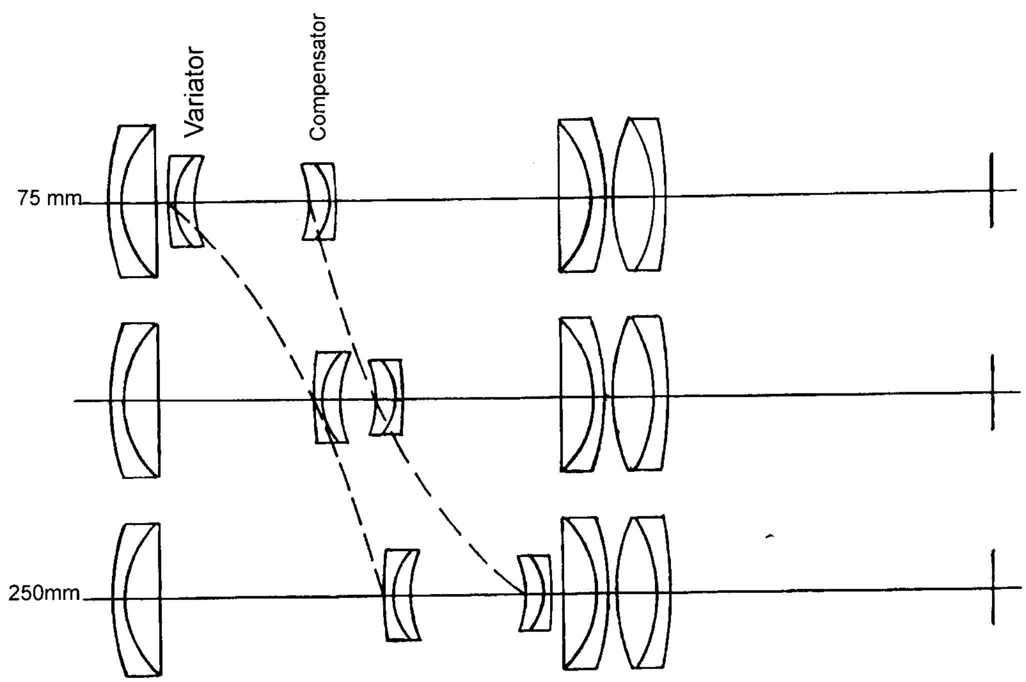
PHOTOGRAPHIC OBJECTIVES #5: ZOOM LENSES

Combinations of lenses can produce new focal lengths. For instance, following a positive lens with a negative lens will produce a longer focal length for the combination, as in the telephoto lens prescription. Moving the negative lens closer and further from the positive one will change the focal length of the combination.

This variable focal length lens combination would vary the magnification and field of view as the relative positions of the lenses are changed, but every time the negative lens is repositioned to change the focal length, the image distance will also change and the whole assembly would have to be refocused. This type of lens is called *varifocal*, and is the type of "Zoom lens" supplied with projectors. After the size on the screen is set, then the focus is touched up.

The true **Zoom** lens has another set of optics to ensure that the focal plane does not change as the focal length varies, essential for zooming while shooting movies or video, and a big help for the still photographer. A *variator* changes the focal length, and a *compensator* ensures that the focal plane is constant.



One way to make a zoom lens. As the Variator, a negative lens, moves away from the fixed positive front element, the focal length of the combination changes. The Compensator moves in response to this focal length change to maintain the focal plane's position.

In the illustration above it can be seen that there is no linear relationship between the variator and the compensator positions. Observing the elements inside a zoom lens while zooming shows this effect in action, creating a mechanical engineering nightmare to get the lenses to move to the appropriate positions. Usually cams or slot and groove mechanisms are employed to move the interior lenses, and sometimes the front element is moved also.

There was a reluctance at first for still photographers to adopt the zoom lens, as it was thought that they could never be as sharp as a fixed focal length lens. But thanks to modern era computing as applied to optical engineering, that fear can be laid to rest.

The big disadvantage (other than price) of zoom lenses is their moderate f/#. With the amount of elements in one, scaling up the design to wider apertures would jack up the price considerably!

The size of the film format determines how ambitious the zoom design might be. For instance, for the medium format Mamiya 645 camera, only a pair of zooms, the 105 – 210 mm f/4.5 and the 55 – 110 mm f/4.5, are offered. The former is a moderate telephoto design, the latter encompasses a weak wide angle through normal ending up at weak telephoto. Their apertures are not that bright at f/4.5, and both would be considered 2X zoom power, which is the ratio of their short and long focal lengths.

Compare that offering to Canon's line up of zooms for their 35 mm format cameras, 28 in all, although there is some duplication of focal lengths incorporating minor variations, such as UltraSonic Motors, Diffractive Optics, or Image Stabilization! Their shortest **Ultra-Wide Zoom** is a 10 – 22 mm f/3.5-4.5, with a few others working in the region of almost fisheye to still pretty wide angle. They have a lot of **Standard** and **Telephoto Zooms** that encompass wide angle through normal ending up at telephoto, like 17 – 85 mm or the wide ranging 28 – 200. Most of these have rather conservative zoom ratios like 3 or 4X, although there is one that has a zoom ratio in the range of the 8 to 10 or even 12X range typical of the video or smaller format digital still cameras, the 28 – 300 f/3.5 - f/5.6. (300/28 = 10.71). The smaller the format, the easier it is to design a zoom lens that is practical to handle and manufacture. There are no zoom lenses for sheet film cameras of the 4" by 5" or 8" by 10" genres.

Some zooms have their f/number change as the lens is zoomed, for instance a 35 to 150 mm f/3.5-4.5 lens. Since the f/# is the ratio of focal length to the diameter of the opening of the lens, it can be seen that for a fixed diaphragm diameter, its f/ratio will increase as the lens's focal length increases. The position of the iris in the lens determines if this will occur.

Along with magnification variation while zooming, the perspective compression/foreshortening changes also. Shots can be lined up to get the appropriate foreground/background relationship by zooming in combination with selection of the object distance.

Cinematographers didn't like this effect in the early days of zooms, as they were used to the way perspective moved while the camera was moved in closer to or further from the subject. But the combination of zooming while moving the camera in or out can produce some very dramatic effects. As an example, there is the famous scene in Vertigo by Alfred Hitchhock where a terrified Jimmy Stewart's face is held constant in size while the camera is backed off by zooming to a longer focal length. This brings the background up to him from behind. All this happens very quickly, increasing the anxiety!