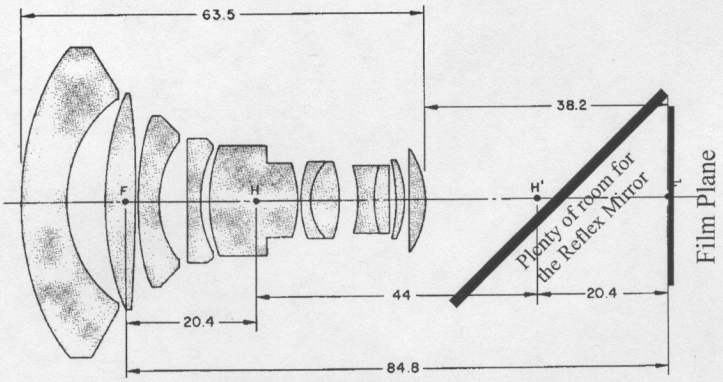
Here is an evolved design of the wide angle principle. This lens has a 21 mm focal length, and a 90 degree field of view in the 35 mm film format! Notice how obliquely the rays that form the edge of the image exit from the rear element which is a scant 7.3 mm (a little more than ¼")from the film plane!

A lens with this short of a focal length could not be used in the reflex view finding mode of an SLR type camera because its elements are in the way of the reflex mirror. A different approach is taken in the design of contemporary wide angle lenses for these types of cameras, the retrofocus or inverted telephoto design, which outputs a lens whose physical dimensions are larger than its focal length!

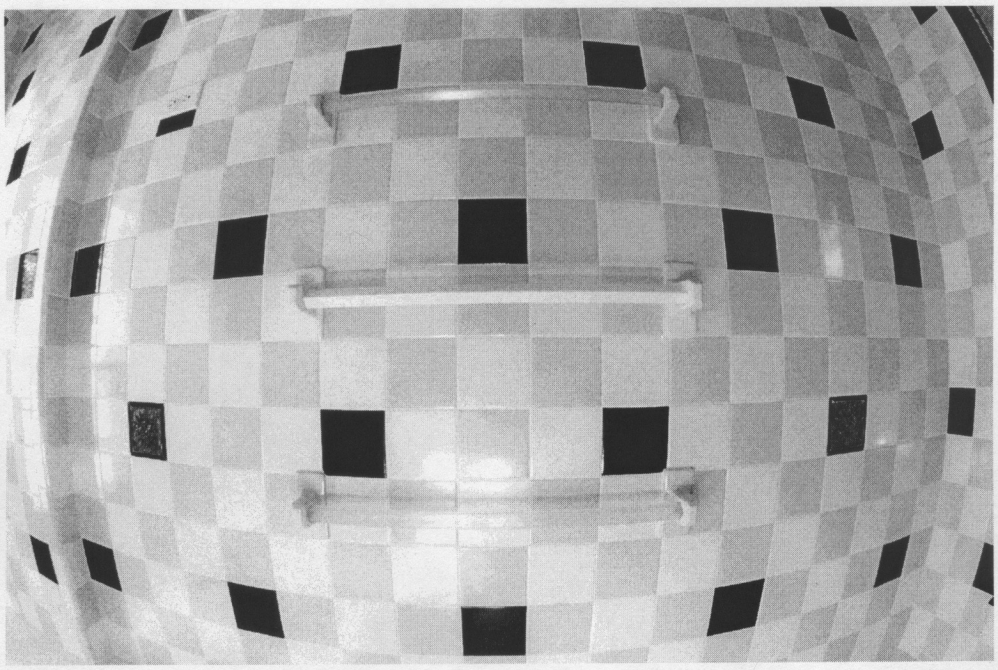
The true telephoto design uses a negative lens behind a positive one to lengthen the focal length of the combination, which is longer than the physical package of the elements. (See the previous section, **TELEPHOTOGRAPHIC LENSES**.) Reversing their order shortens the focal length of the design and leaves a big enough gap

between the rear lens element and the film plane to fit in the reflex mirror.

Another way of looking at how this design works (and how some early cinematographers cobbled together a wide angle lens and the basis for some wide angle attachments that screw on to the front of lenses) recalls what is viewed when looking through a negative lens (a minified virtual image). Use that as the first element, then follow it with a typical kind of normal lens looking through the negative one to provide a real image at the film plane.



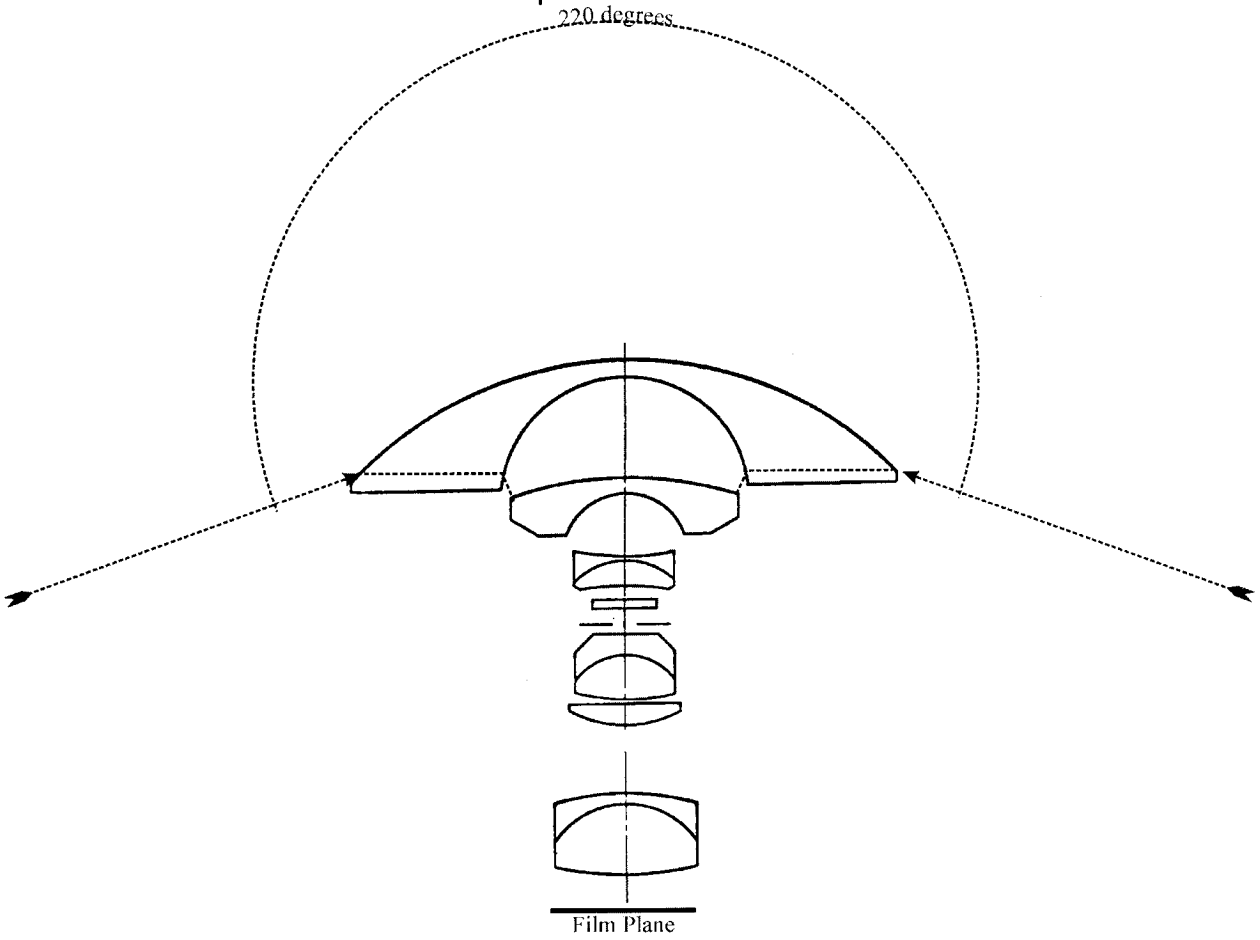
20 mm f/3.5 Retrofocus Wide Angle Lens.
Note the large negative front element and the position of H', the back focal point.



Although using a symmetric design helps eliminate distortion and curvature of field, the geometry of the short focal lengths with rapidly decreasing image size for further object points yields the familiar barrel distortion. The picture above was taken with a Minolta 18 mm f/9.5 lens, which delivers 160 degree field of view across the diagonal of the 35 mm full format.

The ultimate in wide angleness is the fisheye lens. With the radical negative front element light rays not only parallel to the film plane but even coming from behind the

camera can be directed onto the film plane!



6 mm f/5.6 Fisheye Lens produces a 220 degree field of view in a 21.6 mm diameter image