A Lens Primer for Lighting Directors

by Bentley Miller

As lighting directors, we are primarily responsible for image-making—that is, creating interesting, well-crafted visual statements.

To achieve this goal, our focus is usually directed to the selection and use of lighting fixtures, but our choice shouldn't stop there! For a long time, television has been the poor cousin of film for a whole host of reasons, not the least of which is *lens selection*.

For the cinematographer, lens selection has always been of paramount importance as it often influences the look of the entire film. The selection of lenses for television has always been a moot point. More often than not, the television zoom lens is the part of the system that is taken for granted. We assume that because the lens comes with the camera, that it is a single unitized, unalterable package and we leave it at that. Users seldomly give any thought to just exactly what it is that's on the front of the camera.

This article will devote itself to a simplified and hopefully clear explanation of the complex structure of the television zoom lens. We continue the discussion with an introduction to the simple lens, then proceed through to optics.

Zoom Lens and Structure: The Simple Lens

As children, we experimented with many playthings, and more likely than not we were fascinated by something as straightforward, and yet complex, as light passing through a lens. Without thinking much of it as a child, you would hold a lens up to the light, noting that as you moved the lens closer to you or further away that the apparent object size of any object viewed through it changed. You would no doubt have also noticed that the point at which the image formed changed, forcing you to re-focus the image each time you moved the lens. Experimenting with two lenses, moving them in co-ordination effects a change producing a (larger image) magnification without losing focus. This "simple" procedure is the heart of every television zoom lens.

Lens Components

Although a television zoom lens is a complex composite of lenses, they are only discrete units which function in unison to perform a simple task, that is to "move one part of the lense system to change the size of the image, and move another part to keep it in focus".[1] A zoom lens thus by function and definition must have at least two moving parts. The parts are known as the variator and the compensator. The variator moves to change the image size while the compensator moves to maintain focus.

The typical hand-held camera zoom lens is composed of four elements:
1) the focussing group at the front of the lens which makes focussing possible;
2) the variator changes the image magnification;
3) the compensator holds focus when changes are made in focal length;
4) the stationary group that comprises the fourth segment is called the relay group.

Although all of the elements are important, perhaps the most important part for our purposes is the variator. The variator moves back and forth within the lens body to alter the image size, and it is image size that has a direct bearing on lighting, as will be explained later.

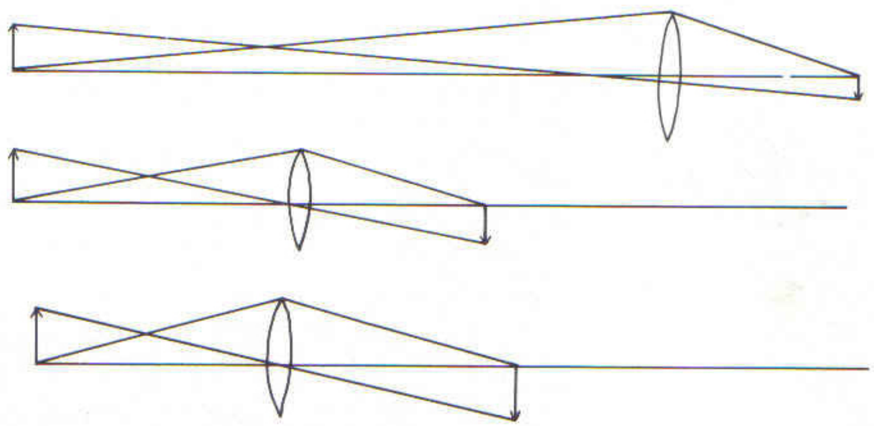

Diagram 1: Changing magnification with a single lens.

Barrel Cam Mechanism

Since the variator and compensator groups must operate in precise synchronization to maintain relative image position, it is imperative that they be aligned and must remain in alignment at all times. This barrel cam mechanism performs the function of maintaining relative position according to precise parameters that are determined by geometric optics principles.

The barrel cam mechanism is composed of two elements: "a linear guide groove (linear cam) and a curved cam groove (curved cam) which matches the lens motion track. Thus, as the outer curved cam barrel rotates the variator and compensator move following the curved cam grooves".[2]. If this were not the case, focus would be lost during the zooming due to mis-alignment of the variator and compensator.

It should suffice to say that because a television zoom lens is more complex than its film counterpart, that there is a greater opportunity for optical aberrations to creep into the final image. Since the path of light rays travelling through a television zoom lens changes markedly during zooming, the lens must be designed to self-cancel aberrations within the lens group or in conjunction with another lens group within the lens to render a balanced output to the image plane.

Optical Path Elongation

Elongation of the optical path is caused by the various elements that we have in our zoom lens. If we step once again into the home lab of our youth, we recall that there is a difference in refractive indices of air and water. A simple experiment which we can refer to is a coin on a flat surface, say a desk in free air compared with a similar coin under water in a shallow glass dish or pan. If we look at the coin on the table at a given reference distance of 3 feet, no matter what angle we look at the coin, it always appears to be the same distance away because it is. Next, if we follow the same procedure using a similar reference point of 3 feet, but this time we substitute the coin in a shallow pan of water, we find that we get entirely different apparent results depending on the angle of view. By placing that same coin in the shallow glass pan partially filled with water and observing the coin at an angle of roughly 2°, the coin appears to be floating at a point midway between the surface of the water and the pan bottom. If we look at the coin from