

## PHOTOGRAPHIC OBJECTIVES #6: PROJECTION AND ENLARGING LENSES

As was mentioned in **PHOTOGRAPHIC OBJECTIVES #6: MACROPHOTOGRAPHIC LENSES**, lenses are designed to minimize aberrations for their intended conjugate distance applications. For picture taking applications, the object distance is long and the image distance is short, resulting in minification, (**CASE 1**) but for slide and movie projectors and photographic enlargers the situation is reversed, a **CASE 3** application.

Theoretically the same lens used for taking the picture could be used for projection, but this is hardly ever the case in practice. The normal lens of the camera would magnify to life size at such a short distance that the projector would need to be in front of the audience. Therefore, projection lenses are usually several times the normal focal length of the format, to move the projector to the back of the room, which also helps prevent distortion.

Projectors hardly ever use fixed focus lenses, since the position of the projector is the only determining factor in the size of the image on the screen. Varifocal lenses are the status quo, and not the true zoom, as there is no need to make the lens more complicated, since once the image size is set by finding the right focal length the focus needs only to be touched up.

There is no need for an aperture in a projection lens since the projected image needs to be as bright as possible. For slide and movie projection a low  $f/\#$  is of utmost importance, for the brightest possible image, even more so for movies as the light is issuing from the projector for only half the viewing time as the film cycles from one frame to the next. With the film moving, resolution is not as critical as in still projection.

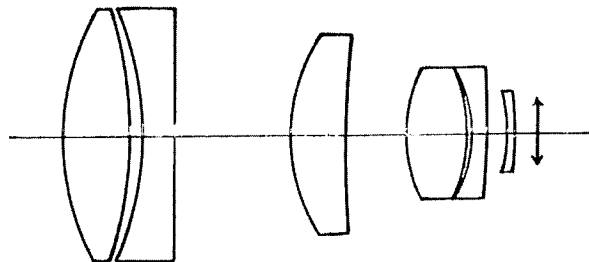


Figure 3.16. Kodak Projection Ektar  $f/1$  lens.

The focusing mount is built into the projection apparatus, making the lens less expensive. Autofocusing is done by the projector, not by the internals of the lens, eliminating the expense of another device in the lens.

Kodak Carousel slide projectors offer two types of lenses, Ektanar-C and -FF lenses to combat curvature of field. The FF stands for flat field, and is recommended for slide shows where the majority of the slides are mounted between glass, so a flat object is imaged onto a flat screen.

But almost all slides commercially processed are mounted in cardboard or plastic, binding the film chip along the edges, and are not necessarily flat but are concave viewed from the emulsion side. So the -C lenses come standard, designed to image a curved object plane onto a flat screen.

Considering that a 35mm slide is roughly 1" by 1½", and the typical projection screen is at least 30" by 30" and up to 50" by 50", so to have the long side of the slide fit the screen would require a magnification ratio in the neighborhood of 30X.

Enlarging lenses are designed for smaller magnification ratios, typically from wallet size to 16 by 20, meaning from about 2X up to 16X for 35 mm format. A 50 mm lens is the default focal length for enlargements from 35 mm, and in general the normal camera focal length is the one that is necessary for enlarging that particular format. (Don't forget, the normal lens is the one whose basic image size fills the film format.)

If a shorter than normal enlarging lens is used on a negative, for instance a 50 mm on a 6 cm by 4.5 cm negative, only a circle of approximately 50 mm diameter of the negative will be projected, the rest of the image vignetted out. Using the longer focal length 80 mm lens that would be used for the 645 neg on the 35 mm neg will cover the whole negative, but the enlarger head will have to be racked up almost twice as far from the paper to give an equivalent enlargement magnification from the same negative.

As a bonus, an enlarging lens could be used as macro lens by hooking them up to a bellows. They are attached to the enlarger with what are known as "Leica threads". (A screw thread that is 39 mm in diameter, with a pitch of 26 turns to the inch. This crazy combination of metric and English units was used to discourage other manufacturers from making lenses that would fit on Leitz's popular cameras!) Never fear, you don't need to buy an expensive *tap* to cut this kind of thread into a mounting plate, just a hole big enough to let the threads fit through because the lenses come supplied with an attaching ring of the appropriate size.

Resolution is a major issue for photographic enlarging lenses, as the final print will be closely scrutinized. See the **Handout, PRACTICAL APPLICATIONS OF RESOLVING TARGETS** to see how well these lenses do.

Luckily low *f/#*'s are not such a high priority, although they do help when focusing. Usually the lens is used 2 or 3 stops from its largest aperture to combat aberrations, with the appropriate exposure time delivered to the light bulb via an electronic timer, having been determined by trial and error. (Photo printing papers have a wide range of speeds, and my typical exposures for 8 by 10's vary from 1 or 2" with Ilford Multigrade at *f/8* to 5 to 10" with Agfa Portriga at the same magnification. Color printing papers like

to standardize exposure times at something like 5" to make sure that all three layers react the same way consistently, and use the aperture to control exposure. This is not such a great idea because there is not as much fine control between the clicks of the f/stops as there is in the timer, which is accurate down to a .1 of a second.)

The two devices above are becoming closer and closer to totally obsolete, thanks to the presence of digital projectors. The lenses in these devices are similar to slide projectors, as they have similar functions and requirements. The Digital Light Processing chips are a tad smaller than 35 mm format, so the focal lengths are similar to the slide projector, but they are usually unmarked as to the true dimension and corresponding f/stop.

But a real advantage these lenses have built into them are tilts to compensate for the fact that the projectors are typically aimed at the screen from above! Something the humble Kodak Carousel was sorely lacking!