
# FILMING THE FANTASTIC

## A GUIDE TO VISUAL EFFECTS CINEMATOGRAPHY

MARK SAWICKI

Focal Press

*Whether you are an old hand at visual effects or just thinking about getting your feet wet with your first indie film, Mark's book delivers a very detailed history and hands-on, step-by-step detailing of effects techniques, both past and present, reminding everyone that visual effects are still about more than just staring at a monitor and watching pixels move.*

—Kevin Kutchaver, Emmy Award winning VFX Supervisor and Founder of HimAnI Productions, Inc.

*This book perfectly addresses the number one problem in the movie business: all decisions are made based on fear. "Will I lose my cushy job if I make the wrong decision?" With this book on your desk that's one less problem to worry about.*

—Glenn Campbell, Visual Effects Supervisor at AREA 51

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We took the journey together.

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and all my good neighbors who let me turn our street into a back lot.

# Introduction

The feature film industry has undergone tremendous changes since I came to Los Angeles in the mid-1970s. The effects business I entered was populated with unique, multitalented artists. Budgets were small and precious, and much preplanning went into effects to make every dollar count. There were individuals in this community who were revered as great artists and mentors, and novices could seek out and talk to these wizards in the hopes of gleaning a few pearls of wisdom about the mysterious art of visual effects. It was the end of the age of apprenticeship, and I was fortunate to work with some of the legendary figures of the business, such as Albert Whitlock, Bill Taylor, and Syd Dutton. Through other circles I became acquainted with other highly regarded effects practitioners, such as Wally Gentleman, Peter Donen, and the great stop motion artist David Allen; there were a host of others. The inspiration and encouragement these individuals gave to me I hope to pass on in this book. My great fortune is to have known these and other master artisans, to have taken part in the Golden Age of effects, and to have seen the transition into the digital age.

I've seen a sea change in the effects industry as a whole. The small business I once knew has been taken over by huge, multinational corporations, and now armies of people create the spectacular effects of today's motion pictures. Each individual artist has a tiny, specific role to play in the creation of an effects picture. In this environment it is very difficult to obtain the overview experience of planning a shot, shooting on set, and executing the final composite. It is also rare to have an apprenticeship with a master. The large facilities have almost completely overtaken the small shops and, along with that, the ability for an individual to wear many hats and learn the craft from the ground up.

Perhaps the most profound change regarding visual effects is the "miracle" of digital. Unfortunately, this miracle and the accompanying ability to manipulate and fine-tune just about everything have resulted in furious production schedules and frantic, free-and-easy shooting with a "damn the torpedoes" attitude. This hectic pace has led to the phrase "fix it in post" and is one of the factors in the high cost of movies today. The "tweak" factor, or the endless reworking of a "fix it" shot to try to get it to look somewhat natural, is enormous. Orson Welles is rumored to have said, "The absence of limitation is the enemy of art." This phrase certainly rings true today.

The great offsetting influence of this trend, however, is that digital gives everyone the ability to tell his or her own story by making a movie. It is for these individuals that I write this book. The lone artist may become discouraged when he or she sees a big blockbuster film—it is easy to feel hopelessly lost and unable to realize your own vision when you only have $1.98. It may seem too complex and astronomically expensive to make any kind of film, let alone one with simple effects. Don't lose hope. Remember that the most complex thing in the world is made up of merely a whole lot of very simple things. The main purpose of effects work is to help put forward a story. Instead of falling prey to the overindulgence of the effects extravaganza, realize that in the world of storytelling, less is oftentimes more. It is a greater talent to make an audience weep or laugh over an endearing depiction of characters than it is to inundate them with a fireworks display of effects.

The purpose of this book is to illustrate certain principles and procedures that facilitate the execution of the basic meat and potatoes of plate photography. By meat and potatoes, I refer to matte painting plates, green screen setups, crowd replication, simple model creation, and the lighting and photography used to create basic effects that can help enhance a story. In earlier days, the effects artist was expected to create the entire shot, which often entailed building a model, photographing it, and executing the final composite using photochemical means. Needless to say, the process was so difficult that the artist learned to "shoot it right the first time." Approaching the effects problem from all these different aspects gives an appreciation for the benefits and drawbacks of each skill. My intention is to enable the independent filmmaker or student to create and shoot elements properly to allow for fast and effective compositing. This book is not camera or software specific. I briefly outline the technical foundations of film and digital capture and focus on several real world scenarios that illustrate the basic concepts in a practical sense. I hope that these step-by-step illustrations of photographic element creation will enable the reader to learn how to preplan and execute his or her own visual effects challenges. With a little preplanning and careful execution you, too, will be able to film the fantastic.

Mark Sawicki
Aboard the Silver Shadow en route to Alaska
September 2006

# Chapter 1
## One-Eyed Magic

In the age before visual effects became a highly technical endeavor, the art was closely related to magic. In fact, Georges Méliès, one of the first great visual effects artists, was a professional magician by training. A magician performs illusions that take place in front of your eyes. In the case of motion pictures, the miracle takes place in front of the one eye of the movie camera.

### The Pinhole Camera

The one common denominator of all visual effects photography, be it film, video, or digital, is the all-important lens. Consumer digital cameras have invisible lens controls save for a zoom button. Due to automation, the focal length, focus ring, and f-stop are hidden from the operator, which makes it difficult for the beginner to get a handle on lens concepts. To bring the reader up to speed fairly quickly, I'll start by discussing an imaging device that came before lenses. Yes, that's right; before glass an image could be focused on a surface using nothing more than a tiny hole in a thin film of metal called a pinhole. As early as the sixteenth century, artists used specially constructed portable darkrooms consisting of an imaging surface (such as an artist's canvas) and a tiny hole on the opposing side to image the world for tracing purposes. The seventeenth-century Dutch painter Vermeer utilized this "camera obscura" in his work.

A pinhole can create an image because it narrowly selects tiny bundles of light reflecting from an object to form a focused image on a surface (Figure 1.1). When light strikes the subject, rays bounce off in all directions (assuming that the subject has a

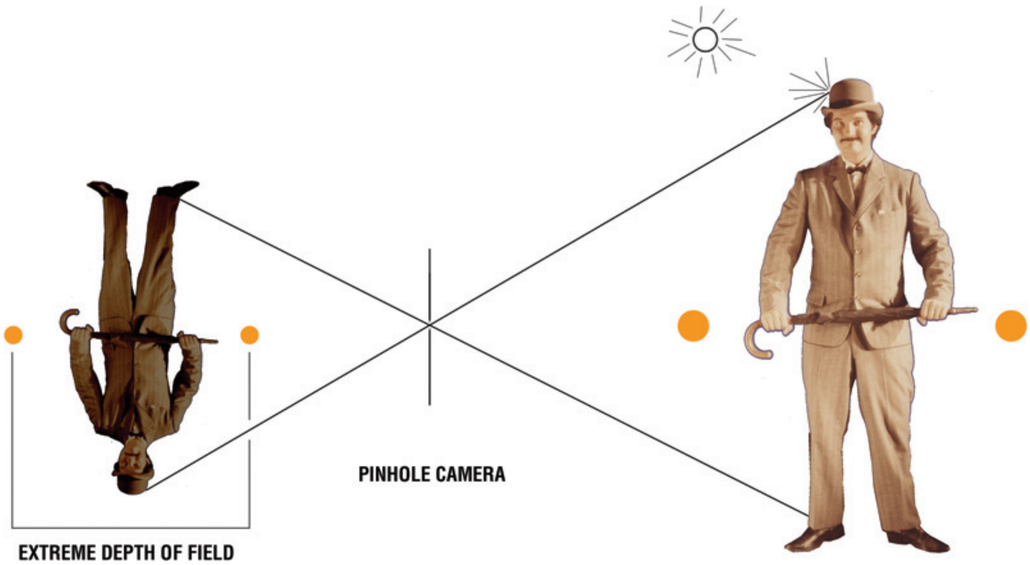


**Figure 1.1:** *The pinhole camera.*

diffuse surface as opposed to a shiny one). The pinhole allows only a tiny cluster of rays emanating from a point on the surface of the subject to make their way through the hole to form a point of light on the imaging surface. If this phenomenon is repeated for all those selected bundles of rays bouncing off each point of the subject, it forms an upside-down image on the canvas.

For those readers who wear glasses, you can experience the same effect by removing your spectacles and viewing the world through a tiny hole formed by curling your forefinger as tight as you can while still allowing light to pass through the center of the curl. You will begin to see things in focus without spectacles. The tinier the hole, the fewer bundles of light and the sharper the image becomes. The drawback to this camera obscura was that it was very dim and could only be used on the brightest of days. If the hole is made bigger, more bundles of light pass through, but instead of tight little circles of light forming an image, bigger blur circles are made that start overlapping with the other circles, creating an unclear image. When the blur circles are small, a sharp picture is produced; when they are larger, a soft or out-of-focus picture is produced. To get a sharp picture, a tiny hole that captures perhaps one percent or less of the bundle of light being reflected off an object must be used, but the resulting image is very dim. The next step was to somehow make the image brighter.

## Refraction and the Lens

Light travels at a rate of about 186,310 miles per second in a vacuum and slightly slower in air. When light hits water, it slows down to about 140,000 miles per second,

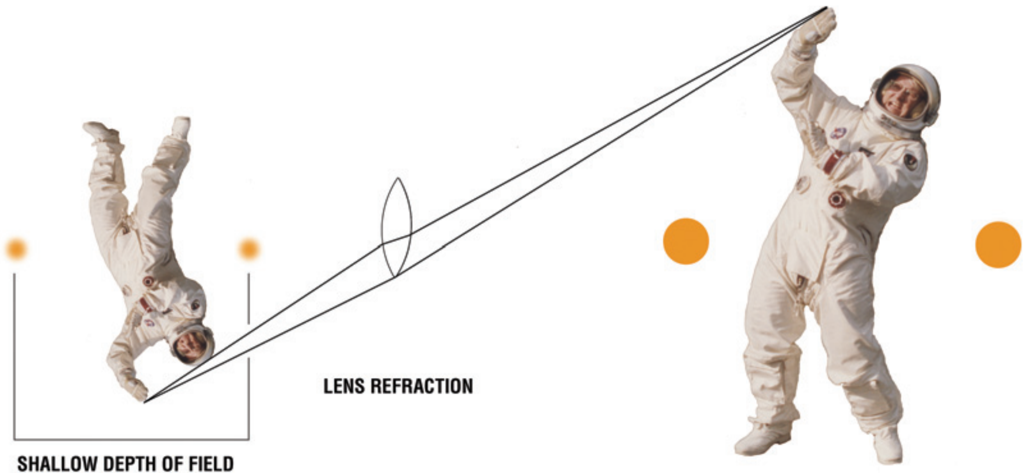


**Figure 1.2:** *The lens captures more rays of light. The astronaut is bright and sharp, but the spheres in front of and behind him are soft and out of focus due to reduced depth of field.*

and when moving through glass light really hits the brakes, moving at 120,000 miles per second. When light goes from a lighter to denser medium such as from air to glass, the rays of light bend. Lenses are shaped to make maximum use of this bending, or refraction, enabling the capture of many more bundles of rays emitting from a subject and bending them all to a "bright" point of focus (Figure 1.2).

When using a lens, the point of light is bright because the lens is capturing 10 percent or more of the rays bouncing off the subject. This is a new phenomenon in that there is only a short range of a sweet spot for the focus of the lens on the canvas that will render the image sharp. Objects in front of or behind the subject will be focused slightly in front of or behind the canvas and will be imaged as out of focus on the canvas or image plane. This limited focus range is known as a narrow depth of field. This means that there will be a certain area in front of and behind the subject that will be in focus while the rest will be progressively softer. This narrow depth of field is not necessarily a bad thing; cinematographers use it all the time to focus the audience's attention on the subject matter. Closeups of actors often have out-of-focus backgrounds so that the viewer can concentrate on the performers' expressions. Conversely, increased depth of field can be used to include more details of the space and is very useful when doing certain types of effects that we will explore later in this chapter.

## Focal Length

The point at which a lens converges parallel rays from a distant source like the sun to a surface is its principal focus, and the measurement from the optical center of the lens to that imaging surface is the focal length. Typical focal lengths include 14 mm, 18 mm, 29 mm, 32 mm, 40 mm, 50 mm, 75 mm, 85 mm, and 100 mm. Modern camera lenses have several lens elements within them to correct natural aberrations that occur within optical paths. Manufacturers take all of these "helper" lenses into consideration when determining the aggregate focal length of the modern compound lens. The important thing to note is that motion picture cameras have sets of lenses called hard or prime lenses of varying focal lengths that have specific fields of view (that is, how much of the world the lens "sees"). There are also zoom lenses of variable focal length that can render a wide range of views from a wide angle (a large expanse) to a narrow angle (the closeup).

## The Iris and Depth of Field Control

If we insert a diaphragm or iris into the optical path, we can gain control over how many bundles of light rays pass through to our lens (Figure 1.3). With a wide-open stop or aperture, the maximum number of bundles of light go through, and we get a bright image but very little depth of field. If we stop down, or make a tiny hole that will allow only a few bundles of rays to pass, then we will get a very dim image with a large depth of field similar to the pinhole.

## The F-Stop

The iris is primarily used to control the amount of light transmitted by the lens onto the recording medium; its secondary function is to regulate the depth of field recorded in each image. The settings for the iris are expressed in numbers called f-stops. The

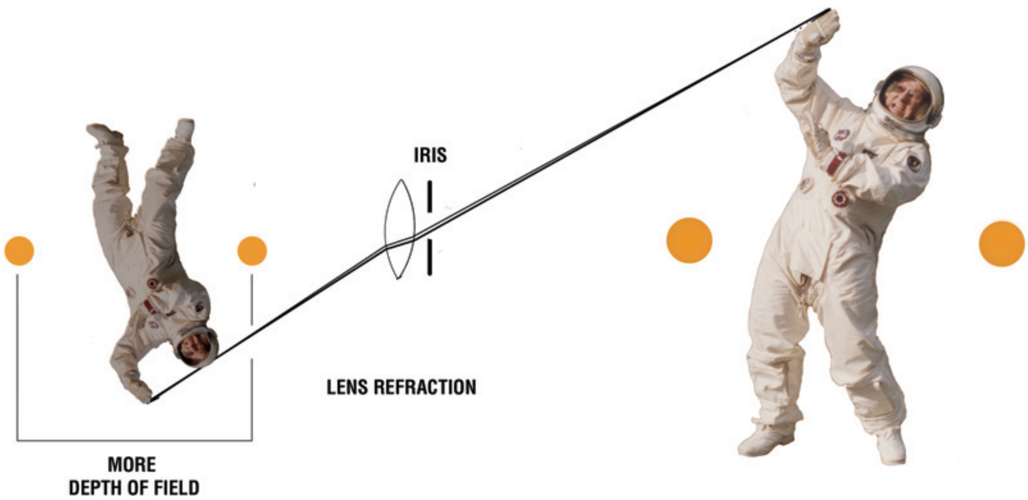


**Figure 1.3:** *The smaller the iris, the fewer bundles of light go through the lens, which, like the pinhole, creates more depth of field. The astronaut is dimmer, but now the spheres on either side of him are sharp because they are within the increased region of focus (depth of field) brought about by the small iris.*

f-number on a lens is obtained by dividing the focal length by the maximum diameter of a ray of light, which passes through the optical axis of the lens. So a 100 mm lens through which passes a beam of light 50 mm wide at its widest aperture is said to be an f/2. I mention this math in passing for those sticklers who need to know the exact origins of things. The important thing to remember about these f-numbers is that they are very useful as an indicator of exposure and depth of field. One of the first things I learned as a cameraman was my f-stop range: f/2, f/2.8, f/4, f/5.6, f/8, f/11, f/16, and f/22.

Each time the f-number goes higher in this range, the iris gets smaller and half the amount of light gets through the lens, thereby dimming the exposure and increasing the depth of field. So f/5.6 lets in half the amount of light of f/4, and f/8 lets in one-quarter the amount of light of f/4 and half the amount of light of f/5.6. According to an old joke about master cinematographers, at the bottom of their desk drawers is a little note that says "big number, little hole; small number, big hole." This, of course, refers to our friend the f-stop.

## The Modern Movie Lens

Unlike consumer cameras, whose lenses are bubbles of glass with a single unmarked ring around them, the professional hard lens has two clearly marked rings (Figure 1.4). One is the focus ring, with definite feet and inch as well as metric markings that indicate the point of sharp focus when measured from the cameras film plane (the point at which the image is focused on the film itself). On many professional cameras there is a marking or a convenient hook for connecting a tape measure so as to measure the exact focus. The other ring is the f-stop ring. Some ranges of f-stop go further than I indicated earlier, such as starting at f/1.4 or ending at f/32. A lens that has a large f-stop capability (small number) is known as a fast lens. Some pro lenses have t-stops, which are the same as f-stops except the markings are based on


**Figure 1.4:** *A consumer lens (left) and a professional lens (right).*

an exact measurement of light going through the lens as opposed to the physical iris measurement.

The zoom lens has a third ring that indicates the focal length. You might ask why we need single focal length lenses when a zoom lens will do everything. In the past, due to less glass used in hard lenses along with other factors, hard lenses were just plain sharper. With today's technology, that advantage is less of an argument. I find hard lenses handy for effects work because they lock down one of the many variables, namely, focal length. If you are doing a composite of a foreground with a background that is shot at a different time, it is the best policy to use the same focal length lens when shooting each element. It is much easier to achieve this match with a hard lens because its focal length is fixed. While a zoom lens can achieve the same result, its flexibility can be problematic in the confusion of production. You have to be right on top of the zoom lens during shooting to take note of exactly where the focal length was set in order to repeat that setting later. This is easier said than done on a busy set. If you are a notetaker or supervisor you might not get the chance to see the zoom setting before it is changed. When using a hard lens it is much easier to note the focal length since it is fixed.

Now that we've had a brief refresher course on the all-important lens, let's move on to the birth of visual effects.

## The Glass Shot

There were many great pioneers of the art of visual effects. One of the early giants was a fellow named Norman Dawn, who started working as a still photographer for the Thorpe Engraving Company in 1905. While there, a photoengraver named Max Handschiegl suggested to Dawn that he might remove an offending light pole in front of a building he was photographing by placing a small piece of glass between the camera and the pole and painting a tree on the glass to cover the pole. The trick worked like a charm. As far as the camera was concerned, because it had only one eye and no depth perception, the tree was a full-sized tree in the scene instead of a small painting on a piece of glass. You can see this basic trick for yourself by closing one eye and holding out your thumb and forefinger as if to crush an object in the distance (as if your hand were the hand of a giant). As long as you use one eye, the illusion of a giant hand is sustained. If you open both eyes, you can see that it is your normal-sized hand just a few feet in front of you. If you close one eye and then the other, you will see that the relationship between your fingers and the object changes from crushing position to a little to the side. This shift in position is due to the parallax displacement of the other eye. Since Dawn's still camera only had one eye and one position, the tree always obscured the pole and the "flat" picture that resulted did not divulge the truth. Later in his career Dawn used this same glass shot technique for motion pictures in a film he made called *California Missions*. In this case, the roofs of the missions he was photographing were sunken in and dilapidated. By painting a matte painting of a roof onto the glass in front of the camera, he made it look as if the missions were whole. The trick used two principles of visual effects photography: the single lens and a large depth of field. Having a large depth of field enabled Dawn to keep both the mission and the glass in focus.

Calculators and depth of field tables in books such as the *American Cinematographer Manual* or David Samuelson's *"Hands-On" Manual for Cinematographers* from Focal Press provide exact distances of the depth of field for each focal length and f-stop at a particular focus setting. These tables are invaluable to effects cinematographers planning projects such as a glass shot to ensure that all the elements (e.g., the matte painting and the mission) will be in focus. The typical depth of field table, as shown in Figure 1.5, has three main components: the f-stop listing at the top, the focus setting along the side, and the cross-reference for the near and far distances that will be in focus. Note that there are several rows of f-stop numbers from a variety of circle of confusion listings. The circle of confusion refers to the size of the tiny circles of light that a lens forms for each point of an image focused by the lens. The smaller the circle, the more exacting the measure of focus. You will notice that under f/2.8 in the top row, the f-stops progress by a stop for each tighter circle of confusion in order to maintain the same near far distance. For the majority of my work I choose the 1/500 inch circle of confusion. Cinematographers who have exacting demands for focus splits within a shot use the tighter tolerances. For the most part I shoot in-focus elements to be combined later in composite. Since I know that I will have the ability to sharpen or blur an element later in composite, I normally choose the larger circle of confusion for convenience. When I use this chart, I will go to my f-stop, let's say f/8 (in the top row), and go down to my focus position on the left of the chart, which might be 8 feet, and then read the box where those two rows intersect to come up with a near focus of 5 feet 9.7 inches and a far focus of 13 feet 3 inches. If my subject sits within these distances then I know it will be in focus. This distance is measured from the film plane.

## The Nodal Point

Another great discovery in visual effects technique was the use of the nodal point. If you return to the example of the giant hand crushing a distant object as you look through one eye, you can see that the illusion disappears as you turn your head. If you look through one eye and pivot your head about your neck (which simulates the pivot point for most cameras mounted on a tripod), you will see that your hand will appear to pull away from the object you were crushing. This is caused by a change in perspective: objects closer to the eye will appear to move away faster than objects farther away. This condition can be nullified, however, if you can pivot around the optical center of your eye. This will be a bit difficult at first, but try it by keeping your eye in the same place and rotating your head around your eye. You will notice that the relationship

## DEPTH OF FIELD

Feet and inches

# 50 mm

| Circle of confusion | | Aperture | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/500 in | | | | | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 |
| 1/710 in | | | | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 |
| 1/1000 in | | | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 | |
| 1/1420 in | | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 | | |
| 1/2000 in | | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 | | | |
| | | Hyperfocal distance | | | | | | | | | | |
| | | 323' | 230' | 161' | 115' | 80' | 57' | 40' 6" | 29' 6" | 20' 4" | 14' 10" | 10' 3" |
| Focus | | Extreme distances in acceptable focus | | | | | | | | | | |
| 3' 0" | Near | 2' 11.7" | 2' 11.6" | 2' 11.4" | 2' 11.2" | 2' 10.8" | 2' 10.4" | 2' 9.8" | 2' 9.0" | 2' 7.8" | 2' 6.5" | 2' 4.5" |
| | Far | 3' 0.3" | 3' 0.5" | 3' 0.7" | 3' 1.0" | 3' 1.4" | 3' 2.0" | 3' 2.9" | 3' 4.1" | 3' 6.3" | 3' 9.4" | 4' 3" |
| 3' 6" | Near | 3' 5.6" | 3' 5.4" | 3' 5.2" | 3' 4.9" | 3' 4.4" | 3' 3.8" | 3' 2.9" | 3' 1.9" | 3' 0.3" | 2' 10.6" | 2' 8.1" |
| | Far | 3' 6.5" | 3' 6.6" | 3' 6.9" | 3' 7.3" | 3' 7.9" | 3' 8.7" | 3' 10.0" | 3' 11.7" | 4' 2.9" | 4' 7" | 5' 4" |
| 4' | Near | 3' 11.5" | 3' 11.2" | 3' 10.9" | 3' 10.5" | 3' 9.9" | 3' 9.1" | 3' 8.0" | 3' 6.7" | 3' 4.6" | 3' 2.5" | 2' 11.3" |
| | Far | 4' 0.5" | 4' 0.8" | 4' 1.2" | 4' 1.7" | 4' 2.5" | 4' 3.6" | 4' 5.3" | 4' 7.6" | 5' 0" | 5' 6" | 6' 8" |
| 4' 6" | Near | 4' 5.3" | 4' 5.0" | 4' 4.6" | 4' 4.1" | 4' 3.3" | 4' 2.4" | 4' 1.0" | 3' 11.3" | 3' 8.8" | 3' 6.1" | 3' 2.4" |
| | Far | 4' 6.7" | 4' 7.1" | 4' 7.5" | 4' 8.2" | 4' 9.2" | 4' 10.6" | 5' 0.8" | 5' 3" | 5' 9" | 6' 6" | 8' 2" |
| 5' | Near | 4' 11.2" | 4' 10.8" | 4' 10.3" | 4' 9.7" | 4' 8.7" | 4' 7.5" | 4' 5.8" | 4' 3.8" | 4' 0.8" | 3' 9.6" | 3' 5.2" |
| | Far | 5' 0.9" | 5' 1.3" | 5' 1.9" | 5' 2.7" | 5' 4.0" | 5' 5.7" | 5' 8.5" | 6' 0" | 6' 8" | 7' 7" | 10' 0" |
| 5' 6" | Near | 5' 5.0" | 5' 4.6" | 5' 4.0" | 5' 3.2" | 5' 2.0" | 5' 0.6" | 4' 10.5" | 4' 8.2" | 4' 4.6" | 4' 0.9" | 3' 7.9" |
| | Far | 5' 7.0" | 5' 7.6" | 5' 8.3" | 5' 9.3" | 5' 10.8" | 6' 1.0" | 6' 4.5" | 6' 9" | 7' 7" | 8' 10" | 12' 3" |
| 6' | Near | 5' 10.8" | 5' 10.3" | 5' 9.6" | 5' 8.6" | 5' 7.3" | 5' 5.6" | 5' 3.2" | 5' 0.4" | 4' 8.3" | 4' 4.1" | 3' 10.3" |
| | Far | 6' 1.3" | 6' 1.9" | 6' 2.8" | 6' 4.0" | 6' 5.8" | 6' 8.4" | 7' 0" | 7' 6" | 8' 6" | 10' 2" | 15' 1" |
| 6' 6" | Near | 6' 4.6" | 6' 4.0" | 6' 3.1" | 6' 2.0" | 6' 0.5" | 5' 10.5" | 5' 7.7" | 5' 4.5" | 4' 11.8" | 4' 7.1" | 4' 0.7" |
| | Far | 6' 7.5" | 6' 8.3" | 6' 9.3" | 6' 10.7" | 7' 0.8" | 7' 3.9" | 7' 9" | 8' 4" | 9' 7" | 11' 9" | 18' 9" |
| 7' | Near | 6' 10.3" | 6' 9.6" | 6' 8.7" | 6' 7.4" | 6' 5.6" | 6' 3.3" | 6' 0.1" | 5' 8.5" | 5' 3.2" | 4' 9.9" | 4' 2.9" |
| | Far | 7' 1.7" | 7' 2.6" | 7' 3.8" | 7' 5.4" | 7' 8.0" | 7' 11.6" | 8' 5" | 9' 2" | 10' 9" | 13' 6" | 23' 8" |
| 8' | Near | 7' 9.8" | 7' 8.9" | 7' 7.6" | 7' 6.0" | 7' 3.7" | 7' 0.8" | 6' 8.7" | 6' 4.2" | 5' 9.7" | 5' 3.3" | 4' 6.9" |
| | Far | 8' 2.3" | 8' 3.5" | 8' 5.0" | 8' 7.2" | 8' 10.6" | 9' 3.5" | 9' 11" | 11' 0" | 13' 3" | 17' 9" | 41' 2" |
| 9' | Near | 8' 9.2" | 8' 8.1" | 8' 6.5" | 8' 4.5" | 8' 1.5" | 7' 9.9" | 7' 5.0" | 6' 11.5" | 6' 3.7" | 5' 8.2" | 4' 10.5" |
| | Far | 9' 2.9" | 9' 4.4" | 9' 6.4" | 9' 9.2" | 10' 1" | 10' 8" | 11' 7" | 13' 0" | 16' 4" | 23' 8" | 96" |
| 10' | Near | 9' 8.6" | 9' 7.2" | 9' 5.2" | 9' 2.7" | 8' 11.2" | 8' 6.8" | 8' 0.9" | 7' 6.4" | 6' 9.3" | 6' 0.6" | 5' 1" |
| | Far | 10' 3" | 10' 5" | 10' 7" | 10' 11" | 11' 5" | 12' 1" | 13' 3" | 15' 2" | 19' 11" | 32' 1" | INF |
| 12' | Near | 11' 7" | 11' 5" | 11' 2" | 10' 10" | 10' 5" | 9' 11.8" | 9' 3.8" | 8' 7.2" | 7' 7.5" | 6' 8.6" | 5' 7" |
| | Far | 12' 5" | 12' 7" | 12' 11" | 13' 4" | 14' 1" | 15' 2" | 17' 1" | 20' 4" | 29' 11" | 69' | INF |
| 15' | Near | 14' 4" | 14' 1" | 13' 9" | 13' 3" | 12' 8" | 11' 11" | 11' 0" | 10' 0" | 8' 8.6" | 7' 6" | 6' 2" |
| | Far | 15' 8" | 16' 0" | 16' 6" | 17' 3" | 18' 5" | 20' 3" | 23' 11" | 30' 10" | 59' | INF | INF |
| 20' | Near | 18' 10" | 18' 5" | 17' 10" | 17' 1" | 16' 1" | 14' 11" | 13' 5" | 12' 0" | 10' 2" | 8' 7" | 6' 10" |
| | Far | 21' 3" | 21' 10" | 22' 10" | 24' 2" | 26' 7" | 30' 8" | 39' 9" | 63' | >100' | INF | INF |
| 30' | Near | 27' 5" | 26' 7" | 25' 4" | 23' 10" | 21' 11" | 19' 9" | 17' 3" | 14' 11" | 12' 2" | 10' 0" | 7' 8" |
| | Far | 33' 0" | 34' 5" | 36' 10" | 40' 6" | 47' 9" | 62' | >100' | INF | INF | INF | INF |
| 40' | Near | 35' 7" | 34' 1" | 32' 1" | 29' 9" | 26' 10" | 23' 8" | 20' 2" | 17' 0" | 13' 6" | 10' 10" | 8' 2" |
| | Far | 45' | 48' | 53' | 61' | 79' | >100' | >100' | INF | INF | INF | INF |
| 50' | Near | 43' 4" | 41' 1" | 38' 2" | 34' 11" | 30' 11" | 26' 10" | 22' 5" | 18' 7" | 14' 6" | 11' 6" | 8' 6" |
| | Far | 59' | 63' | 72' | 88' | >100' | >100' | INF | INF | INF | INF | INF |
| 60' | Near | 50' | 47' 8" | 43' 9" | 39' 6" | 34' 6" | 29' 6" | 24' 3" | 19' 10" | 15' 3" | 11' 11" | 8' 9" |
| | Far | 73' | 81' | 95' | >100' | >100' | INF | INF | INF | INF | INF | INF |



**Figure 1.5:** *This is a typical depth of field table for a 50 mm lens. For my work, I usually choose the 1/500 inch circle of confusion.*

between your hand and the object stays the same aside from your inability to stay perfectly still (things will bobble a bit). What you have just done is pan about the nodal point, or the point at which the light rays converge, as if you panned around the center of your pinhole. When you do this, all elements (the hand and the object) stay locked together. This concept allows us to do simple moves on effects, such as the glass shot, without revealing the trick. Using these earliest of principles, we have the basic building blocks of visual effects. The great thing is that these principles are universal and can be used with stills, film, video, or digital—any medium that uses a lens.

## Drawbacks of the Glass Shot

The principle of the glass shot is easy enough to grasp, but in reality executing one is quite challenging and requires a good amount of artistic skill. One of the challenges facing the artist is changing light conditions. In order to obtain enough light for depth of field to come into play, you are usually shooting outdoors with a constantly moving sun. Painting is not a fast process, and each shadow that is painted will only match for that moment in time. Fortunately, most members of the audience will not notice that the shadows do not match exactly, as long as the direction and intensity are close. In my experience, you have a window of about 30 minutes to an hour to shoot the shot before the effect starts to give itself away. So if you paint a tree on the glass that casts a shadow toward the right and you rough it in at 9 a.m., by the time you finish detailing the tree it may be 1 p.m.—all the shadows will have moved directly underneath the real environment, but not in your painting. The solution to this problem would be to come back the next day and shoot the glass shot at 9 a.m. This situation demands that the camera and glass rig are carefully marked as to their position and reassembled exactly the same way the next day. If possible, the best practice is to create a "hot set" situation as is done on an effects stage and leave as much as possible in place to avoid constant realignment. In the case of an outdoor glass shot, I recommend leaving the glass frame and tripod at the location and removing only the camera and painting, as they are the most valuable items and can be put back in place in a repeatable manner.

Another approach that can be a more flexible solution is to build a three-dimensional model and use these same principles to create a foreground miniature shot. The beauty of using a model is that because it is a dimensional object, the shadows will always match because the sun will affect the model and the real environment in exactly the same way. Accordingly, there is no longer a need to hit the sweet spot time of day when the lighting matches the painting. The drawback to using a model is that it is limited by its very physicality. It is good for buildings and terrain alteration but doesn't have the flexibility of a matte painting. In other words, if you needed to remove a hill and replace it with a flat horizon with a stormy sky, the glass shot would be the technique of choice. Since it takes a great deal of practice and skill to become a good painter, let alone a matte painter, I will demonstrate the principles outlined here by showing how to create a foreground miniature that is simple to build, flexible (regarding shadows), and very forgiving. So, put on your artist's beret, and we will venture into the world of art and create and execute a foreground miniature composite using a home digital camera.

## Building and Shooting a Foreground Miniature

When we put on the artist's cap, we engage the other side of our brain and enter a "touchy-feely" realm. Even though there are formulas that artists use for perspective or determining composition, art is not easily summed up by an equation. Professional artists have a grounding in perspective, color theory, and composition and use it as a foundation for their work, but freely break rules on occasion because it just plain looks or feels right. Without formal training, the best way to learn is by observation. If you look at imagery and its details, you can fairly quickly pick out the falsehoods of a representational rendition, be it a painting or visual effect, by comparison with the real thing. With enough practice and skilled observation, you can come to the same conclusions as the skilled professional: if it looks right, it is right. It is advantageous for those pursuing visual effects photography to attend art classes and practice traditional art skills. You can progress faster by starting with pencil and paper than by starting with software. As the old saying goes, it takes a thousand drawings to get to the one good one. The sooner you get started on those thousand, the better off you'll be.

The greatest asset you can have when creating a piece of art (especially representational art, like the model we are about to build) is the ability to see and observe the real thing you are creating. Our model will be a miniature street with a crashed aircraft on the pavement. As you go about collecting your materials, take note of the various streets you use in your travels. What color is the asphalt? Does it have many cracks? Are there spots of tar and imperfections on the surface? What kind of painted markings does it have? Are the lines perfectly straight and even? Look at the street at different times of day, in soft light and in glare. If you look carefully, you will discover how wonderfully imperfect the real world is (as if we didn't know). The great mistake made by beginning model makers working traditionally or with computer graphics is that the models they build are far too perfect. They look like plastic toys and don't have the aging and wear and tear that exists in the real world. We won't fall into that trap. Let's move on to the gathering of some basic materials.

### Basic Model-Making Materials

There are many materials to choose from when building a model. Keep in mind that for the movies we need to use materials that are light, flexible, and easy to work with. Time is of the essence, and a model that is huge and unwieldy needs a bigger budget and many more people to deal with it. I have found that for the small, independent filmmaker, great starting materials for a model are foam board, hot glue, and water-based paint. Foam board consists of two pieces of art card sandwiching a core of Styrofoam. It is very light and sturdy and is easy to cut and paint, so we will use foam board to create our miniature street. The other component of our model is the crashed aircraft, and here we get into some happy imaginative shopping. In the professional world, models are painstakingly built to specific scales using exacting blueprints. For the purposes of this exercise, we will wing it. Go to your local hobby or craft store and peruse the plastic models aisle. You are about to engage in the practice of "kit bashing," a term used to describe the practice of cannibalizing commercially available toys or model kits to create unique miniatures for motion picture use. What does your fallen aircraft look like? For this example, I purchased an inexpensive plastic kit in order to obtain the ready-made shape of an airplane.

So, for your model you will need the following materials (Figure 1.6):

- A sheet of foam board (white), approximately 3 × 4 feet
- Hot glue and a hot glue gun (a robust model)
- Gray, black, and textured spray paint to create the base tone for the street
- Water-based black paint
- A selection of large and small paintbrushes and an old toothbrush
- A plastic airplane kit (preferably prepainted)
- A utility knife or X-Acto blade for cutting the foam board
- A Dremel or similar tool for cutting apart the plastic model

It is always a good idea to think backward when designing visual effects. In this case, we want to place the model in front of our camera and have it stay in focus. We also want to do a slight pan, so the model will have to be slightly bigger than what the camera will frame. Finally, we want to build the model so that it can be supported easily and so we won't have to worry about it when we go on location.


**Figure 1.6:** *Materials and tools for creating our foreground miniature.*

## Determining the Size of the Road

Without exhaustive preplanning we can determine focus and size fairly quickly by going outside in lighting conditions similar to those that will be used in our shoot and focusing on a yardstick using the widest angle possible on our consumer video camera. It would be very useful to get a friend to help you, as annoying problems frequently come up, such as your super light tripod blowing over as you're adjusting your yardstick or the necessity for an assistant to put high-contrast targets on the foreground and background so that you can focus. For this example, I had an assistant move the yardstick toward and away from the camera as I adjusted the focus in the eyepiece until a point was reached at which both the yardstick and the background seemed to be in focus at the same time. Since the quality of the video camera's eyepiece can be marginal, it is a good idea to shoot a short shot of the yardstick in what you think is the best position, which in this example is the point at which I see 15.5 inches of the yardstick. After you shoot this short test, play it back on a good television set to verify that both the stick and the background are in focus. If the yardstick is soft you may have to position farther back, where, for example, you might see 18 inches of the stick. You will be using your camera's manual focus setting. I recommend using the widest zoom setting, because wide-angle lenses have more depth of field than longer focal lengths. If I place the yardstick in front of my camera at the point where it and the background are in focus, the widest lens tells me that the front of my model takes up 15.5 inches in the front, and if I make the depth of my model road about 10 inches and move the yardstick 10 inches farther back, then the lens will see 19.5 inches of the stick at the far end. This is our horizontal field of view (Figure 1.7).

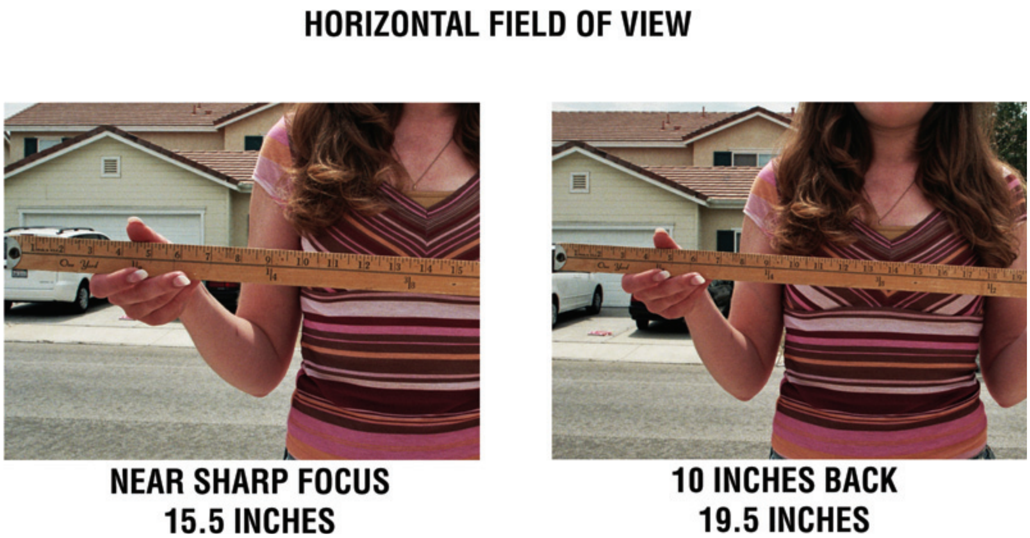


**Figure 1.7:** *Finding the horizontal field of view as a planning aid for building our model.*

So, using dead reckoning, which is an educated guess as to how our shot might unfold, we can figure that if we made our miniature street 28 inches long, we should have enough to cover our field of view and also allow for a limited pan without having our lens go off the edge of our model. We'll make the depth of our miniature about 20 inches to allow it to go out the bottom of the frame to ensure that we don't see the bottom edge of our model road. As for mounting, we'll use a small, sturdy workbench and attach the model to it using convenient spring clamps. I use this dead reckoning approach a great deal in my work, as my assignments often involve general ideas that need to be realized in a practical manner with the ability to accommodate change. In this case, by making the length of the street 28 inches long, a variety of pans could be accommodated before shooting off the end of the model.

## Painting

For our street we will start with the base color by painting the surface with a texture paint that matches the tone of the real street. There are many fabulous spray paints available today that can simulate sandstone, rock, and even chrome. Be sure to look at the sample texture painted on the cap of the can and make sure that the texture is tiny enough to scale in to the real road. Remember, our road is only 2 feet wide, whereas the real street is about 20 feet wide. If the texture is too course it will look as if our street has large boulders and furrows, so keep it subtle. In this case, after I sprayed the texture coat I let it dry and went over it with a wash of gray spray paint to tone down the texture a bit (Figure 1.8).

Next, take a utility knife and cut a jagged crater hole toward the center edge of your model street (Figure 1.9). Remember that we want to make sure that our depth of field


**Figure 1.8:** *Blending the texture paint and the gray paint makes a toned-down, irregular surface that better simulates a real road.*

**Figure 1.9:** *Cutting the crater hole. Remember to rough up the Styrofoam underneath to create a jagged texture.*

will keep both the model and the background in focus. Placing the crater at the far end of our model road (away from the camera) puts it into the "safe zone" for focus. What I consider the safe zone is anything that is farther back from the point at which the yardstick was in focus in the test. This ensures that the crater will be well within the sharp depth of field region. Make your crater very irregular and organic and save the leftover pieces to create a debris field. Cut jagged cracks emanating from the crater hole, remembering not to make anything uniform in appearance.

After cutting and sculpting the foam, we will take a mid-size brush and use black paint to accentuate the cracks and make uneven roadway stains. For this step I used an almost dry brush and the technique of pouncing, or pounding the brush very rapidly onto the surface to gently stipple in the tone so that it creates a natural feathering (Figure 1.10).

We can also use thicker black paint atop a toothbrush and spatter black dots to give the appearance of oil spills, etc. (Figure 1.11).

For our aircraft I roughly assembled the model kit and then artistically disintegrated it using a Dremel tool with a cutting wheel (Figure 1.12). Always wear goggles and a dust mask when working with power tools such as this, as it is very easy for small pieces to get away from you. When cutting the fuselage, I made sure that there was enough of a "profile" of the model so that it will be perceived as aircraft wreckage.

## Mounting the Model

The hot glue gun is a particularly effective tool for constructing movie models because it is fast, holds well, and can be changed instantly. For this model, I made sure to

**Figure 1.10:** *Pouncing the black paint into the crater.*

**Figure 1.11:** *The spatter technique.*

glue the model at the far side away from the camera so that the big globs of glue won't appear in the picture and give the trick away. The glue is extremely hot when it exits the gun and can be very painful should some land on your skin. As a precaution, I always keep a container of cool water nearby to dip my hand into should an accident occur (Figure 1.13).

## Aging

The final detail painting involves loosely pouncing in scuff and burn marks onto the fuselage (Figure 1.14). This model is extremely small, and the more you can break up the smooth surface of the model, the less it will look like a toy. Another trick is to spray on a film of dulling spray over the model. This mottles the surface and thus

**Figure 1.12:** *The model can be cut with a Dremel tool, hacksaw, or utility blade. Be sure to wear protective gear!*

**Figure 1.13:** *This glue is terrific, but extremely hot. Be careful and keep some cool water handy but far from electrical appliances.*

lessens the chance of getting a big smooth glare off the surface, which is also a dead giveaway that you are using a model. After the final detailing the model is ready for photography.

## Finding the Nodal Point

Finding the nodal point on any camera is a simple process of trial and error. The important step is to come up with a device that will allow you to slide the camera forward and backward in relationship to the pivot point of your tripod. For this exercise I used a small strip of metal with a hole for mounting it to the tripod and

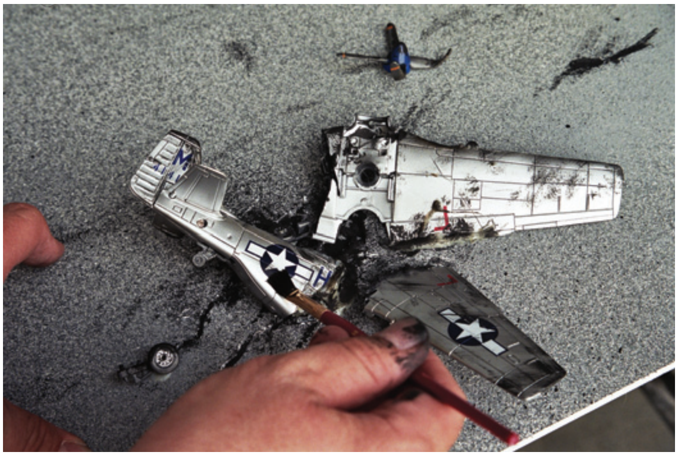

**Figure 1.14:** *The final aging of the model.*

**Figure 1.15:** *My nodal mount is a slotted strip of metal bolted to the tripod.*

a slot that allows me to mount the camera and slide it forward and back (Figure 1.15). This mounting device is not found in any store but can be either manufactured or repurposed from another application. I will leave this as a mild creative challenge to the reader, as it is part of the visual effects craft to make "gizmos." You know the objective (to make a movable camera mount); now run out to the hardware store and come up with something that will perform the task. To find the nodal point, position two posts in front of the camera so they appear to be next to each other. One post should be close to the camera and the other farther back. Position the camera so that the center of the lens is over the tripod head (this is a good starting point). Now pan the camera and see whether the posts move in relationship to each other (Figures 1.16–1.19).

**Figure 1.16:** *My camera is bolted so that it can slide forward and backward in the slot toward and away from the center of rotation of the tripod. The camera was positioned so that the center of the lens is atop the pivot point of the tripod. This is a good starting position for finding the nodal point.*

**Figure 1.17:** *A setup for adjusting to nodal point. To find the nodal point, position a vertical pipe close to the camera almost in alignment with a light pole in the distance. Set the zoom to the widest focal length. Pan the camera and take note of the gap between the poles. If the gap opens and closes as you pan, you are not on nodal.*


**Figure 1.18:** *If objects move toward and away from each other when panning, you are not on nodal.*


**Figure 1.19:** *The lens is on nodal when all objects stay in the same relationship to each other when panning.*

If not on nodal, move the camera forward or back slightly, lock it down, and pan again. You will have achieved nodal point when there is no change in the gap between the poles. Remember that each focal length will have a separate nodal position because the optical center of the lens changes as you adjust the focal length. For this shot, always keep the lens at the widest position so you have a repeatable situation. In other words, if you achieve nodal at your test site at the wide position, it will still hold true when you move the camera nodal rig and position it for the model as long as you have locked down the camera and use the widest lens setting. Once you reposition the camera on the miniature, you can double-check the nodal position by panning on the model. If there is any "slide," you can make last-minute adjustments before executing the shot. Note that this setup only allows you to pan on the nodal. A tilt on nodal would require a much more elaborate rig. A professional nodal rig is shown in Figure 8.4.

## The Composite

Set up a table facing the street and mount your model to it. Position the camera with its nodal point mount at the same distance from the model that you had from the

**Figure 1.20:** *The back of the model road is aligned with the curb of the opposite sidewalk. Note that while panning, the relationship between the tail of the plane and the tree stays locked. The foreground miniature is an extremely simple and effective effect that can work in a wide range of lighting conditions. By using dead reckoning we have been able to execute a shot that is usually preplanned on the drawing board using horizontal and vertical lens angles to determine field of view. Professional motion picture lenses have many tables that indicate field of view and depth of field that enable you to preplan a shot like this before any construction. Typically, art directors and designers will map out a top and side view of the setup and be able to indicate the exact position of camera and model in relationship with the full-sized set. We will examine this preplanning method in more detail in Chapter 9.*

yardstick you viewed earlier. In this case, if you set the yardstick on the miniature road just in front of the crater you should see 15.5 inches when the camera is set at the widest zoom setting. This will ensure that everything from the yardstick back (including the model) will be in focus. Move the camera up and down and adjust tilt until the back of the miniature road aligns with the bottom of the curb on the opposite sidewalk (Figure 1.20). The front of the road should go out the bottom of frame. This alignment of street and curb will be our convenient "split line," or the place where the two elements join. This example is known as a "hard split," which is usually difficult to hide, but since the roadway is so different in tone from the curb we buy it as a logical transition and the join works well. Set the camera to manual focus and adjust so that both the model and the background are in focus. Turn off the auto focus to avoid any unwanted changes in focus as you pan the camera. Position the actors on the opposite sidewalk and have them react to the model aircraft as if it were full size. Pan with them as they walk down the sidewalk and have the wreckage come into view. As you can see, this is an extremely effective visual effect, as the shadows always match the background and we have the ability to move the camera.

Experiment with having your performers point at the plane and observe what looks right in the camera. The line of sight of the actors looking at the effect element (the wreck) is known as the "eye line" and needs to be preserved when shooting elements separately. Sometimes the eye line may be peculiar, as the line of sight might not necessarily be directed at the model. The quickest way to check this is to have the performer point at the model. If his or her arm seems to point at the model in the camera eyepiece, then the eye line is correct. If the actor's arm seems to be pointing away from the model, have him or her choose another object to point to that seems

**Figure 1.21:** *Side view of the foreground miniature setup. The two boxes below the workbench were used to level the miniature road since I was on a slanted driveway. Note the spring clamps attaching the foam board to the wooden table, ensuring that the surface was flat and yet easily adjustable. The dotted line indicates the split line between the two elements. The white card was only used for this illustration as a background to show the placement of the video camera.*

**Figure 1.22:** *A wider view of our foreground miniature.*

to correspond to the model in the eyepiece. In the performance, the actor should react to this other object, having it represent the model.

Remember that the foreground miniature effect only works for a fixed focal length. If you were to zoom in during the shot, the model and background would begin to pull away from each other, so you must always leave the lens at one focal length. This simple technique can create some truly wonderful results (Figure 1.22). The important thing to remember from this exercise is that the majority of visual effects boil down to very simple ideas. When elements are shot separately, it is the best policy to shoot each element as if it were part of a single "in camera" composite such as this one. The image elements will combine perfectly if we take care to use the same focal length, focus setting, f-stop, lighting, and camera position (station point) for each element. If, for example, we shot our background in side lighting with a wide-angle lens and then shot the model in front of a blue screen with a long focal length lens with lighting coming from the top, there would be no way to get those two elements to "marry up" and look convincing. This is why grabbing an image from a totally unrelated shot to stick in to another shot is a generally bad idea that rarely looks correct.

In the next chapter, we will examine how effects became more efficient by moving away from on-set in camera techniques to a system that transferred much more of the work to the controlled environment of the studio.

# Chapter 2

## The Fabulous Art of Matte Painting

A great development in visual effects was the latent image matte process. This technique involves the use of mattes to selectively obscure a portion of the frame, enabling this unexposed section to contain a new element shot at a later time. The ability to spread out the task of compositing elements over time was a vast improvement over the foreground miniature and glass shots, in which everything had to work all at once. The idea behind this technique is that photographic film does not "expose black," unlike video, which actually records a zero component, or black. If a black silhouette is photographed using motion picture film, the emulsion regards that area just as it would a darkroom. The film in that area remains unexposed and can still react to light at a later time unless processed. This black silhouette is known as a matte. If two exposures are recorded atop each other on film, a double exposure or superimposition results in which light areas overtake darker areas, two lighter images combine to form an even brighter area, and two black images leave the film dark where they overlap. This superimposition effect is good for ghost effects or atmospheric haze. If, however, a piece of art (a matte) is created that obscures a portion of the image in front of the camera lens (the sky, for example), the ground plane can be shot then the film wound back, and by using a countermatte the unexposed sky area could be exposed (to a painting of a sky) while protecting the previously exposed ground plane. If the join between the matte and countermatte is done skillfully, a convincing composite results in which both photographic "elements" combine seamlessly. These mattes are known by many names: male and female, hold-out and burn-in, cover matte, etc. The terms hold-out and burn-in relating to specific elements are the best way of describing the breakdown of the shot. For example, "lessen the density of the fire's hold-out matte" refers to a black shadow image of the fire "holding out" the background image and how opaque the fire matte was to light. Mattes can obscure either 100% of the light they are holding back or merely a percentage. No matte at all would lead to the superimposition effect, whereas a 50% density would let half the amount of light through leading to a slightly transparent element, which is good for effects such as fire and smoke that by nature are slightly transparent. Even though digital cameras can't re-expose on a second pass like film cameras, they still make use of mattes in postprocessing operations.

In digital, the matte is referred to as an alpha channel or key. The alpha channel is used as an elaborate switch in software to determine which image gets turned on and which gets turned off or how much of an image gets blended with another, such as when a foreground is composited over a background. There are several methods for producing an alpha channel. Three of the most common are the drawn or rotoscope method, in which the matte is made by hand; a color difference key known as green screen and blue screen, in which the matte is derived from the difference in color between the subject and the colored screen; and the ever-popular luminance key, in which the matte is obtained from the brightness values of the subject. In the case of the flame example in Figure 2.3, the brightest part of the image creates the most density. When using film, printing the color negative onto high-contrast black-and-white film creates a luminance record. The resulting matte is clear in the area that was black and has a variety of densities in the flame area. If this matte were placed over a print of a background element in order to rephotograph the image, the matte would dim the exposure of the background in the areas where it has density. On a second pass, the flame against black would be exposed, allowing its image to come through at a variety of exposures from 100% (the white part of the flame) to a partial exposure when the flame is orange. To merely superimpose the flame, the background would be photographed without a matte and then the film re-exposed to the flame on black. The black prevents re-exposure of the background in that area and allows the flame to double-expose over the background. In digital, the same effect is achieved by blending both elements over each other using a "screen" method. In this case the software analyzes the brightness values of both images and does an add mix of the values to re-create the superimposition effect as used in film. You can view this effect in Photoshop by creating two image layers and blending them using the screen option.

## Preserving Image Integrity

The great advantage of in-camera shots and the latent image technique is that the new element is photographed on the exact same film as the live action element. There is no duplication required to juxtapose the two elements, and so there is no image degradation, which was a huge challenge in the photochemical process. The problem could be likened to making a copy on a photocopier, then copying the result yet


**Figure 2.1:** *The double-exposure or superimposition effect. This is one of the rare cases in which mismatched lighting can be tolerated in an effect. For example, evil spirits always seem to be lit from below as if from the fires of hell. In this example, in the first exposure, the actor closed the door, looking at nothing. In the second exposure, all the lights in the room were turned off, and the actress walked through the open door into the rays of light beaming up from the floor. The area behind her was a sheet of black velvet. The bottom picture shows the effect of the double-exposure. Note the effect upon the actor's hand when the "ghost" passes over it. Areas that are black on the ghost take on the color of the door, while lighter areas overpower the tone of the door.*

again. Each time you make a copy of a copy, the image gains in contrast and loses detail. A cardinal rule in effects is to have each shot look like the one before it so that the imagery doesn't "bump." The duplication problems were so severe in the 1950s that many films, such as *Forbidden Planet*, would duplicate the film only during transitional effects such as dissolves and then would cut back to the original negative. In the dissolves that appear throughout that film, the shot changes from regular quality to poor quality just as the dissolve takes place; as soon as the event ends, the incoming shot changes back to regular quality.


**Figure 2.2:** *A split-screen composite using mattes. The top image shows the first exposure: the actress with the right side of the frame obscured by a matte. The film is wound back to the start, and the next image is of the actress on the other side of the screen with a countermatte that prevents re-exposure of the first pass. This second exposure is combined with the first to create the final composite in the bottom picture. The mattes had out-of-focus edges that allowed for what is called a "soft" split.*

While the latent image technique involves no duplication, it does require great skill and fortitude since the effects person must work with the original negative. One mistake, and the priceless negative is altered for good. Needless to say, the methods had to be well thought out and foolproof. I was fortunate to work with Albert Whitlock, Bill Taylor, and Syd Dutton at Illusion Arts, where the age-old tradition of latent image matte paintings was still practiced well into the last decade of the twentieth century. What follows is a step-by-step outline of how this brilliant system was utilized by Illusion Arts.

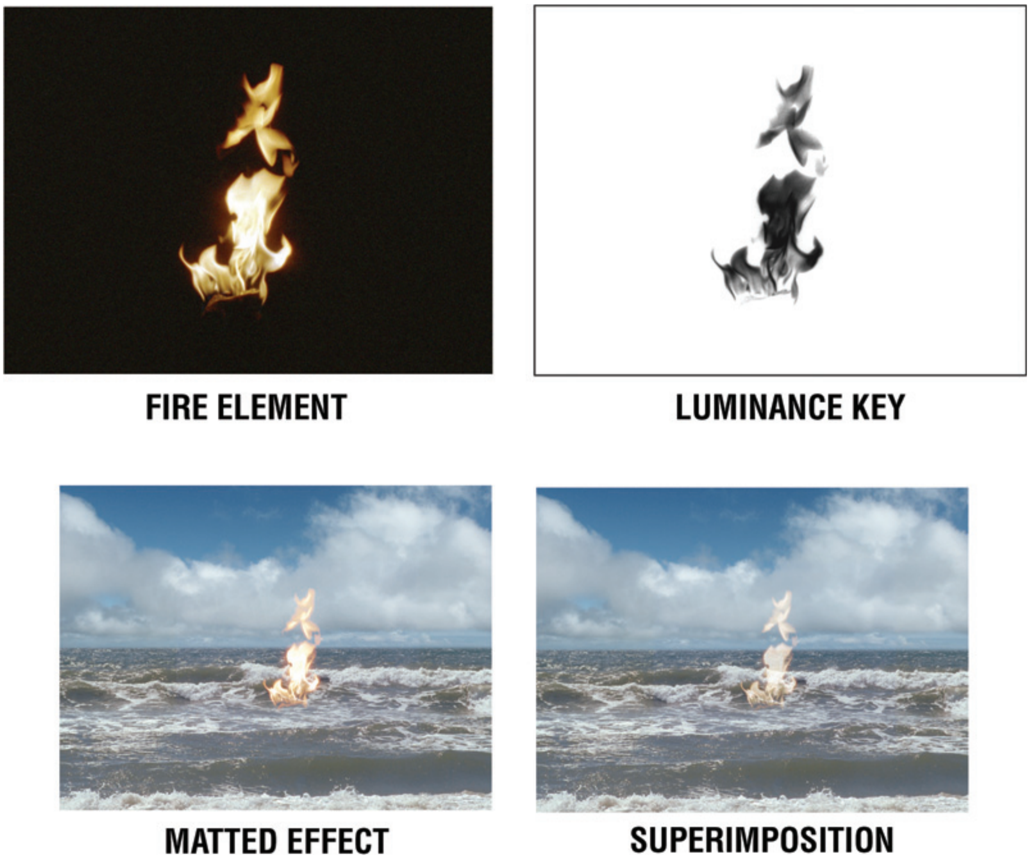


**Figure 2.3:** *An example of pulling a luminance key off of a fire element yielding a partial density matte. A luminance key creates a matte based on the brightness of the image. The hottest part of the fire creates a dense matte, the colored edge of the flame creates a partial density, and the black surround has no brightness so it becomes clear. Using a matte to composite the fire over the ocean gives the fire more "presence." Superimposing the fire using just the element and the digital "screen" blend creates a transparent, ethereal fire.*

## Previsualization

Long before Photoshop, matte painters were held in high esteem and valued for their contribution to realizing the exotic locations of a movie. To start this process, the director and producer came to the shop with a script and an idea, such as having their character go to Dracula's castle. After discussing with the director the feel of the type of castle he or she had in mind, the matte artist usually drew two pre-production sketches on butcher paper, one sketch reflecting one artistic direction (for example, a low, squat castle with broken battlements), the other reflecting a different approach (a tall, Gothic castle with spires rising to a stormy sky). The client often chose elements from both sketches, and so a third composite sketch was then made to confirm the final look.

**Figure 2.4:** *A rough previsualization sketch. Courtesy of Illusion Arts.*

This procedure was a wonderful way to involve the client and lock in a direction. One unfortunate drawback of the digital world is that everyone is empowered by paint programs and thus fancies themselves as artists. Instead of narrowing down the possibilities for the look, this empowerment often leads to an ever-expanding vision. The challenge for today's effects artist is to rein in the temptation to throw everything into a shot just because it can be done. The matte painter's sketches hold together with the simple integrity of a painting with a single vision. When everything gets thrown into a shot via committee, it reads false. The time-tested question to ask is "What is the shot about?"

## The Scout

In many instances, the painter went to the location ahead of time with the production personnel to plan where to place the camera, work out the time of the shoot, and decide whether special platforms need to be built and how much time to allow for that construction. The type of film, the format, and any special considerations such as blue screen foreground were worked out at this stage.

## Preparation

The day before the shoot, the camera gear was set aside for pick up and the batteries were charged overnight. The camera package was owned by the visual effects facility, thereby eliminating the unpredictability of camera rental. Since the shots were original negatives, the camera had to have good registration (a steady image) and good flange focal distance (all lenses were sharp), and camera speed was checked by tachometer (absolute 24 frames per second). Owning the camera allowed the operator to periodically shoot steady tests and focus tests to ensure that the camera was a reliable instrument.

Further preparation included redundancy. Batteries and motors occasionally fail on location so two of each of those items were always included. The specialized gear consisted of a very sturdy tripod or wooden platform that enabled the camera to be "locked down." In the latent image technique, unlike the foreground miniature shot outlined earlier, the camera could not move. If moves were needed, they were added later using duplication techniques. A special frame was built to allow for the construction of a matte in front of the camera lens. This frame was a super large matte box that placed a matte about 2 feet in front of the lens to obtain a slightly soft edge. The main camera package consisted of the following:

- Camera, typically a Mitchell Fries, which was capable of multiple camera speeds and had a through-the-lens viewfinder with a place to insert a viewing clip (more on this later)
- Two camera magazines
- Two sets of batteries
- Sturdy tripod
- A lockable tripod pan and tilt head
- Special matte frame
- Set of camera lenses: 18 mm, 24 mm, 32 mm, 50 mm, 85 mm with filters

**Figure 2.5:** *The Mitchell Fries camera. Courtesy of Illusion Arts.*

**Figure 2.6:** *It some cases it was necessary to build steady platforms for the camera. This structure built by master grip Larry Shuler shows the typical opposing strut design that takes all movement out of the tower. Courtesy of Illusion Arts.*

- Black matte card and black duvateen fabric for creating the matte
- AKS kit
- A wheeled transportation cart to carry the items

The AKS kit contained any number of extraneous items that might be needed on location, such as clothespins, camera tape, duct tape, sticks of wood, razor blades, C-clamps, screws, bolts, a canvas bag, rope for lifting equipment up to high platforms, and a battery-powered drill. This gave rise to the name AKS, which stands for all kinds of stuff.

## Camera Bag

The personal camera bag of the operator was very important as well. Mine contained the following items:

- A light meter (incident and spot) plus mini gray card (more on this later)
- A tape measure and inclinometer (to measure distance and angle of the camera)

- A note pad
- Extra film cores and black bags (a film core is the plastic hub that raw stock is wrapped around)
- Pens, pencil, grease pencil, dry erase marker, and portable slate
- Leather gloves (for handling hot lights)
- Clothespins, C-clamps, spring clamps
- A hat, sunscreen, sunglasses, salt tablets, and aspirin (there are many times when you are not briefed as to where you are going, and you don't want to be taken to the middle of the desert without these items)
- *American Cinematographer's Manual*
- Mini tool kit (screwdrivers, etc.) scissors, flashlight, dust mask
- Lens cleaner, cloth, canned air

## The Shoot

On a typical shoot day I arrived at perhaps 5:30 a.m. to wait for the production truck to load our equipment and the crew and take us to the location. Upon arrival, we contacted the unit production manager to get our bearings and to find our set-up location. If time permitted, the crew grabbed coffee and a bit of breakfast before getting down to business. After the meal, the crew set up the tripod and camera, ensuring that the camera was level horizontally and would be fine-tuned to the matte painter and director's wishes. Matte painting shots are usually establishing shots that are wide angle views. We typically used an 18 mm lens. Once the composition was finalized, the crew began to construct the matte on the big matte frame. Usually this was a two-person operation: the painter looked through the camera and gave commands to the grip and operator to raise or lower the black card on the frame to coincide with the area in which the painting would go. The matte would be subtly shaped to create an uneven matte line that would disguise any obvious split. After the matte was created, the frame was blacked in using black cloth extending to the camera to ensure that no stray light contaminated the black area. During this preparation phase, the film magazines were taken to the production camera truck and loaded with the raw stock set aside by the Director of Photography to execute the shot. This step ensured that the composite was made on the same stock that the cinematographer chose to shoot the movie on. This guaranteed a consistent look to thephotography. The exposure setting was usually given by the Director of Photography to further match the filmmaker's intent.

## Shoot Procedure

Before threading the camera the gate was removed and cleaned. The gate is the smooth metal runway with an aperture window cut out of it that the film would ride against as it moved through the camera. After cleaning, the gate was put back, the film was threaded, and a short 20-foot burst of film was run through the camera.

**Figure 2.7:** *A shot of a matte frame with a black card matte in front of the camera. Matte painter Mark Whitlock is standing next to the rig. Mark and I were sent to an extinct volcano in Hawaii to shoot this plate. The funny thing was that much of the background wound up being matted out, as can be seen on the matte box. We replaced so much of the background with a painting that the matte shot could have been done in Burbank. I didn't mind the trip to Hawaii, though. Courtesy of Illusion Arts.*

**Figure 2.8:** *The background plate with the matte in place. Courtesy of Illusion Arts.*

This test run was removed from the take-up magazine and both sides were examined for scratches or damage. After the determination that the camera was functioning well, the film was "seated" against the aperture in its exposure position and a white grease pencil mark was made on the film along the straight edge of the camera gate. This mark indicated the frame line position on the raw stock.

A tiny side notch was also cut out of the edge of the film as a guide for start and stop points when winding back the film in the dark.

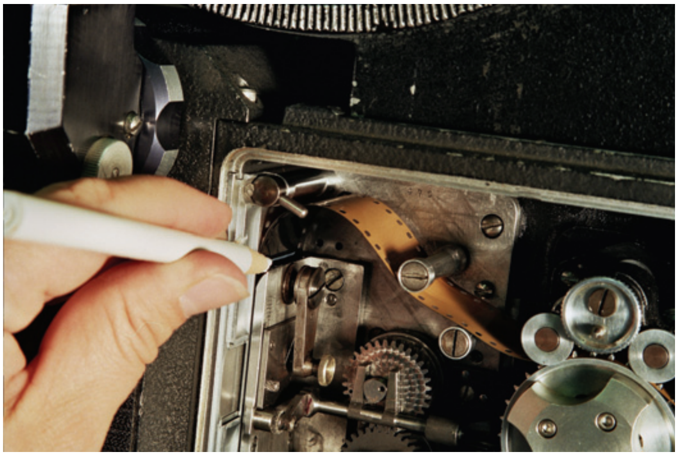

**Figure 2.9:** *Marking the frame line.*

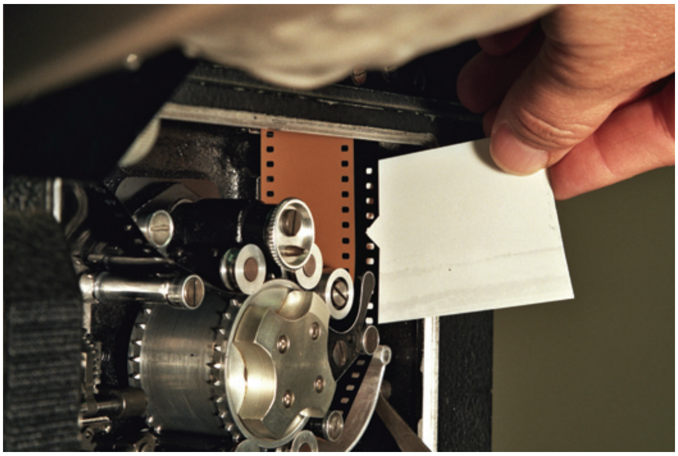

**Figure 2.10:** *Notching the film for take identification.*

After the camera was set, the camera height, tilt angle, lens, focus, light direction, f-stop, and any other possibly helpful information were recorded to be able to recreate the camera setup later should it be necessary. After this was done, all that remained was to wait for the actors and director to take their places. When the actors and director arrived, the effects camera was ready to roll.

The shoot order was as follows:

- Shoot take one, including about 20 feet of preroll before action, noting footage and the director's comments, such as "That was great" or "So-so." This helped rate the takes. After each take, the camera door was opened, the film was seated, and a grease pencil line and notch in the film were made.

- Shoot take two and repeat the above steps.
- Shoot take three and repeat until the director was satisfied.

After the required number of takes was shot, a 400 foot run of test footage was photographed. The test footage does not require actors; only the background scenery is needed. This footage will be used to develop and test the painting, thereby preserving the precious takes for the final composites. After this shot we again put in a grease pencil mark and a notch.

The final element to shoot was a small bit of footage to send to the lab for processing to check the exposure and provide imagery to begin the painting process. First a burst of film was shot with the matte, then the matte was removed and a burst was shot without the matte. Finally the camera tilt was brought back to level and a burst of level camera was shot. The camera was then broken down and both the camera package crew and film were taken back to the effects studio.

## Darkroom Procedure

When back at the studio, the film magazine was taken to the darkroom and placed next to a pair of film rewinds. A number of prepared cans, labels, and black bags were set aside to contain all the takes, the test footage, and the "with and without/level camera" exposure. If it was a dry day we ensured that the room was humidified, and we were prepared to wind back the film slowly, as quickly winding film creates static electricity and spark exposures on the partially exposed film. With the lights out, I began winding the film taken out of the take-up magazine onto film cores, tail to head, feeling the edges of the film for the notches that I made during the shoot. At each notch I broke the film and put that roll into the appropriate can. I repeated this process until I filled each can, then turned on the lights after ensuring that the cans were taped securely. I double-checked my notes with the number of cans and the amount of film. The 400 foot test footage will always be the heaviest can. I then sent the with and without/level camera roll to the lab for developing and printing. The other cans were placed in the freezer to arrest any chemical change the film undergoes after exposure. Some films allow latent exposures to redden with time, even before development, if left out at room temperature.

## Studio Procedure

When the "with and without" film was picked up from the lab, it was examined to ensure that it was exposed properly and the image was in focus. In this way the artist can catch a problem before the first brush stroke is committed. The negative of this footage was placed in the matte camera, which is a very sturdy "locked-down" effects camera that points at a large easel that accommodates front and back lighting. The

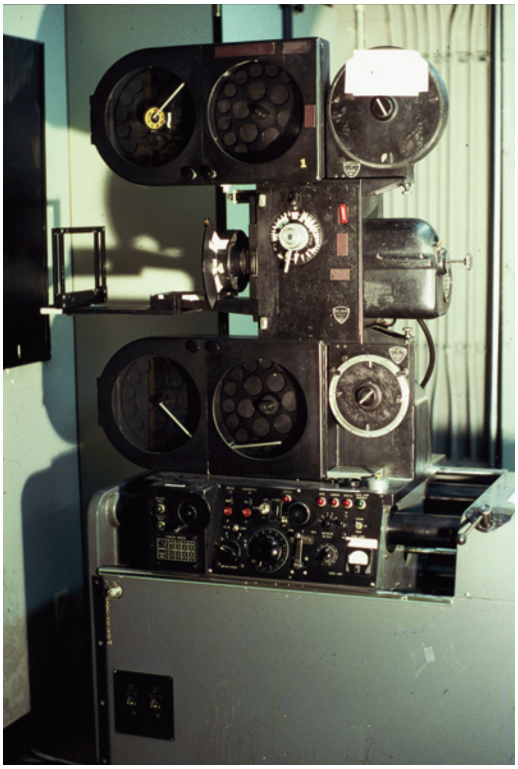

**Figure 2.11:** *The studio matte camera used for shooting the painting. This special camera could also be converted into a projector, allowing previously shot imagery to be traced onto the painting surface. This tracing process is called rotoscoping. Courtesy of Illusion Arts.*

camera is unique in that it also serves as a projector, allowing the live action element to be imaged onto the painting surface for tracing purposes.

A large fiberboard sheet with frame was placed in the easel against a repeatable "pin stop" to ensure that the painting could be returned to the same place for each effects shoot. The process of projecting the negative onto the easel and tracing is called rotoscoping and is used in both traditional and digital techniques. Essentially, it is the hand drawing of mattes derived from previously shot footage either by projection or by drawing on a computer. The matte line was traced along with a brief sketch of the live action element. A reference was taken of the middle of the frame of the level camera negative and then transferred to the shot angle and drawn out as the horizon. When a picture is taken at level camera, the horizon line will always be center frame. To illustrate the importance of level camera, I'll set aside the current example from Figure 2.8 and move to an illustration of a house extension and sky replacement painting.


**Figure 2.12:** *By going to the level camera clip and bisecting the frame, the horizon line can be determined. Note how the vanishing point for the edges of the window is at the horizon line.*


**Figure 2.13:** *Finding the reference point for the horizon and getting a rough estimate of camera height. The actress was approximately 5.5 feet tall; if she was stacked on top of herself until her stacked figures reached the horizon and the figures were counted, it could be seen that the camera was located 5.5 feet/figure × 3.5 figures = 19.25 feet above the point where the actress was standing.*

Figure 2.12 is a shot taken at level camera. Lines drawn from each corner of the frame intersect at the center, showing exactly where the horizon is. You can see how important the establishing of the horizon is by projecting lines from the window frames on the building at the right. The projected lines meet at the vanishing point, which rests upon the horizon. These vanishing points are very handy in order to keep paintings of buildings in the correct perspective.

The blowup of the picture in Figure 2.13 shows a convenient reference point where the horizon line intersected an object, in this case, the top of a window frame. We


**Figure 2.14:** *A cloud replacement and set extension making use of the vanishing point.*

used this information to transfer the horizon line to its proper position on the actual frame, which had a tilt. Another benefit of shooting level camera is that the approximate height of the camera can be found. In this case I was shooting from a hill looking down. I had the actress stand next to the light pole as a reference. In Photoshop I cut and pasted her on top of herself to use her as an organic measuring device. Since she was about 5.5 feet tall, I got a fairly good idea of the camera height by counting the figures. Obtaining the camera height by picture analysis is handy should you need to shoot another element that needs to fit into this photograph. In this case it would have been difficult to measure the height on location, as I was on a gently sloping hill instead of a tall platform.

Figure 2.14 shows the actual shot. We transferred the horizon line to the proper position on this photograph and used it as a guide for drawing perspective lines. This ensured that our set extension diminished in perspective accurately. In this case the painting was a clone of the building at the right, but there was more to it than a straight copy. The clone had to be scaled in size and the roof rotated so that it fell within those all-important perspective lines. One of the many skills a good matte painter must master is matching perspective. Correct perspective is a critical component of a believable matte painting. I'll now return to the traditional example.

## The Painting

After the guidelines were drawn on the surface, the artist roughly blocked in the sky and earth tones and painted the countermatte using shiny black paint below the split line. Shiny black paint is used because highly reflective surfaces tend to send the light away from the surface in the opposite direction and away from the taking lens. Flat paint tends to diffuse the light and show up as a dark tone, thereby contaminating

**Figure 2.15:** *First blocking in of a painting. Courtesy of Illusion Arts.*

the previously exposed live action element. The basic procedure for creating a matte painting is to go from rough to detailed. It is a process of constant refinement. When the first rough in of the painting was done, it went in front of the matte camera to shoot the first exposure test.

## Exposure Wedges

The painting was placed in a holder and lit by eight lightbulbs at the top and eight at the bottom that were run at a voltage of 90 volts. The reason for this was twofold. Shooting with 16 lights was a redundancy scheme that precluded lightbulb failure from ruining an original negative shot. If a composite was done with two lights on either side of a painting and one light blew out during the exposure of the latent film, the error would be irreversible. If one bulb out of 16 failed, the subtle dimming would likely not be noticed. Running the bulbs at 90 volts instead of the customary 110 volts was a cost-saving measure that greatly extended the life of the bulbs. The bulbs were also switched on and off instead of being slowly brought up to full brightness via a dimmer. The sudden shock to a bulb when it is instantly turned on tends to cause it to fail at that moment, which is better than having it fail while the camera is shooting. Another fail-safe idea.

Since the bulbs ran at 90 volts, their color was a bit warmer than normal (more on this later). As a result, colored filters were used to bring them back to the correct color needed for the film to see the light as white. The focus and f-stop on the lens were fixed, and a combination of color filters and neutral density (gray) filters for controlling exposure were used to create what is called a "wedge." A wedge is a short color test in which each frame of film is exposed with a unique combination of exposure and color. For fine-tuning the exposure, the camera shutter was used to

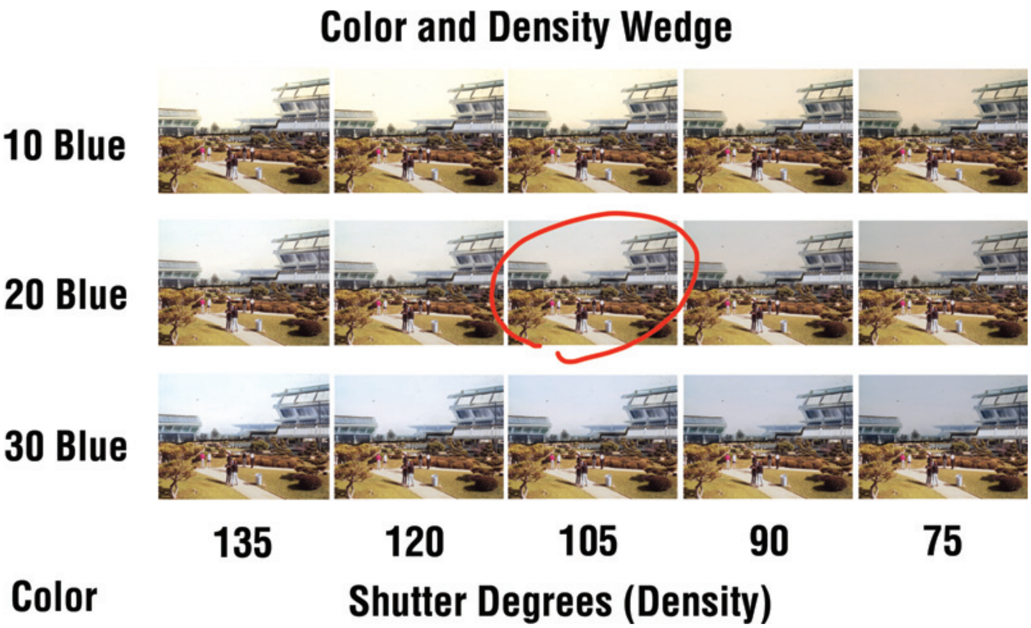


**Figure 2.16:** *In this wedge, only the painting changes color and density. An instant composite is obtained because the painting is being photographed on top of the previously exposed live action. The black paint in the live action area of the painting prevents re-exposure of that portion of the film. The circled frame indicates the exposure that reproduces the matte painting exactly, in this case 20 blue at a 105 degree shutter angle.*

shorten the exposure times in very small increments, such as 170, 150, 135, 120, 105, 90, 75, 65, 58, and 50 degrees. Using the camera shutter in this manner lessened the need for putting any more filters into the light path than were necessary. A neutral density filter could be eliminated if the proper exposure could be arrived at from f-stop and shutter. The idea was to hit the correct exposure in the middle of the wedge at around 105 degrees. With each wedge the artist would be able to see the painting brighter and darker, which gave insight into what the tones were doing as the painting was being created.

To start, the test footage was threaded into the matte camera and the grease pencil line was used to ensure that it was threaded on the frame line. A short burst of the painting was shot, perhaps 2 feet, and the camera room was then turned into a darkroom and the short test piece was removed and quickly processed using a dip test method. The dip test consisted of dunking the film into developer for about a minute and then removing it to a fixing bath to "fix," or keep the processed image from fading. After processing, the dip test was examined in the light to make sure that the camera was threaded on the frame line and that the painting was exposing over the proper area of the film. To cut down on the amount of waste, the exposed film was allowed to pile up inside the camera body instead of being threaded into the magazine take-up chamber.

A typical wedge was based on a guess exposure derived from the sensitivity of the film ISO and the amount of light used. When the dip test was approved, a slate was photographed for 1 foot and 14 frames. There are 16 frames or pictures in 35 mm film, which left two frames before the 2 foot mark to leave blank (in the painting area) to act as a visual separation before the wedge. The first wedge consisted of putting a 10 blue filter behind the lens using a convenient slot and shooting one frame for each of the shutter positions mentioned earlier. One frame of black was shot as a separation, then the 10 blue was replaced with a 10 blue (10b) plus 10 cyan (10c) filter and the shutter range was shot again. Following this, 20b, then 20b 10c, then 20b 20c were wedged in that order. After the wedges, a 2 foot burst at the guess exposure was shot as a "normal." When the wedges were finished, all lights were turned off in the camera room and the shooting port through which the camera viewed the painting was closed to allow the camera to be downloaded without fogging the film. Since there was only 400 feet of test footage, as little film as possible needed to be used for each wedge. The customary 2 feet on either end was a safe zone to allow for handling in the film lab. Typically each wedge was only 5 feet in length. This short amount was awkward for labs accustomed to thousands of feet of film, but they were accommodating. The wedge was canned up and sent to the lab for development with a called light print. A called light print is one for which the lab is given three specific numbers for the amount of red, green, and blue light to use when making the print. These three numbers are established via a variety of tests and then are locked as a way to avoid having the lab make a "timed" print, where they determine the color of the lights used to make the print. The camera report typically indicated "Develop as normal; make one print at red 23, green 22, blue 20 on printer C5." Specifying the printer to be used also limited the variables and allowed the artist to have full control. Two prints made with the same lights on different printers can be slightly different, so that possibility was eliminated.

## Dailies

The next day the negative and print were delivered to the shop and the print was examined on a color correct light box for evaluation. The painting was placed on the artist's easel, which was also illuminated, by color correct light or a sky light if available. The objective was to look at the film and the painting and pick an exposure and color combination that made the film reproduce the painting accurately. This gave the matte artist full control of the image. An exposure was picked, such as 20 blue at 105 degree shutter. This frame was marked and used by the artist as a reference when starting to develop the painting. After the painting was roughed in further, another wedge was done that held the 20 blue filter and varied only the exposure. We had then locked down another variable and were only dealing with exposure and the painting itself. Each day the painting was further refined and the blend between the painting and the live action was fine-tuned. A typical matte painting done with this technique would take about a month doing a wedge each day.

## Sky Mattes

Matte paintings are static. A degree of realism can be obtained if movement can be introduced into the picture. One of the standard methods for giving life to a painting is the animation of the sky. This brilliant trick was devised by Albert Whitlock himself. The idea is to make the painting oversized so that the east–west border goes beyond the field of view of the camera. This allows room to pull the painting horizontally to impart movement to the clouds. This is accomplished with the use of three mattes placed about 1 foot away from the lens of the matte camera. The mattes were pieces of tape placed upon 4 × 5 inch sheets of glass held in a frame. Matte number one revealed the uppermost portion of the sky containing the foreground clouds. Matte number two exposed the mid-sky region, and matte number three exposed the sky horizon and the rest of the matte painting. To make the matte lines or "join" between the mattes invisible, one glass would be placed atop the other in register in order to place the "countermatte." To do this I viewed the reflection of the pupil of my eye in the glass so that it rested atop the edge of the tape forming the matte. I then placed a piece of tape across from the first matte to form the countermatte. This method also ensured that I created an even gap between both mattes to create a seamless blend between one exposure and the other. When a scene was photographed through a soft matte, the image fell off into darkness gradually. If a countermatte was made with a gap, then this fall off was replicated and the two soft edges falling off to 50 percent in the penumbra of the matte shadow combined to make a blended 100% exposure. Blending a matte this way can be thought of as creating a mini-dissolve within the blend of the two pictures. If the gap is too big, the two exposures will overlap and create a bright superimposition, resulting in a "white" matte line. If the gap is too small or overlapping, there will be no exposure between the two exposures, resulting in a "black" matte line. The painter accomplishes this blending by using stippling or dithering methods to blend the painting into the black paint.

## Sky Animation

Once the sky mattes were created, a test of the sky animation was done using raw stock. This gave us the necessary information while saving the precious test footage for the development of the painting. The painting was usually overpainted by about 12 inches on either side of the field of view of the matte camera. This meant that the maximum length of the painting move was 2 feet. Any longer than that, and the frame of the painting would begin to drift into view. The speed at which the foreground clouds moved depended on the shot itself. A dramatic, stormy sky would move much faster than the sky on a bright, sunny day. The other factor was the length of the take. To be safe, any animation performed ran the length of the entire shot so that nothing stopped or started abruptly, giving away the trick. In Figure 2.17 it was determined that the clouds would move at a casual pace, so we needed to move the painting only 8 inches. The shot was 40 feet long and the camera was shooting at a speed of 4 frames per second, so we made the following calculations:

Projector film speed = 24 frames per second

Frames = 16 frames per foot × 40 feet = 640 frames

Matte painting camera speed = 4 frames per second

Real time = 640 frames ÷ 4 frames per second = 160 seconds to shoot the shot

Painting speed = 160 seconds ÷ 8 inches = 20 seconds per inch

As I operated the camera, the master grip, Lynn Ledgerwood, pulled the painting by means of a hand crank operating a lead screw that slowly moved the painting. At first glance this may seem a primitive technique in this age of computers and motors, but manual animation of a latent image painting made a great deal of sense. Since there was no going back on a latent shot, it was critical to have a real-time human component at the wheel. If a mathematical miscalculation was noticed during the actual shoot, then the camera operator would tell the painting mover to slow down or speed up to avoid catastrophe. A mechanical clock was used for the timing. After a timing test to get the speed of the hand crank to yield 1 inch every 20 seconds, the first matte, revealing the foreground sky, was inserted, the frame counter was set to zero, and the first animated exposure commenced. After this pass, the painting was positioned 2 inches past the center mark (the first pass was started 4 inches past center, since the move was 8 inches in total) and the speed was reset to 1 inch every 40 seconds. The camera was rewound (with the shutter closed) to zero, and the second pass with the mid-ground cloud matte inserted was exposed. After the second exposure, the lower matte was inserted, and the painting was positioned on the center mark and left static for the final exposure. The result was a wonderful effect of not only clouds that moved but also clouds that changed and drifted apart as they became lost in the soft matte lines of the splits, truly an elegant matte painting motion enhancement. It worked so well partly because it was matting the same thing over itself so the integrity of both elements was flawless. This trick carries over even into the digital age.

## Painting Enhancements

### Miniatures

On occasion, paintings were enhanced by placing in front of the paintings miniatures such as cotton clouds or model trains that were also animated in the manner previously described. The beauty of miniatures placed directly in front of paintings is that these elements were "self-matting," or essentially not needing mattes, much as

OVERSIZE MATTE PAINTING WITH 1.85 EXTRACTION

WHITLOCK PROCESS OF SKY ANIMATION USING SOFT SPLITS

**Figure 2.17:** *Dynamic animation of a static painting using soft splits. The innermost rectangle represents the 1.85 composition that will be seen in the theater.*

foreground miniatures do not need mattes. The lighting could be controlled and viewed as it would appear, so blending issues were easily dealt with.

## Printed-in Elements

Next, smoke coming from chimneys was inserted into the shot by using the camera as a contact printer. A roll of film containing smoke elements against black was threaded up against the latent image roll in the camera using a technique called "bipack." The painting was removed, and a black matte with a tiny window in the area above the location of the chimney on the matte painting was used to send light through the lens of the camera through the smoke element and "print the smoke" above the chimney as a double exposure onto the latent shot.

Waterfalls, explosions, and lightning clouds were also added in this manner. Shooting the paintings through bipacked black on clear film elements could add flying birds, blowing tree branches, and silhouettes of people in the distance. Sparkling water enhancements were accomplished by superimposing moiré patterns and interference

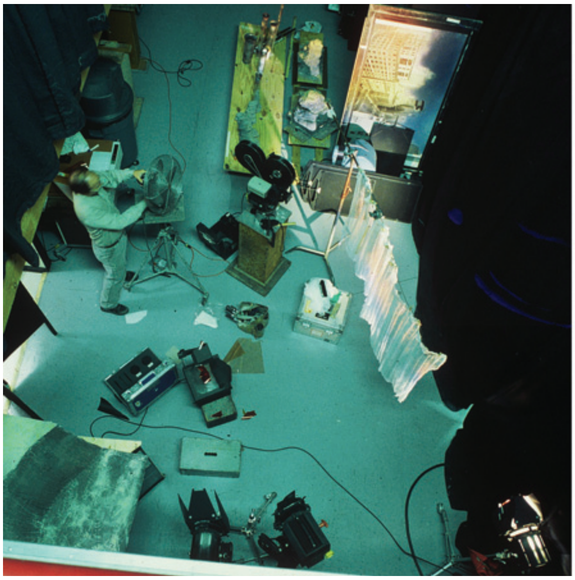

**Figure 2.18:** *An aurora borealis "gag." Hanging curtains blown by a fan are lit with strips of colored gels. When the room lights are off, the camera exposes nothing but shimmering colored light. Master grip Lynn Ledgerwood concocted many of these gags. Courtesy of Illusion Arts.*

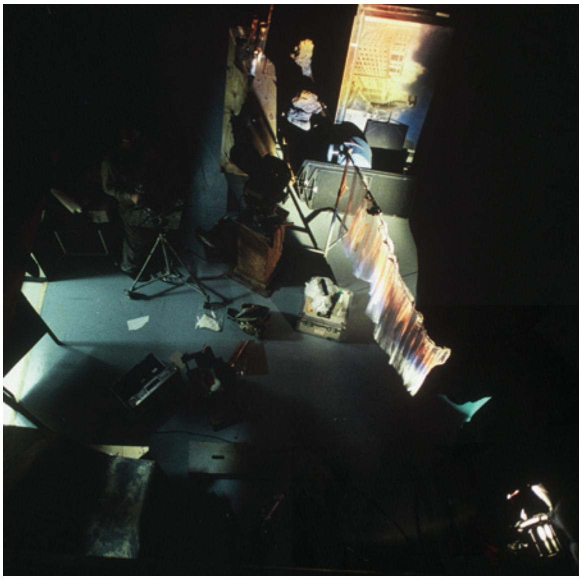

**Figure 2.19:** *An organic aurora borealis effect.*

**Figure 2.20:** *The waterfall element.*

**Figure 2.21:** *Falling baking soda powder shot at high speed was often used for waterfall elements. A power drill with a bent center bit in the chuck provided the vibration to set the powder going. The camera is in the foreground, wrapped in protective plastic. The powder is falling just in front of the camera. Featured are Lynn Ledgerwood and operator Adam Kowalski. Courtesy of Illusion Arts.*

gags onto the painting as a double exposure. Figure 2.25 shows two identical scribble patterns. Typically these simple patterns were drawn as black ink on white paper, and large (8 × 10 inch) high-contrast litho negative films were made from them (clear lines on a field of black). When these two films were placed on top of one another and one was moved against the other, magical light effects could be achieved. In this case, the light interference created a swirling, tornado-like effect.

You can observe this by making your own pattern in Photoshop. Begin by making a new file as a field of white. Create a new layer above it as a field of black. Select

**Figure 2.22:** *Shooting an airburst explosion element for a matte painting of a Civil War fort in the film* Glory. *Courtesy of Illusion Arts.*

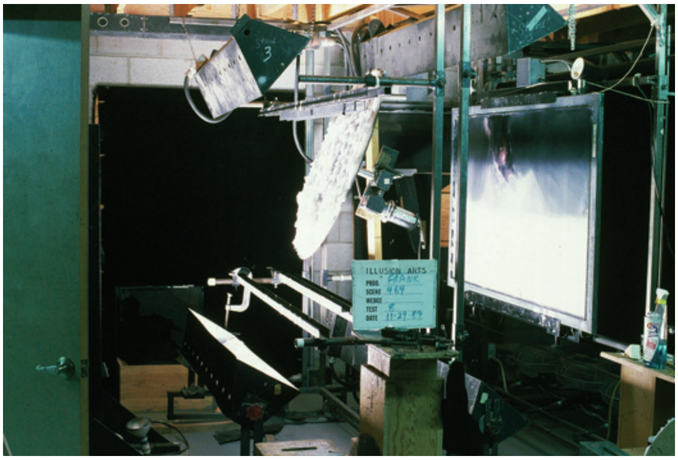


**Figure 2.23:** *A rotating wheel of cotton balls often doubled for turbulent boiling clouds. The matte stand has several slots for paintings and mattes along with ample front and back lighting. Courtesy of Illusion Arts.*

an eraser and erase a random scribble (like the illustration) over the black with a small brush. Duplicate the scribble layer and observe the effect by moving one scribble layer against the other. You can try many other patterns to achieve water sparkles, rain, energy bursts, etc. This simple idea can be used in the digital age as an alternative to complicated particle systems.

## The Final Shoot

Once the painter was satisfied with all the tests and wedges and a short run of test footage was composited for the client's approval, we were ready to put through the

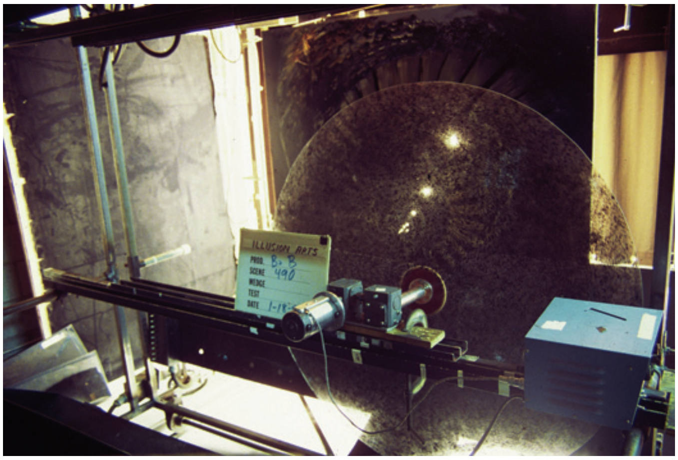

**Figure 2.24:** *A slowly rotating wheel of blotchy paint acted as an interference pattern to animate torches. The torchlights were scraped away from paint on glass or carved through paintings on Masonite (fiberboard) to allow back lighting. The camera's exposure saw only a flickering light pattern of torches against black. This setup was used for one of the many paintings done for the television show* Beauty and the Beast. *Courtesy of Illusion Arts.*

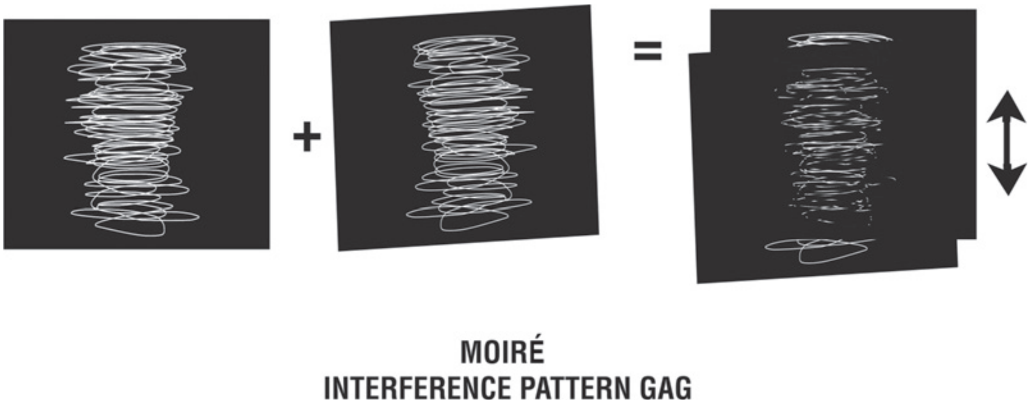


**Figure 2.25:** *Two simple patterns moving against each other can create magical results. This trick dates back all the way to the nineteenth century.*

latent shots. We started with the least preferable take to use as a dress rehearsal. If any unforeseen issues cropped up that might cause flaws in the composite, then only the least favorable take was wasted. If all went well, the client could use this as a fallback take. We then slowly moved on to putting through all the takes, saving the hero take (best take) for last. During my years as a matte photographer using this brilliant system, I had an error on only one take out of more than 1000 shots. The error involved misreading a count so that some critical action occurred during the exposure of the slate. Since we had fallback takes, this was not a disaster.

The latent image method was an elegant process for the creation of matte paintings that allowed for art and commerce to exist in happy union. Though the technique is obsolete, the thought process and reasoning behind its execution are timeless. As mentioned in the text, we can use many of the same tricks and procedures in the digital age.

**Figure 2.26:** *Latent image with matte in place. Courtesy of Illusion Arts.*

**Figure 2.27:** *A dry run composite on test footage. Note that the detailing has not been completed on the left building. This shot shows the wonderful integration of a tiny train miniature sandwiched between a foreground and background painting. The train was lit to make it appear as if it fell into the shadow of the painted building in the background. This particular shot was the last latent image effect that I had the pleasure of compositing. For me, it marks the end of a great era of traditional hands-on effects work. The year was 1996. Painting by Syd Dutton of Illusion Arts.*

If you would like to watch an excellent documentary on this age-old process, I highly recommend *Albert Whitlock, A Master of Illusion*, available from First Light Video Publishing (www.firstlightvideo.com). Another program that that featured Illusion Arts specifically was *Movie Magic*, episode 108, "Matte Paintings," produced by GRB Entertainment/Vision Films.

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# Chapter 3

## Stop Motion

Of all the branches of visual effects technique, stop motion animation more than any other laid the groundwork for the computer graphic methods of today. Stop motion animation is the process of animating a three-dimensional (3-D) model frame by frame in a linear manner to achieve the appearance of motion. The traditional drawn animation technique differed from stop motion animation in that it easily lent itself to a factory modality in which the animation process could be distributed among many different artists. In traditional drawn animation, the key animator would draw the "key" poses of the character in motion. A character jumping a fence might have the key drawings of a running pose, a crouch before the jump, the jump itself, the descent, and the landing. These key poses would be handed off to an "in betweener," who would create the drawings in between the key poses. These drawings, in turn, would be sent to a "cleanup" artist, who would make the sketchy drawings consistent by creating finished, clean line art. Pencil tests, or shooting the drawings a frame at a time on an animation stand so that the rough animation could be viewed, would be done throughout these operations to check on the motion before committing to the final artwork. When the animation had received final approval, animation cels (clear acetate sheets) would be inked for the outlines of the character and painted on the reverse side to obtain solid flat color with clean lines. These finished cels would then be photographed on an animation stand using color film. This assembly-line approach of drawn animation led to the involvement of many hands and the resulting high refinement of the art.

Stop motion animation, however, involved a lone animator animating a figure directly in front of the camera as a final shot. Since the process was unrepeatable and each

**Figure 3.1:** *Stop motion animation of dolls for a rock video. In the 1980s many animators used their apartments as makeshift studios. Note the simple two-light arrangement of soft key light (at the right) and soft fill bouncing off a card suspended from the chandelier. The animator is Juniko Moody shooting with a 16 mm Bolex camera.*

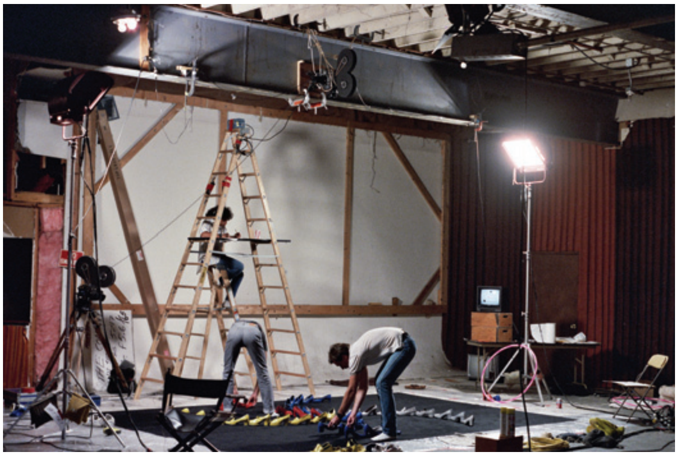

**Figure 3.2:** *Stop motion animation of shoes. To increase the amount of footage, two 35 mm cameras were used. Note the safety lanyards on the camera clamped to the steel beam at the ceiling. Juniko Moody is supervising the animators from the ladder. This was from the rock video "Point of No Return" by Nu Shooz, produced by The Company and directed by Wayne Isham.*

take was unique, tests were worthless. In effect, each take was treated as a final, much like an actor performing on the stage.

There were attempts at creating an assembly line approach to stop motion. The most successful example of this was the *Puppetoon* films of George Pal. In Pal's approach, a team of wood carving experts would create thousands of individual wooden puppets that were identical except that each had a slightly different pose. A running cycle

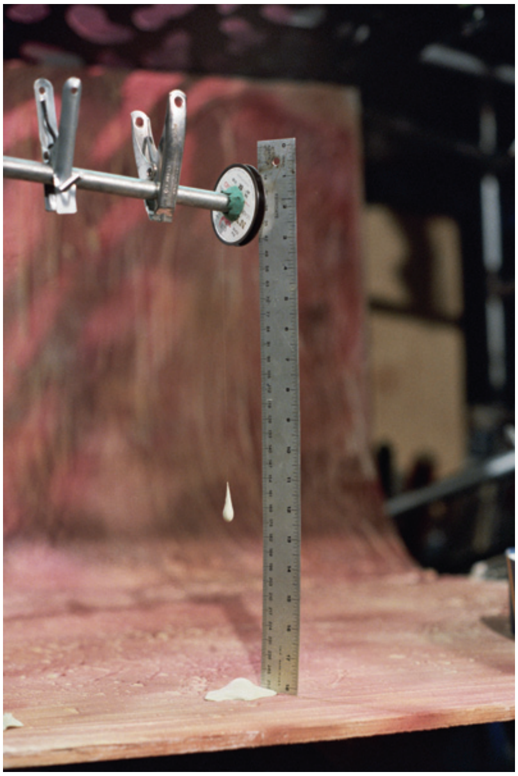

**Figure 3.3:** *To plot the movement of certain objects, measuring devices such as this ruler could be used in between exposures to gauge the moves. The clay drip is suspended from a very thin monofilament fishing line. From* Germs and Communicable Diseases, *Aims Media.*

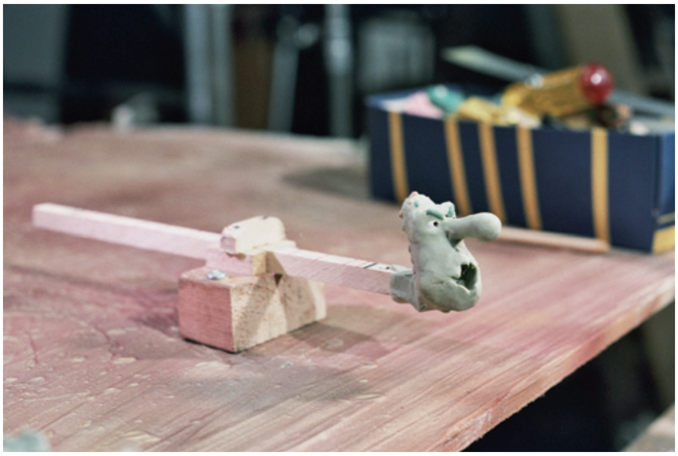

**Figure 3.4:** *Some figures could hide their own support. In this case, the clay head was suspended from a rod of wood with guide marks for animation. The clay body and head hid the support when the character was filmed from the front. From* Germs and Communicable Diseases, *Aims Media.*

**Figure 3.5:** *A typical stop motion animation setup. Out of view of the taking camera, the figure is "tied down" by being bolted to the table from underneath. The device to the right is a surface gauge. This gauge is used as a reference pointer to show the animator the previous position of the puppet when it is manipulated for the next frame. After the puppet is positioned, the gauge is removed and the frame is exposed. Digital capture systems such as the Stop Motion Pro product allow the previous frame to be superimposed upon the current frame on a video monitor to create an ultra precise reference of the puppet's location on the previous frame. From* How to Create and Animate a Clay Puppet, *available from www.firstlightvideo.com.*

**Figure 3.6:** *In this scheme for flying figures, the characters are attached to a sliding Plexiglas sheet. Their support is hidden when photographed from the front. This simple idea of attaching figures to clear planes is still used today in digital shots requiring live actors to interact in computer graphic environments. This method is detailed in Chapter 13 and illustrated in Figure 13.17. From* Germs and Communicable Diseases, *Aims Media.*

**Figure 3.7:** *An example of replacement head animation. In this case a mold was made of the master doll head and molten clay was poured to generate multiple heads that were sculpted to create the extreme expressions.*

could have perhaps 10 different figures of the same character in 10 different running poses. These figures were placed on the stage and photographed one frame at a time. After each frame, the figure was replaced by the next figure, and the next frame was shot. When the animator reached the tenth figure the next logical pose would cycle back to the first figure, and the process would continue. This process was called replacement animation. About 7000 different figures would need to be created for one 10 minute short; the labor and quality control needed were staggering. The great advantage of this technique was that each figure could be created with extreme squash, stretch, and distortion just like drawn animation.

Replacement animation was so expensive and cumbersome, however, that it gave way to the use of one poseable figure manipulated by a lone animator. There are many pioneers in the stop motion field. Such luminaries as George Pal, Jiri Trnka, Wladyslaw Starewicz, and more recently Nick Park, the creator of *Wallace and Gromit*, refined the puppet film. A tie-in with visual effects came with the work of Willis O'Brien, whose visual effects artistry brought the original (1932) *King Kong* to life. With his clever integration of stop motion models and live action, O'Brien created the blueprint for the tricks we use today.

## Stop Motion Combined with Live Action

Before *King Kong*, O'Brien had created the effects for the silent film *The Lost World* by juxtaposing dinosaur models with live action through the use of the latent image technique, as described in Chapter 2. The blend between the actors and the models could be made seamless, but their interaction was limited. The performance of the actors being captured as a latent image had to be fairly generic: there was no way to have the puppet and the actors interact closely, as the live action would not be seen until processing. The scale and dynamic composites were so startling at the time, however, that many thought that the apparitions were real. For *King Kong*, O'Brien improved upon his methods, making use of superior models, glass shots, miniatures, and, most importantly, rear projection technique to allow close performance interaction between the live action and the animated characters.

## Animation Puppets

The animation figures used in *King Kong* were built around a metal ball and socket skeleton whose joints could hold their position after each pose. Kong's body was built up from sponge rubber, then was covered with fur pelts. Though the figure could hold its position for each frame, the fur could not be so controlled. Viewers of this early animation of Kong can see handling marks from the animator's hands on the model; this gave the fur a nervous electric energy. For the dinosaur models, the sponge rubber body was covered with textured latex for the reptile skin. As the art progressed, this "buildup" technique was replaced with a method of sculpting the creatures in clay, making a mold, and then injecting foam rubber into the cavity so that the foam rubber would surround the armature and take on the shape of the sculpture.

## Multiplane Glass Shots

To alleviate the expense and labor of creating dimensional jungle sets that also might be accidentally bumped or sag during the stop motion process, many of the settings were huge paintings done on glass. The animation figure was placed atop a stage that contained many holes for bolts that would tie down the feet of the puppet, enabling

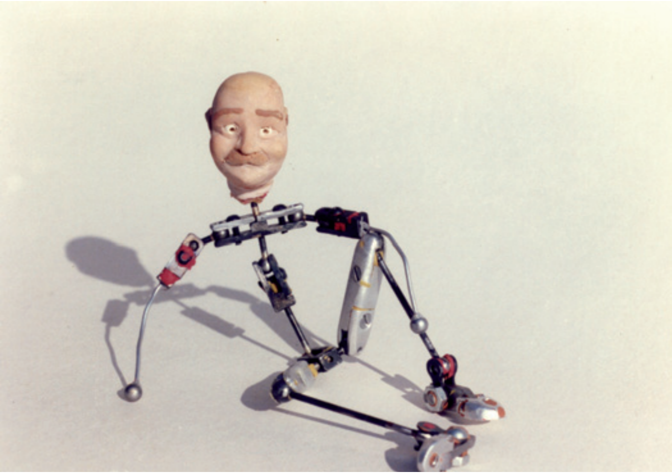

**Figure 3.8:** *An example of a highly tooled stop motion armature.*

it to defy gravity and stand on one leg during the animation process. The stage was sandwiched in between the glass paintings that created the environs while at the same time hiding the mechanics of the puppet stage. This procedure was similar to the technique used to integrate the train model into the matte painting illustrated in Chapter 2. If close interaction between puppet and foliage was needed, the branches and leaves were made of tin, which could remain stable yet be easily manipulated during animation. This type of animation setup could also be shot as a rear projection plate or element. At a later date, the actors would be assembled in front of a rear projection screen and a composite would be made by photographing the actors and the animation footage together. The actors would be able to see the projected image and react to the animated creatures, thereby furthering the believability of the shot.

## Rear Projection within Miniature Sets

Another way in which O'Brien controlled the interaction of the live action with the animation was through the use of stop motion projectors that could project one frame of movie film for long periods, like a slide projector. These projectors would cast an image upon miniature rear projection screens that were inserted behind models of cave openings, or similar convenient hiding places. After each frame of animation was photographed, the projector would be advanced one frame and the animator would create another pose. The lighting would be adjusted so that both the projected image and the animation set would be in balance, thereby allowing the animator to see the final composite as the animation progressed. As the live action rear projected performance advanced a frame at a time, the animator could make the puppet interact convincingly with the prerecorded live action footage. This "what you see is what you get" post-process methodology was a tremendous breakthrough in visual effects. Its other advantage was the ability to use compositing to create the sense of tremendous scale with models under very controlled conditions. Attempts to use giant animatronic creations usually fell prey to the limitations of physics and were seldom successful. There were cases in *King Kong* where large props were used for close interaction with the actors, such as Fay Wray being held in Kong's hand, but that technique was used sparingly.

## The Dunning Pomeroy Process

Another groundbreaking compositing technique used in *King Kong* was the Dunning Pomeroy process, an early blue screen procedure that worked with black-and-white film developed by C. Dodge Dunning and perfected by Roy J. Pomeroy in the late 1920s. This clever process utilized the idea of color cancellation whereby a yellow filter would block blue light yet allow yellow light to pass through unimpeded. The way the process worked was to shoot a plate in black and white and create a special print in which the silver of the image was replaced with yellow dye. In other words, a black area on the film would be rendered as a region with deep yellow dye and a light region would remain clear on the film. This low-contrast image would be almost impossible to see unless it was viewed against a blue screen. The blue light would go

**Figure 3.9:** *A yellow dye transparency is shown against blue, yellow, and white backgrounds. Note how the contrast increases greatly in front of the blue card.*

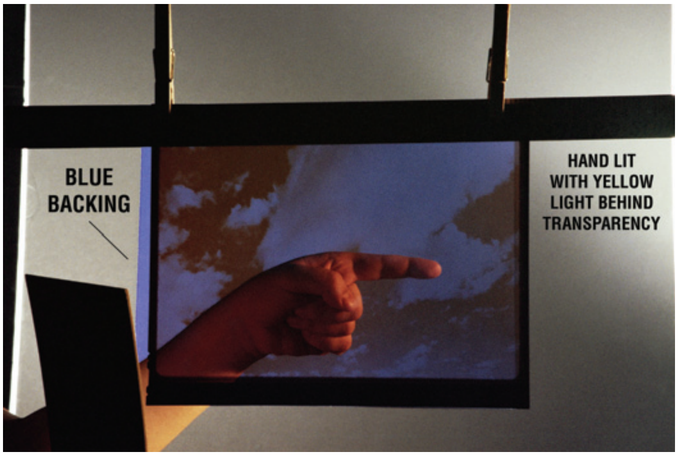


**Figure 3.10:** *A Dunning shot as it appears on color film. The large transparency is suspended in front of the hand instead of being a roll of film bipacked in the taking camera.*

through the clear areas of the film easily but would be blocked by the yellow dye. This brought up the contrast of the plate and allowed the image to be seen. Conversely, if this yellow image was viewed against a yellow screen, the entire film would appear transparent and no image would be seen.

In practice, the procedure was to place the yellow print against the black-and-white raw stock in the camera behind the lens. This turned the camera into both a film printer and a taking camera. When a yellow lit foreground figure was placed in front of a blue screen in front of this camera arrangement, the blue screen would reveal and print the background onto the black-and-white stock while the yellow lit foreground would pass through the yellow plate as if it were transparent.

**Figure 3.11:** *A closeup of the completed Dunning shot, as it would appear on black-and-white film. This technique can be used with a digital camera as long as the final product is intended to be a black-and-white image. In that case the color would be "turned off."*

The transparency used in these illustrations was created through a double exposure onto color film. I first shot a field of a deep yellow-orange color on one pass. On the next pass I photographed a black-and-white print of clouds. The dark tones of the print were overtaken by the orange color, and the white of the print added to the orange color to turn it light. After these exposures were made I took the film negative to a still lab to get an 8 × 10 transparency. You can create a similar effect using Photoshop (Figure 3.12) by importing a color photo, changing its mode to grayscale (throwing out all the color), and then changing the mode back to RGB color (steps 1 and 2). What this process does is create three identical color records over each other. Next, go into the color curves control to the blue channel and bring down that curve until it is flat, thereby throwing out all the blue information (steps 3 and 4). Then go to the green curve and lower it by one-half to swing the tone to more of an orange color (step 5). Finally, adjust the brightness and contrast to obtain a yellow-orange image that will increase in contrast against a blue screen, yet let the yellow illuminated foreground through (step 6). I arrived at these settings through experimentation. After creating this yellow-orange background, I sent the file to a photo service to get a large transparency. Unfortunately, as more and more photochemical processes are replaced with digital, it has become more difficult to find large transparency film, let alone a lab that can process the material. The illustration is nonetheless useful as an introduction to blue screen technique.

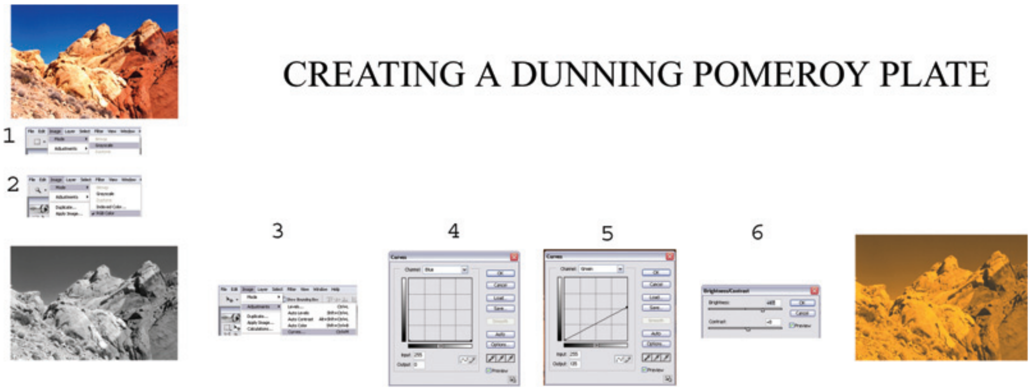


**Figure 3.12:** *Procedure for making your own Dunning Pomeroy plate in Photoshop.*

This technique would have created a beautifully convincing composite on the black-and-white film, complete with fine detail and the retention of fast-moving, blurred elements. Though I can't be sure, I can guess that it may have even been possible to look through the back of the raw stock as the composite was photographed to see the effect as it was happening, assuming that antihalation backing for film had not yet been developed (see Chapter 5). The great advantage to the Dunning Pomeroy system was that it could be used with larger expanses than in a live action rear projection setup. A projected image might be limited to being 10 feet wide in order to have the image be bright enough to rephotograph, whereas a blue screen could be much larger since it could be lit with many lights as opposed to the single projector lamp of the rear projection process. *King Kong* was a milestone in visual effects history. In this amazing film O'Brien established brilliant methods of combining stop motion animation with live action photography. O'Brien's technical achievements laid the groundwork for the furthering of the art of stop motion visual effects by his protégé, Ray Harryhausen.

## Ray Harryhausen

Ray Harryhausen saw *King Kong* at the age of 12, and it inspired him to become a stop motion artist. He was largely self-taught in his early years and received a great deal of encouragement from O'Brien. O'Brien hired Harryhausen as an animator for the movie *Mighty Joe Young*, the only big stop motion feature on which O'Brien and Harryhausen worked together. Eventually, Harryhausen struck out on his own, to become one of the greatest independent stop motion visual effects artists in the history of cinema. Since he worked alone on low-budget films, he often did not have the resources for utilizing the methods of *King Kong* and *Mighty Joe Young*, which entailed large sets with glass paintings. In order to work within the tight confines of space and budget, Harryhausen devised a compositing method that revolutionized the art.

## Dynamation

To avoid undue set construction, Harryhausen came up with a method of sandwiching the animation figure within the live action plate itself through the use of mattes. The procedure was fairly straightforward. He would typically go on location and shoot the live action plate, which usually entailed actors running away from nothing. When this footage was processed and developed, a special low-contrast print was made that was projected onto a screen behind the figure. The puppet was lit to match the lighting and shadows of the plate.

Between the animation puppet and the camera was an easel that contained a glass matte that obscured the bottom half of the shot, hiding the stage and the lower half of the rear projection screen.

Harryhausen would animate the figure interacting with the live action plate until the end of the shot and then would wind the camera back to the beginning. At this point he would create a countermatte obscuring the area he had just photographed and revealing the view underneath. He would then remove the puppet and stage and photograph the bottom of the rear projection plate. In this way he was able to insert his figures within the live action itself for a startlingly realistic composite. In practice, I suspect that he may have shot the lower half first and then underwent the time-consuming animation. In effects work, one rule of thumb to protect against catastrophe is to start with easy things, so if there is a mistake with exposure, for example, it isn't so devastating to start from scratch. If Harryhausen had spent two days animating a shot and then made an error on that last exposure pass, I'm sure he would have been beside himself.

**Figure 3.13:** *In a dynamation shot, the footage of the actress would be rear-projected behind the model and its support.*

**Figure 3.14:** *A dynamation matte hid the support and allowed the creature to appear to be coming out from behind the structure.*

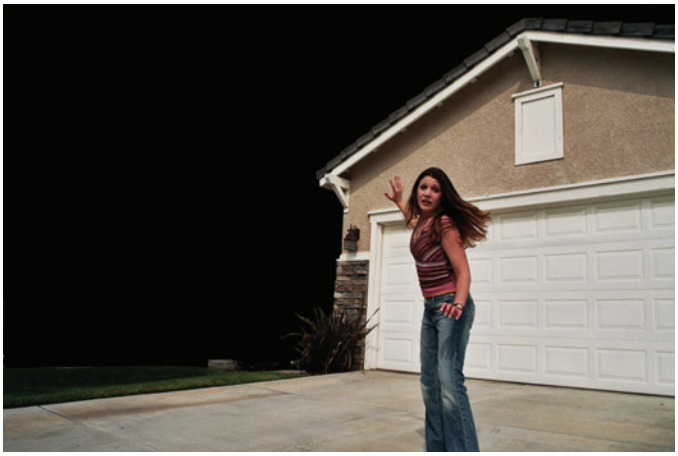

**Figure 3.15:** *After completing the animation, a countermatte replaced the first matte, the puppet and stage were removed, and the second pass filled in the remainder of the live action.*

Harryhausen's other milestone was his refinement of the use of miniatures to substitute for live action elements in order to achieve close interaction with animation figures. For example, if a cyclops were to pick up Sinbad by his boot, Harryhausen would have the puppet reach down to the point where its hand would be aligned on top of Sinbad's boot on the projection screen. At the appropriate frame, a miniature boot would be substituted so that the shadow and contact between the monster's hand and the boot were real. The miniature boot would obscure the projected image of Sinbad's boot and would be aligned to join with the actor's pant leg. Another example of this technique is a live character stabbing a monster with a sword. A substitute miniature sword would enter the real model, aligned with the real sword on the

**Figure 3.16:** *The completed dynamation shot.*

screen beyond. This ability to see the composite in real time and control all the elements in such an intimate, exacting manner was almost like photo retouching frame by frame. Harryhausen's miraculous work established him as one of the giants in the field. He was the inspirational figure for almost all the prominent effects wizards to follow.

## Go Motion

One of the drawbacks to the stop motion process is the fact that each pose of the arrested figure is rendered absolutely sharp. There is no blur to the animation figure, whereas the background live action characters have all sorts of motion artifacts. In Harryhausen's work this was a minor consideration, as this effect seemed to enhance the fantastic illusions he created. Only on special occasions did he create synthetic blurs to prevent a strobing effect with fast-moving figures. Many animators that followed made attempts at recreating motion blur in their work. Jim Danforth and David Allen followed Harryhausen and further refined the process along this and other lines. The easiest method for blurring was moving the puppet during the exposure of the frame, such as by tapping the wings of a flying model so that it wobbled during the exposure. Another method was to paint Vaseline on a foreground glass to soften the appendages of the figure. Multiple exposures over the same frame of different poses created a ghostly pseudo-blur effect that was quite effective. The most controlled method of blur creation was called "go motion." Go motion was created at ILM by Phil Tippet and others for the film *Dragon Slayer*. The animation puppet was connected to a computer-controlled motion device that would move the puppet's limbs during the exposure, thereby creating blur. This was truly the high point of the art in the period before *Jurassic Park* and digital dinosaurs.

## How Do Traditional Stop Motion Effects Relate to the Digital World?

Today, animation puppets and rear projection are very rarely used, but the concepts are used every day within computer graphics imaging (CGI) software. The beauty of this software is that it combines the best of the stop motion and traditional drawn animation craft. A skeleton, for example, can be built using a computer much like the ball and socket armature of the past; instead of being covered with foam rubber, the computer figure is layered with many polygons. The animation, instead of being done in a linear fashion from start to finish, can now be constructed using key poses with the digital figures and having the computer do the in betweens. Furthermore, the movement can be edited and refined at leisure to create very sophisticated performances. The replacement animation technique as done by George Pal also has a computer counterpart, except that the computer models can be made with precision in consistency and the data from one model can be morphed into the other, creating even more "in between" flexibility. The computer does the blurring as well. Viewing the render of a blurred frame in some software applications shows that it is reproducing an early stop motion idea of overlapping multiple positions on the same frame. The computer, being tireless, can do this many more times than a lone stop motion animator and thus can generate a smooth, seamless blur. The rear projection screen and projector are replaced with a polygon behind the figure upon which the live action plate is mapped. There is no longer a need for stages, tie downs, or wires, as the problem of the physicality of gravity does not exist in the digital environment. The animator today, however, as in the past, must still impart a sense of mass and gravity to the animation so that it reads as a real object. Another unchanging component is that the figure must be lit to match the plate, as was done for dynamation years ago. The basic ideas remain the same; it is only the tools that are different.

Many visual effects supervisors spent their early years studying the work of the great stop motion masters. The tricks that Harryhausen and others used are directly transferable to the digital medium. Performance animation, the misdirection of the eye, the placement of split lines, composition, and lighting are all foundations of the art of visual effects in any medium. Understanding the general ideas behind how the stop motion shots were done also goes a long way toward helping to previsualize effects elements in the storyboard stage. I learned a very useful trick from the late animator David Allen while observing him working on his film *Primevals*. When I opened his script I noted that the dialogue, as usual, was on the right-hand page while the storyboard breakdown was on the left-hand page. Within each of the storyboard panels were colored outlines surrounding certain picture elements. For example, people in the foreground observing the monster were outlined in blue, signifying that that element would be shot blue screen. A red color might designate a stop motion model, etc. This was a terrific way to break down an image into its component parts. Using blue screen elements in the foreground made sense because it would be difficult to make frame-by-frame animated dynamation mattes to have

**Figure 3.17:** *A quick method for storyboarding and planning effects shots is to shoot stills at the intended location to get an idea of the background plate and then draw on top of the picture to complete the shot. As a further planning aid, the element can be outlined with a color such as blue as an indication of the technique. In this case, I took a photo of the background looking down over a tall bridge. I then drew in a hanging character and outlined him in blue. This shows me the effect and my intention to shoot the actor and ledge in front of a blue screen.*

a person pass in front of the animation puppet (though Harryhausen and others on occasion have had to resort to this method). In many cases it was much easier to have foregrounds be blue screen elements.

## Executing a Dynamation Shot with the Computer

Ray Harryhausen animated and composited some very impressive flying saucers in the film *Earth vs. the Flying Saucers* (1956). They were so effective that some of his shots have been used time and again as stock footage in many black-and-white television shows. Consider a shot of a flying saucer crashing into a lake. Using a traditional dynamation method, Harryhausen would have suspended the model saucer from wires in front of a rear projection screen with a soft dynamation matte cutting through the water. He not only would have painstakingly animated the saucer on wires, but also would have carefully painted the wires so that they would blend in with the background. When the ship hit the water at the dynamation split line, he would have added an animated sea spray using white cotton or another substance to simulate the explosion of surf as the saucer crashed. Once again, the bottom half of the water would have been a separate exposure.

Next, I will break down a shot executed by Glenn Campbell, effects supervisor at Area 51, doing the same effect using Lightwave software. The plate was a still frame pulled from stock. The saucer was put together out of simple basic shapes using computer modeling and texturing and was placed in front of a polygon mapped with the background plate. A CGI model placed in front of an image-mapped polygon is much the same as a traditional model placed in front of a rear projection screen. The saucer was lit to balance with the background (Figures 3.18–3.20). No wires were needed for this saucer, and its internal spinning disc was put on a cycle so all that was needed was to key frame its erratic behavior and trajectory. Now this is where the shot gets

**Figure 3.18:** *The background plate.*

**Figure 3.19:** *The wire frame of the flying saucer model.*

**Figure 3.20:** *The final textured model lit to match the background.*

really clever. Another polygon plane was made just below the model that became a surface that the saucer could pass through (Figure 3.21); this surface could also capture the shadow of the saucer. Campbell could then tell the software to replace the gray tone of this surface with a front projection map of the background water. The front projection idea was derived from a projection compositing technique refined in the 1960s (explored further in Chapter 12). It is as if the camera and projector were one and the same, and the background plate was projected onto a table and background screen. As viewed right down the barrel of the projector lens (as can be done using software), there is no distortion of the image. As the ship approached the water, the key light was able to cast a shadow upon the polygon without "lightening up" the image of the water. This is a further advantage of computer light: while it is a struggle to make it look real at times, it is a godsend when something can be lit without casting a shadow, or in this case, when a shadow can be cast without lighting something.

As the ship crashed, it merely passed through the polygon. The polygon not only was told to accept the shadow and reflection of the saucer, but also was made to be slightly transparent so that the front of the disc could be dimly seen underneath the surface (Figure 3.22). To enhance the effect, another polygon that carried the image and matte of a water spray explosion was added (Figure 3.23). This can be thought of as a perfectly invisible sheet of glass with a picture of water spray attached to it, not unlike a paper doll cutout. It not only shows an image but also can cast a shadow and reflection, which the spray does (Figure 3.24). Take note in this figure that the immediate foreground has been isolated with a matte similar to the dynamation

**Figure 3.21:** *The saucer passing into a polygon surface that is told to capture the shadow of the saucer. This same surface will be instructed to map the water image onto it and also retain the reflection and shadow of the saucer.*

**Figure 3.22:** *The polygon now has the front projected map of the water surface. The shadow and reflection of the saucer are clearly visible. Note that the polygon is also slightly transparent, allowing us to see a dim image of the tip of the saucer under the water.*

system that prevents the water spray reflection from contaminating the shoreline. The blur is automatically put in by the program, and as an added bonus Campbell animated the CGI-taking camera to bob and shake as if the cameraperson were struggling to get the shot. These subtle embellishments went a long way toward making this an excellent example of a classic effects shot.

**Figure 3.23:** *The water spray element.*

**Figure 3.24:** *The water spray laid on top of the polygon surface, allowing it to cast a reflection. Note that the foreground is protected as a separate layer, preventing the reflection from passing over the shoreline.*

Today's software allows us to build upon the pioneering work of Harryhausen and add details that would not have been possible using the original technique. The effects field as a whole owes a large debt of gratitude to Harryhausen, not only for his artistic contributions but also for his development of dynamation, an elegant strategy for creating fantastic illusions.

**Figure 3.25:** *The finished shot, executed using strategies similar to the dynamation process originally developed by Ray Harryhausen. The saucer breakdown is courtesy of Glenn Campbell of Area 51.*

## Front Projection

Rear projection, while extremely useful, was hampered by the drawback of generating a soft image since it was going through the translucent medium of the screen. Spill light had to be avoided as well to prevent the image from being washed out. Other issues, such as "hot spots" where the center of the screen was brighter than the outside, were also a common plague. To resolve these issues, a method known as front projection evolved that owed its success to the properties of a unique material known as Scotchlite, made by the 3M Company. This screen material is composed of thousands of glass beads that are mirrored on half of their surface. The bead acts as a microscopic parabolic mirror that retroreflects light directly back to its source. Scotchlite can be seen every evening on the freeway, as all road signs are coated with it. Your headlights hit the Scotchlite letters, and you see the brightness of your headlights reflecting back. The material is 1000 times more efficient than white paint—it is a remarkable invention.

In visual effects we use this screen in the following way. We front project the plate over the actor and onto the screen. Since the screen is 1000 times more efficient than white, any white that is on the actor appears black by comparison and the image reflected off the actor is imperceptible. We can light the actor to match the brightness of the front projection plate without fear of washing out the screen, as the screen is not so much bouncing and diffusing light as it is reflecting the image with millions of tiny mirrors. In order to eliminate the shadow cast by the actor from the projector, we place the projector and camera at right angles to each other and use a semitransparent mirror to align the optical paths of both

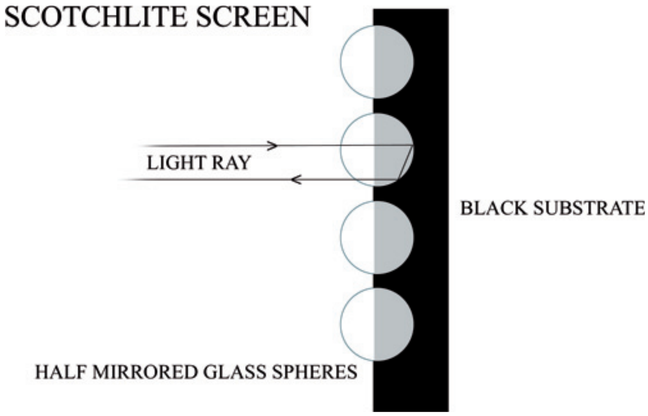


**Figure 3.26:** *Diagram showing the principle behind Scotchlite. A ray of light travels through the transparent glass sphere and reflects off the mirrored surface on the backside, where the ray is reflected straight back to the source.*

lenses, as if the camera and projector were one and the same, and so the actor "hides" his own shadow (see Figure 12.7). This process was used to great effect in *2001: A Space Odyssey* and *Close Encounters of the Third Kind*. The principle of front projecting an element onto a polygon in the computer is a direct descendent of this technique. A further refinement is "sticky front projection," which is when the plate is wallpapered onto the polygon, allowing limited camera push-ins into the plate, which can simulate perspective shift for short shots.

An excellent training program for learning where to place split lines and the organization of elements can be had by studying the Harryhausen films. The advantage of watching these classic films is that the animated creatures readily distinguish themselves from the live action, so you can pick out the separate elements and split lines if you look carefully. The staging and matte logic used in these effects are masterful. I recommend *Mysterious Island*, *Jason and the Argonauts*, *First Men in the Moon*, and any of the *Sinbad* series. For those wanting to view a step-by-step exploration of stop motion animation using a digital camera, I have created three video programs on the art of clay animation, which are available from www.firstlightvideo.com. The first program explores stop motion animation via the timing and animation of a toy truck. The second program explains simple sculpting and painting skills for creating characters. The final program shows how to create a flexible clay character and animate an animation cycle. These video programs illustrate the use of a simple Logitech web camera to accomplish the animation exercises. For those who would like to execute animation using their own digital camera, I recommend using animation software from www.stopmotionpro.com.

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# Chapter 4

## The Frame Is the Thing: All About Film Formats

In visual effects, an imaginative storyboard sketch becomes the starting point for what can be a Rube Goldberg collection of processes that lead to its photographic realization. The starting point is always keyed to the end goal. The first question I ask when a new job comes into the shop is "What's the format?" The answer to this question lays the foundation of everything needed in the photography phase. To explain more about formats and their evolution, I will trace a brief history of the movie frame.

### The Basics of Movie Film

#### The Frame of the Picture

After 35 mm film had been established, the aspect ratio, or frame of the image on the film, had to be determined. Since humans live in a horizontal world (having two eyes side by side), painters throughout history have tended to paint rectangular images with the long dimension on the horizontal plane. This generality evolved into the first aspect ratio for motion pictures with an image that was four perforations high and with the full distance between the perforations. This first format was a classic 3 : 4 ratio, or three units high by four units wide. This is typically expressed as a 1.33 : 1 aspect ratio, or simply 1.33. The Academy of Motion Picture Arts and Sciences standardized this and other formats, and as a result this original format is also known as full silent Academy.

## Keeping the Picture Steady

It is important that each frame of a motion picture be registered upon metal pins during exposure to prevent the moving image from bobbing around. The perforation holes for negative film are called Bell and Howell perforations, after the inventors. In the early days of film, round holes were used, but they were subject to great wear and tear from the camera movement and caused a lot of jitter when projected. The Bell and Howell perforation is a round hole with a flat top and bottom. In a camera movement there are two pins, one large and one small, that will engage these perforation holes during exposure. One is made small to allow for shrinkage of the film under different temperatures and humidity. The big pin is full fitting. The Bell and Howell registration process is of tremendous benefit to the effects professional because each element will be rock steady, and when composited with other registered elements, the images will remain locked and won't weave against each other, which would reveal the illusion of the composite.

Print film uses the larger square KS (Kodak standard) perforations to allow for more looseness for prints that are projected hundreds of times. The projector weave that occurs is not objectionable since the entire image swims together. Traditional effects processes created steady elements by always copying film on pin-registered printers. Today, as we will see in Chapter 6, we digitize elements shot on film for the computer. For effects work it is important to scan film using a pin-registered scanner that will hold each frame in place with Bell and Howell pins as it is being scanned. This will ensure that steady images shot with a pin-registered motion picture camera will yield steady pin-registered scans. Modern digital cinema cameras and projectors eliminate weave altogether, as they are an electronic medium and therefore are not subject to the physicality of film.

## The Sound Era

In the early days, matching sound to picture was quite problematic. Early systems involving synchronizing phonograph records with the running film often failed due


**Figure 4.1:** *Full Academy 1.33 format showing the Bell and Howell negative perforations and the KS perforations used on the subsequent print.*

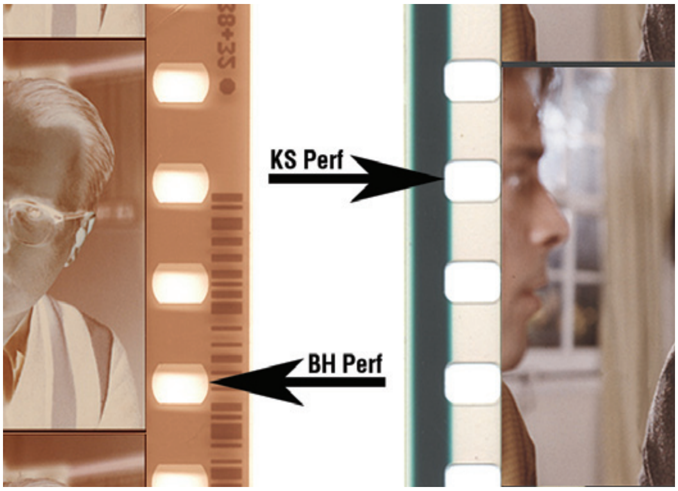


**Figure 4.2:** *A closer view of the perforation holes.*

to skipping records, breakage, or any number of obvious limitations. The solution came with the idea of placing the sound record onto the film itself. The problem was where to put this optical sound track, as almost all of the useable area on the film was taken up with picture area. The answer was to shrink the picture and pull it over to one side of the film to leave room for the sound track. The ratio of the image remained roughly the same at 1.37, with a slight compromise in image quality (in that it was a smaller picture). This ratio is so close to the original format that it is often called 1.33 as well. The new sound projectors not only were modified to read the sound track off the film, but also had a specially cut mask that allowed only the picture to be projected and not the sound track. To prevent darkening of the picture caused by the edge of the image circle of the lens encroaching on the frame, the lenses for the cameras were offset on the new center for this Academy aperture. Yes, that's right—both the silent format and the sound format are called Academy and have roughly the same aspect ratio, so to discern them the terms full aperture or silent Academy are used for the original format and Academy is used for the sound format.

## The Television Era

When television came about in the late 1940s and early 1950s, it took the world by storm. People could watch programming at home in the same aspect ratio that the movies had. The television screen was much smaller and the reception was questionable, but it was free. The film studios worried about loss of market share and struggled to come up with an inexpensive solution. Their answer was to change the aspect ratio to create a "big" screen that differed from the TV competition. This simple change was the creation of a new mask for the sound projectors that created a longer rectangle within the Academy aperture known as 1.85. This created the illusion of more picture

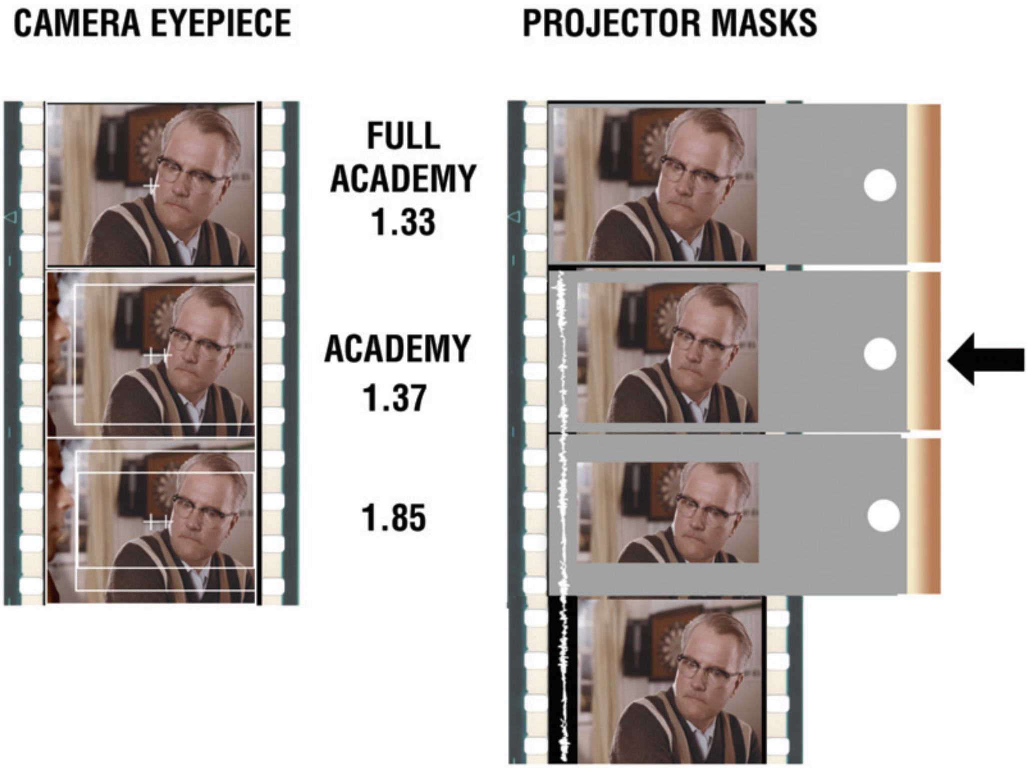


**Figure 4.3:** *Comparison of 1.33, 1.37, and 1.85 formats. Note how the mask obscures the sound track information imprinted on the film. Also note the secondary crosshair for the re-centered lens.*

area, when in fact it merely cropped out what was there to begin with. The taking cameras still shot the entire full aperture with the lens centered for Academy, but the image was composed using ground glass viewing systems with markings that showed the various framings. This was an unexpected boon in that it is an early example of oversampling. The cinematographers shoot more than they need and compose for that part of the image that is going to be projected. This is a great aid when a microphone boom inevitably shows up in a shot. It becomes a simple matter to reframe the image in post to take out the microphone, C-stand, grip, or what have you. No blowup of the image is required because there is plenty of picture top and bottom and in the sound track area. This format remains one of the most popular aspect ratios today. A similar format with a 1.66 ratio was developed in Europe, but 1.85 is the dominant format.

## CinemaScope

To further offset the pressures of television, film studios developed a true wide screen using the maximum picture area on the negative. The process was called Cinema-Scope, and it involved special lenses that would squeeze and "unsqueeze" the picture

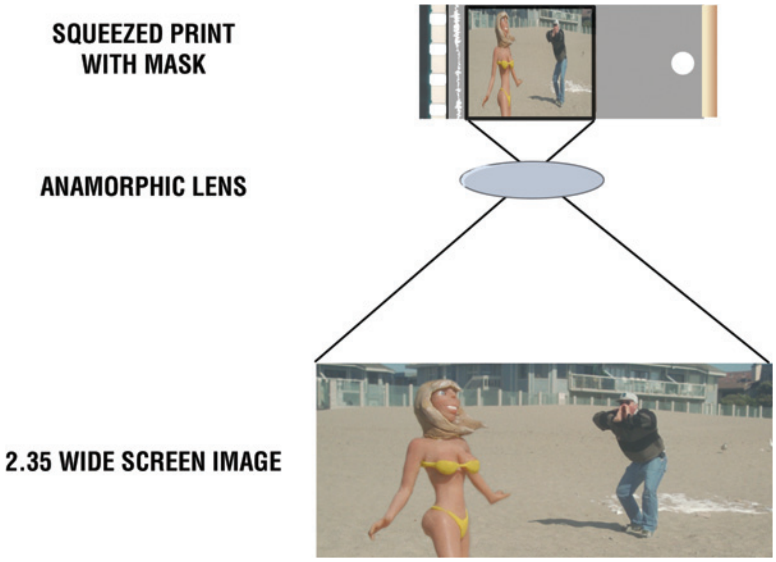


**Figure 4.4:** *The 2 : 1 optical compression of CinemaScope is unsqueezed using an anamorphic lens on the theater projector to derive the widescreen 2.35 presentation.*

in the horizontal dimension. The new aspect ratio was 2.35; this was accomplished by shooting the full top and bottom of full silent Academy while leaving out the sound track area and applying a 2 : 1 horizontal squeeze to the image. When the print went to projection, an unsqueeze lens was used to expand the picture to the new wide format. This was an early form of what could be called optical compression and is a good visual way of grasping similar compression schemes of digital formats. Because the entire vertical image area of the frame is used in the CinemaScope aperture, there is little opportunity for recropping, but the gain in picture fidelity is enormous. This format is usually reserved for the "big" pictures with major stars and high-end production values.

## Super 35

Because many lab processes occurred between photography and the release print, a system was devised that utilized the maximum image area on the film while shooting with normal lenses for the 2.35 format. A final squeezed anamorphic print would then be made from these normal "flat" pictures. This process is called Super 35 and involves shooting the full aperture and composing for the 2.35 aspect ratio. It results in an oversampled image top and bottom that allow for later recomposition if needed.

## Viewing Movies on Television

The changes from 1.33 to 1.85 and 2.35 created compositional problems when films were shown on television. To an unsophisticated audience, letterbox appeared unusual;

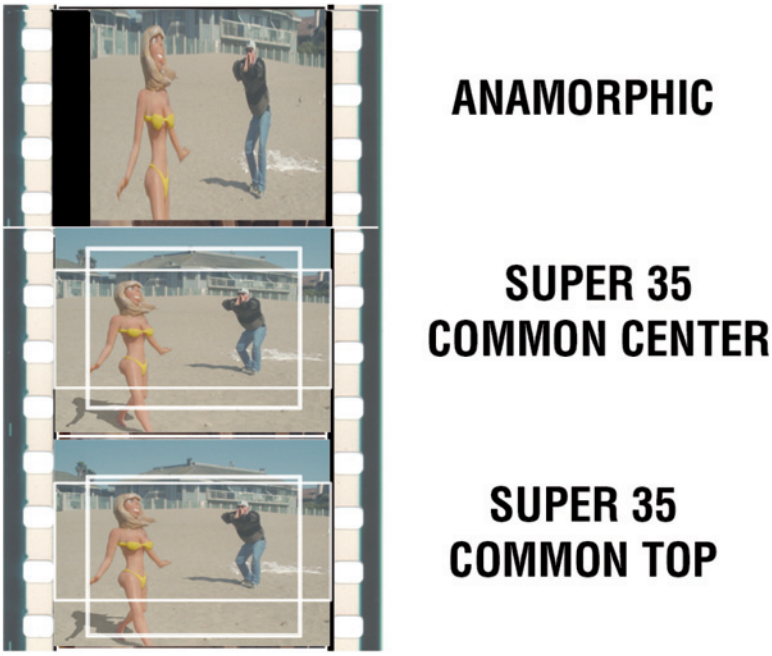


**Figure 4.5:** *Super 35 formats as compared with CinemaScope. While the anamorphic process squeezes the image from the start, the Super 35 process shoots a flat normal image composed within a 2.35 frame. Prints made from a flat Super 35 negative are squeezed and include the sound track for widescreen projection. Note the different TV extraction schemes on the Super 35 systems.*

people thought that something was wrong with the TV set. As a result, the 1.33 TV ratio was cropped out of 1.85 pictures by allowing more of the top and bottom of the image to be revealed. Good cinematographers would always protect for television when shooting a 1.85 picture by ensuring that microphones, etc. were out of the TV ground glass markings in the camera. The 2.35 projects were more troublesome. Methods called "pan and scan" were devised that would select the best compromise extraction of the 1.33 from the widescreen. This often led to unsatisfying results.

The Super 35 format, because it is oversampled, allows more of the top and bottom to be brought in to accommodate the 1.33 frame. The common center format, in which equal amounts of top and bottom were extracted, caused consternation among some cinematographers, who felt that too much headroom was given to the recomposed images. To alleviate this issue, a modified "common top" format was created so that the TV extraction maintained the same headroom and revealed more of the bottom to force a consistency of the cinematographer's intent. The optical house would obtain a film clip that showed the production's framing guidelines so that reframing could be accomplished accurately. The common top format can occasionally have peculiar issues, as when shooting telescope or binocular shots in which the circle vignette will be off-center in the TV extraction.

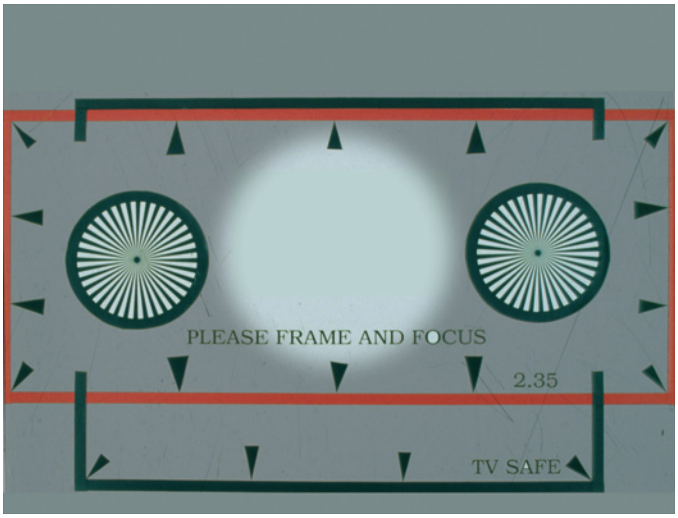


**Figure 4.6:** *A telescope or binocular matte presents compositional conundrums with common top systems. The circle will be center frame in 2.35, yet will appear off-centered to the top of the frame upon TV extraction.*

## Exotic Formats

### 3-Perforation

The 3-perforation pulldown was developed as a production cost-saving measure. By not shooting the extra perforation of image area, one-fourth of the film cost can be saved. The downside is that specially modified equipment (such as cameras, synchronizers, and film transports) is needed to handle this unusual format. The other drawback is that the oversampling advantage of Super 35 is lost, so when problems occur such as microphone booms appearing in shots, you have to either blow up or create a matte painting to hide the mistake. Preparing counts or numerical instructions for an effect can be difficult because it involves introducing 3-perf numbers into a 4-perf world. This can create confusion unless you build or rent special equipment that will read out in 3-perf frames. I've never seen a study on the subject, but I think the cost savings at the beginning may be overtaken by the cost overruns at the end of a 3-perf show. As more facilities adapt to this specialized format this will be less of an issue.

### Super 16 mm

Regular 16 mm film is smaller than 35 mm and is still perforated on both sides of the image. As a result, the image area is reduced. The format is fine for 1.33 TV production but falls short for blowup to 1.85. The Super 16 format eliminated the perforations on one side of the film and allowed the image to go all the way to the edge of the film, creating more image area. This has become a viable capture format for high-definition broadcast when the negative is put directly into a scanner made

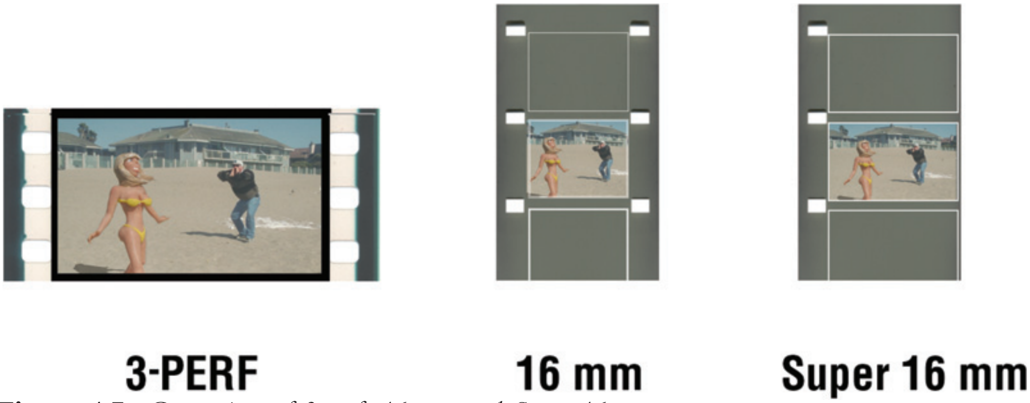

**Figure 4.7:** *Comparison of 3-perf, 16 mm, and Super 16 systems.*

for this purpose. The danger of shooting 16 in this manner is that the bulk of 16 mm handling equipment is designed to transport the film on both edges. It is very easy to accidentally run the negative through a film-cleaning machine or printer that was designed to touch the film on both sides of a dual-perforated stock and expose the precious negative to damage along the far side of the image area. You must be very conscious of the journey the negative will take after photography so as to protect the original. If the film goes from camera to processor to scanner only, it can greatly reduce the chance of damage. The drawback of 16 mm for effects work is the inherent instability of the image, especially with Super 16 because it is registered on only one side using the looser square perf.

## VistaVision

VistaVision was developed in the 1950s by Paramount to give ultra high fidelity to widescreen imagery. The image was captured on an 8-perforation wide image, which doubled the amount of film area normally used for production. The format fell out of favor until 1977, when John Dykstra brought back its use as a visual effects format for the film *Star Wars*. This format again made use of the oversampling idea: effects were shot and composited onto VistaVision and then reduced to CinemaScope for the final product in order to maintain and preserve the quality of the imagery. With the widespread use of scanning and digital manipulation of images, VistaVision is not used as often today, but the practice of starting out with including more information than the final product will contain continues with the choice of scanning resolution. Starting with a resolution higher than the final output resolution allows an image to be blown up or manipulated much more than would be possible otherwise.

## 65 mm

This is an extremely large film format that is 65 mm in width. As with 35 mm film, the image can be distributed upon this larger negative to yield a variety of aspect

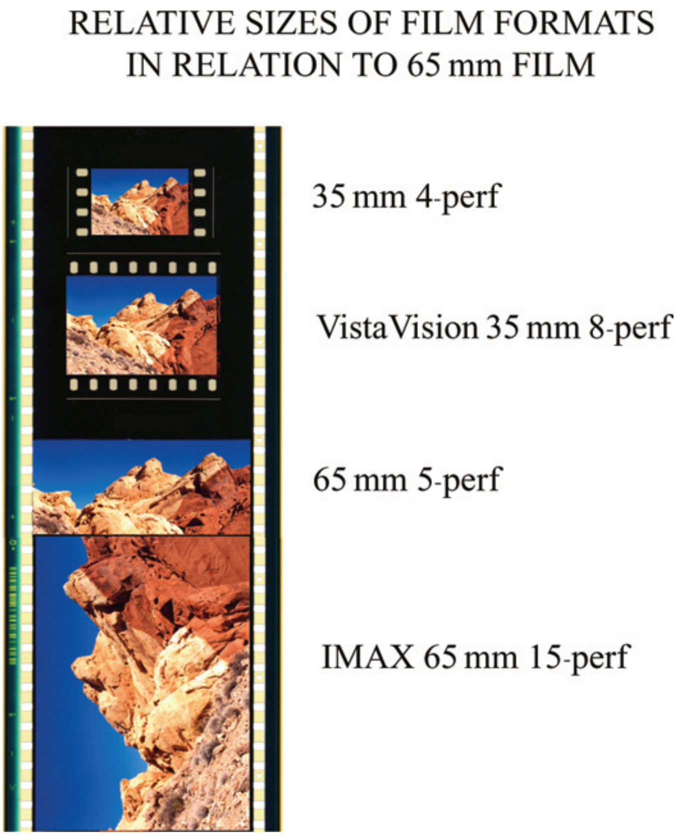


**Figure 4.8:** *Comparison of different film formats laid on top of 65 mm film. The 35 mm is full silent Academy format. IMAX is 10 times the size of a conventional 35 mm image.*

ratios and images sizes. A standard 65 mm movie format is a 5-perf tall image having an aspect ratio of 2.2. This negative is then printed onto 70 mm print stock. The print stock is slightly wider on the outside of the perfs in order to accommodate sound track information. The 65 mm film can also be used to expose for IMAX, which has a 15-perf image with a 1.37 aspect ratio. As you might imagine, this is an extremely expensive format that is commonly utilized for specialty museum presentations.

## What About Digital?

During the development of high-definition television, there was much debate over what the aspect ratio of this new medium should be. Based on the film formats discussed previously, there were many heated debates about adopting one of the aforementioned film aspect ratios. The final result was a compromise aspect ratio that became 16 : 9 or 1.78. When different film aspect ratios are broadcast into this frame, the image is cropped or resized to fit within this standard. When a digital cinema camera is used to make a motion picture, one of the aspect ratios listed above for film will be used for composition. The completed picture will be projected in the theater using one of the film ratios regardless of what medium captured the images. The main difference is how the image is captured and the amount of resolution the image contains. We will examine these new cameras in Chapter 7.

# Chapter 5
## How Film Works

Despite the clarion call to shoot everything digitally, motion picture film continues to hold its own. The reason for this is the fact that it is a proven technology that has been refined over a century of use and is the most high-resolution archival medium we have going. If film were of poor quality, the digital folks wouldn't be trying to mimic it so much. Two things make this clearly apparent. First, each time you shoot a motion picture frame at a rate of 24 frames per second (fps), you get an exposure time of 1/50 of a second. In that flash of an instant, a movie film frame captures 40 megabytes of information! Second, I can go to a film vault and pick up a roll of film shot by Charlie Chaplin in 1916, hold it up to the light, and still see the image. I recently went to pull some digital files off an old Exabyte tape that was very popular a few years ago and was lucky enough to find one person in all of Hollywood who could read it. Home movies have to constantly be copied onto the current medium of the day lest they be lost. Such is the modern world, and we all ride the wave of change. On the positive side, digital has eliminated all the annoying problems associated with film, such as scratches, dirt, and image weave. There are many similarities between film and digital regarding the way these mediums capture and record light. The film system is an impressive template.

### Persistence of Vision

Movies came to be through the discovery that if you moved a progression of images past the eye fast enough, the brain would perceive them as a single moving image. Devices such as the Thaumatrope, the Phenakistiscope, and the Zoetrope were fun optical toys that capitalized on this phenomenon, which is called persistence of vision. These toys were the foundation of motion picture technology. After much study, it was found that disparate images needed to be presented to the eye at a rate faster than 45 images per second in order to avoid the perception of "flicker." Now this might seem puzzling, since the standard movie frame rate is 24 pictures per second. However, the movie we see projected in the theater actually flashes each picture two times in front of the audience through the use of a two-bladed shutter. In the movie camera, the film is pulled down in front of the aperture during the dark cycle when the spinning shutter disc blocks light from entering the camera. After the film is seated, the disc spins to the cutout section of the shutter that allows light to expose the film. After exposure, the shutter blocks the light, and the next frame of film awaiting its exposure is pulled into position and seated. A movie projector essentially does the same thing, with the exception that the shutter has two cutout sections; this allows a single frame to be projected twice before it is replaced with the next, which speeds up the refresh rate to a point where persistence of vision is achieved.

## Composition of Film

Black-and-white film is composed of an acetate base and a very thin film of emulsion filled with millions of tiny silver halide crystals that are sensitive to light. After exposure, the film is processed by first running it through a developer that turns the lightstruck crystals into silver (rendering them black) and leaves the crystals that saw no light unaffected or clear. This is the reason film starts out as a negative image. The next chemical is a stop bath that halts the development process. The final step is the fix, which chemically tells the film not to be sensitive to light anymore and therefore "fixes" the image onto the film. In order to see a positive image, this negative is contact printed onto another negative film that will reverse the polarity of the image and yield a positive picture. The beauty of this system is that the original negative can be stored in a vault and kept safe, while the print takes the abuse of constant projection.

To further explore how film emulsion records light, a plot on graph paper called a D–log E curve can be created. This plotting scheme was invented by two gentlemen by the names of Hurter and Driffield (this is why it is also referred to as an H & D curve). The D stands for density and the E for exposure. To plot these curves, first the film is exposed in a device called a sensitometer that has a light source that illuminates a step tablet. A step tablet is a series of graduated densities on a piece of glass that goes from absolutely clear to dead black with a series of varying gray densities in between. It has a contrast range of 1000 : 1, which means that the blackest part of the tablet is 1000 times more opaque to light than the clearest section. Once the film is exposed on the sensitometer it is processed, and then each step of the imaged step tablet is read on a densitometer. A densitometer is like a miniature light meter that reads the density of film, or how opaque it is to light. On the D–log E curve, the

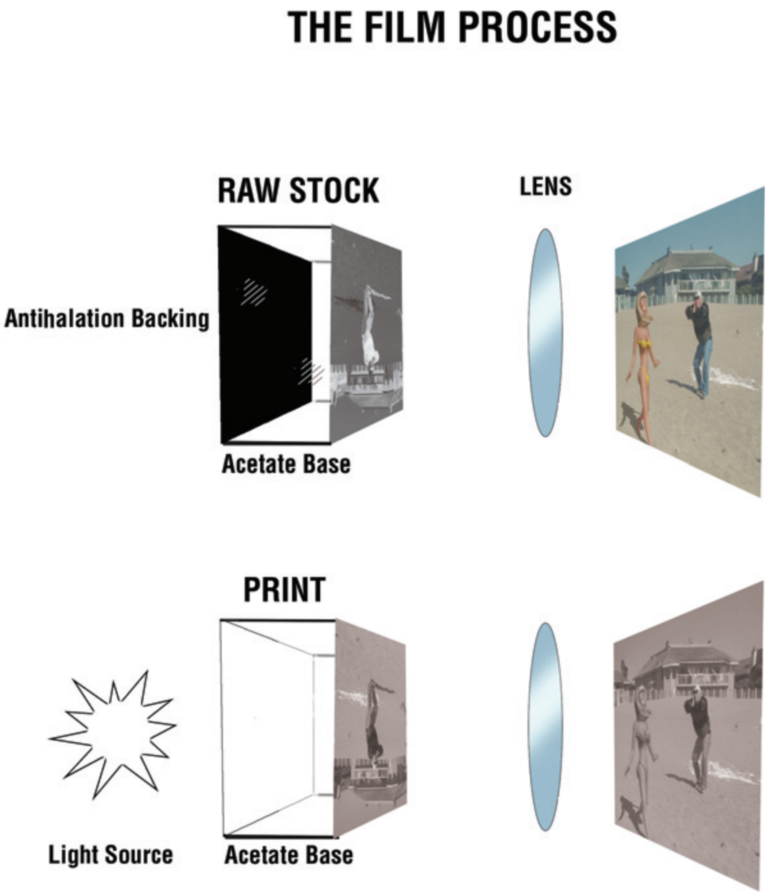


**Figure 5.1:** *The black-and-white film process. The raw stock has a thin emulsion containing millions of light-sensitive crystals that when exposed to light and processed result in a negative image. The antihalation backing prevents light from bouncing back and re-exposing the emulsion from the opposite side. The antihalation backing is removed during processing. A print of the negative yields a positive image that can be projected.*

*x* axis represents the exposure coming through the step tablet on our sensitometer. The *y* axis represents the densities yielded by the film as read on the densitometer.

The math used is logarithmic, which means that the numbers used to express the values on the step tablet are such that they appear as an even progression to the eye. If you used straight linear numbers such as 10, 20, 30, 40, etc., the difference between 10 and 20 would appear much greater to the eye than the difference between 80 and 90. By using a logarithmic scale, the ratio of brightness between adjacent steps is constant, rather than the difference being constant as when using linear arithmetic. This type of math is very handy for photography, because numbers stay constant. One example is in the use of neutral density (ND) or gray filters used to dim down the light for photography. To darken the light by a stop, you would add 0.30 ND,

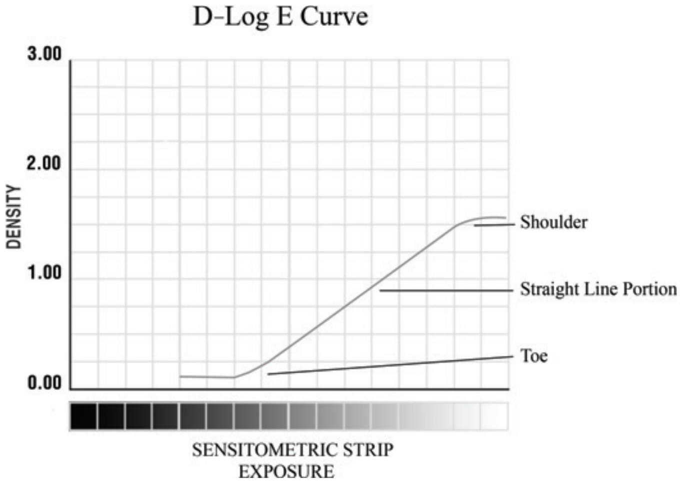


**Figure 5.2:** *The Hurter and Driffield D–log E curve. The characteristic curve of a film's response to light has three sections. The toe is the shadowy underexposed regions. The straight line section is the midpart of the range, and the shoulder represents the bright overexposed section of the film.*


**Figure 5.3:** *A densitometer reads the density of film, or how opaque it is to light. For color film, the wheel above the sensor can select a red, green, blue, or clear filter to get different color readings off the film. The number display indicates that the film being read has a density of 0.44 to white light.*

which would cut out half of the light. To cut the light again, you would add another 0.30, creating a 0.60 ND that cuts the light by another half, or two stops of light. For three stops you would add another 0.30 to get 0.90 ND. In a linear system (which would always double the figures), the numbers quickly become unwieldy, as 30 would become 60, then 120, then 240, and so on.

Looking at the graph from left to right, the first few steps are clear to the same degree, so there is a flat density response on the D–log E curve where the density is that of clear film, or about 0.06. Where the step tablet changes from black to a dark gray, the film began to see a bit of light and started getting slightly denser, to, let's say, 0.08. Eventually the density and the exposure changes start to react in a repeating pattern, that is, $x$ amount of exposure increase gives you $y$ amount of density change. The first part of the curve is known as the toe, and the part that gives repeating results is called the straight line portion. There will come a point at which the density will not increase as much as the exposure increases and the curve will start to taper off, until it becomes flat again when the film obtains maximum density. This section is called the shoulder. The reason this curve is so important is that it expresses where deep shadows, highlights, and midtones appear in the image. If the film is underexposed, there will be no information from perhaps the middle of the straight line upward. This translates into a very light negative that has hardly any density. As a result, when you make a print you will have to just barely kiss light through the thin negative, which will mean you won't get any dense blacks on the print, so the blacks become muddy and you lack contrast. Conversely, if the film is overexposed, the negative becomes really dense and you have to slam light through it to make a print. As a result, you lose graduated details in the highlights because that area has been flattened out in the shoulder, and you will again lose density in the blacks because you may have not left any clear film to print through due to overall fogging. The straight line portion is the area where the exposure of the elements you want to keep should appear. In other words, for a closeup, the actor's face should be placed well within the straight line region.

## How Do You Know How to Expose the Film?

When shooting film, a device called a light meter is used to tell us how to expose the film. There are three types of light meters. One is a reflected light meter, which reads the light reflected off an object. This type of metering is found in many cameras, which you just point and shoot. The light is "metered" through the lens, and an exposure value is determined. Another device is an incident light meter, which has a translucent sphere atop the sensor that evens out the light hitting the meter. This meter measures the light hitting the object and is the most common in professional use. The third type is a spot meter, which is a reflected meter with a telescope and eyepiece so that you can see exactly the portion of the image that you are taking a reflected reading from.

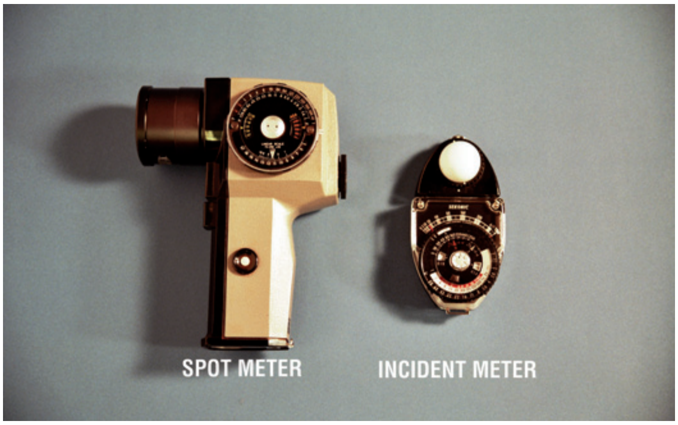


**Figure 5.4:** *Two of the most common light-metering devices: a spot meter and an incident meter.*

The meter has to be adjusted for the sensitivity of the specific film that is being used. Film emulsions have different EI (exposure index) ratings that indicate the film's sensitivity to light. This rating is also referred to as ASA (American Standards Association). A highly sensitive film might have an EI of 500. These means that you could perhaps shoot in regular room light conditions. An EI of 50 means that you would need bright light to expose the film properly. Each time the EI number doubles, the film gains one stop in sensitivity. If you need f/8 to shoot with film with an EI of 50, you could shoot the same shot at f/11 if you loaded up film that had an EI of 100.

Typically, you would use an incident meter at the subject facing the camera. You would set the meter to, say, EI 100 and take the reading, and it would tell you the f-stop you should use shooting at 24 frames per second (or another frame rate) to obtain a good exposure on the straight line. Another way of obtaining good exposure is to use what is known as a gray card. A gray card is a small card that is painted a perfect gray on one side and white on the other. Some cards, such as the one manufactured by Kodak, have a gray, white, and black reference all on one side of the card.

This calibrated 18 percent gray card is used as a subject and reference for a point that is right in the middle of the most important part of the D–log E curve between white and black. You would put the gray card at the subject and read it with the spot meter to obtain the correct f-stop.

Figure 5.5 shows what you would see in the eyepiece of an older Pentax spot meter. A reading is being taken off a Kodak gray card; the little circle shows the area that is being read, and the needle points to the exposure value (EV) number of the reading. On the outer dial of the meter you would align the number 11 with the central pointer and then read the f-stop across from the exposure time or frame rate you were using. The number 11 is relative; in bright light conditions the EV might read

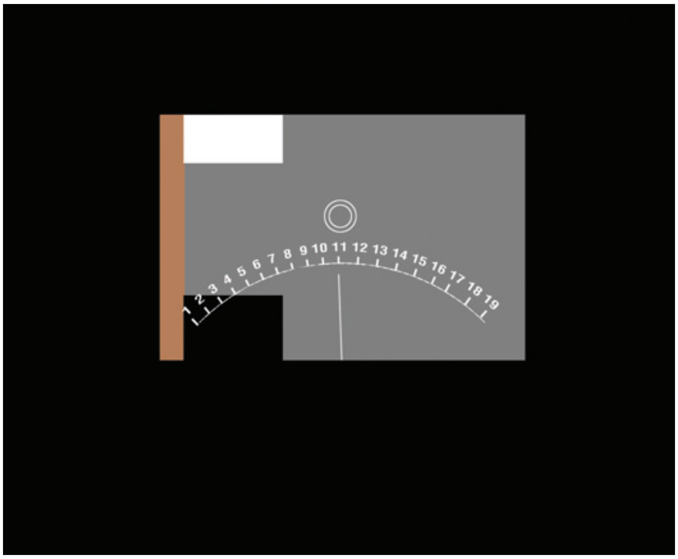


**Figure 5.5:** *A view through a spot meter focused on a gray card.*

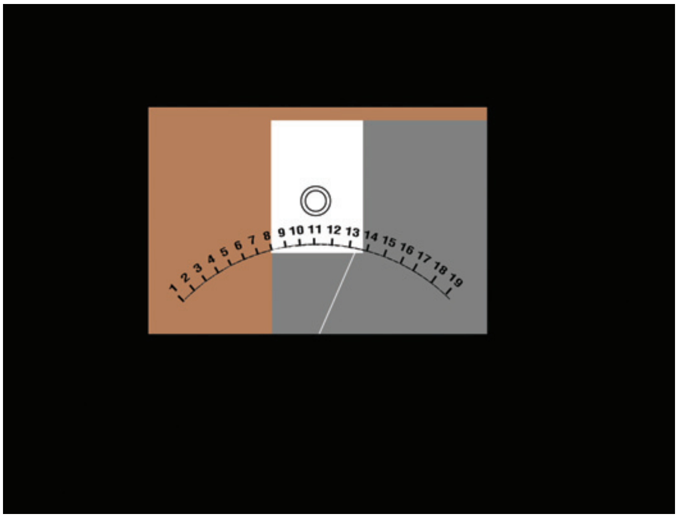


**Figure 5.6:** *A spot reading off the white section of the gray card.*

12. The number 12 just means that it has one stop more light than 11. If you read the gray and get 11 and put that on the center mark and find that at 1/50 of a second (24 fps) you get an f/8, you will discover that if the card is put in brighter light conditions and the EV winds up being 12, the f-stop will be f/11, or one stop darker to compensate for the added light (at 24 fps).

As you point the meter to the white card, you will see that the EV jumps from 11 to a little over 13, or $2\frac{1}{3}$ stops. The black card will do the inverse. The EV readings

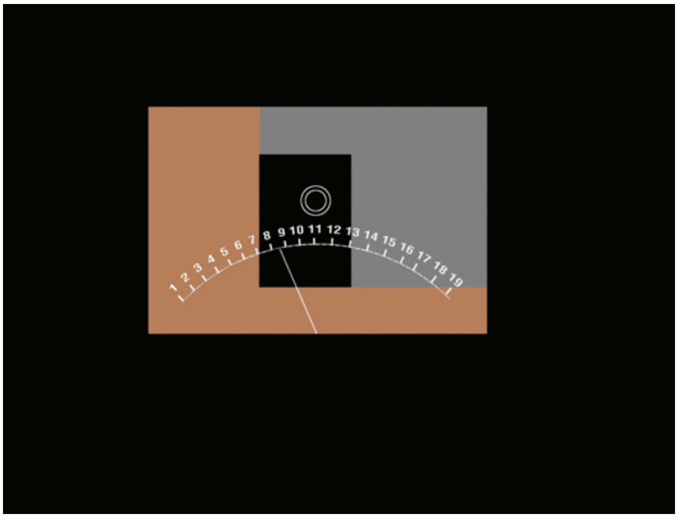


**Figure 5.7:** *A spot reading off the black section.*

are valuable in that you can isolate the brightness values in the scene according to zones. The zone system was devised by famed black-and-white still photographer Ansel Adams and is a way of predicting the tones and contrast that will appear in a photograph. The gray card is zone 5, and Caucasian skin tone is zone 6. In Chapter 10 we will see how you can use a spot meter to determine not only the exposure but also the relationship of different tones within a scene.

> You might wonder why the card is 18 percent gray instead of 50 percent, which would seem a logical halfway point between black and white. Kodak arrived at 18 percent because visually it looks like halfway between black and white; that is why it makes a better reference. It is gray because gray is an equal mixture of all colors. When a gray card is positioned in a shot and made to look gray in a print, then all the colors will reproduce properly. This gray card system is vitally important not only for film but also for digital.

If the film is over- or underexposed, the tones on the gray card will lie on different portions of the curve and will begin to distort the image by flattening it out. In other words, instead of there being a healthy space between white, gray, and black, the difference between them will be decreased, resulting in a low-contrast image and a loss of detail.

## Contrast

Contrast, or gamma, is technically defined as the slope of the straight line portion. The steeper the slope, the more contrast the image has; in other words, it has fewer

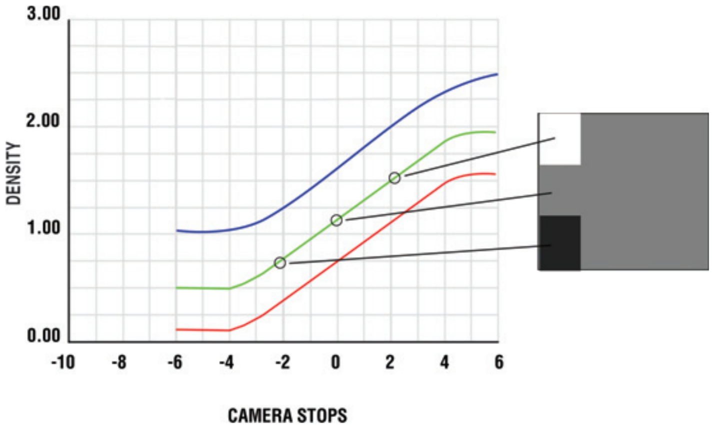


**Figure 5.8:** *This graph shows where the reference tones on a gray card lie along the green curve of a color emulsion. If we project the gray card exposure down to the bottom scale, we see that the gray exposure becomes the zero point and the white is $2^1/_3$ stops brighter than gray.*

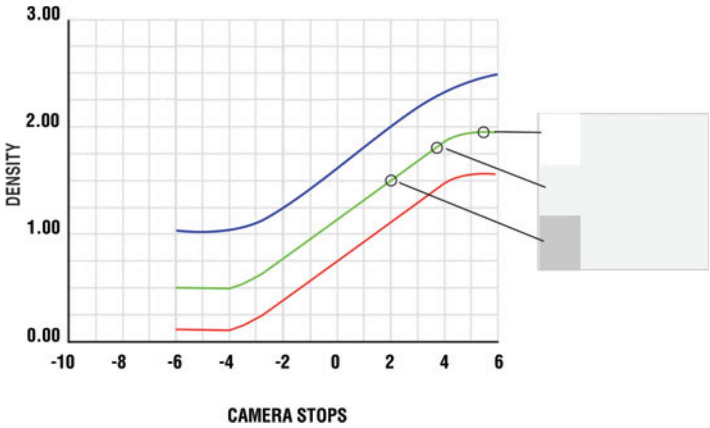


**Figure 5.9:** *An overexposed gray card.*

steps between white and black. Certain high-contrast films used for mattes and titles are pretty close to being just black and white with no gradations at all. In a low-contrast film, the curve is much flatter and will contain many variations of gray along a large exposure range with less density at the top. Most negative film has this low-contrast feature and has a gamma of around 0.65. The rounded-off number 0.65 is derived by dividing the rise over the run in the straight line of the curve. So if the negative film goes up in density from 1.00 to 1.19 over a one-stop increase of 0.30 on the exposure line, that is a rise of 0.19 divided by the run of 0.30, or 0.63, which is the gamma, or contrast, of the film. The film that the print will be made from is a higher contrast film of about 2.0. The reason for this seemingly peculiar mismatch is that a low-contrast negative can capture a much broader range of light than a higher contrast film. Film can capture a range of light spanning 8–10 stops

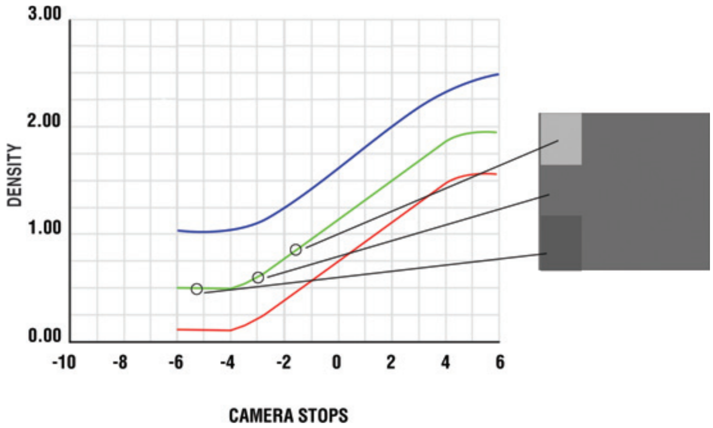


**Figure 5.10:** *An underexposed gray card.*

(8 for the straight line portion and 10 if you include the toe and the shoulder). When we make a print with the high-contrast film, we are selecting a certain portion of the image on the negative that we want to see. With the negative positive system, we can print the film up or down to emphasize the highlights or shadows and place important information on the print. So having a low-contrast negative gives what's called wide latitude, which allows for a wide printing range. The goal, of course, is to reproduce the scene so it has a one-to-one relationship between exposure and density, just like we see with our eyes. The final "curve" when we view the film in a theater would look like a line that evenly bisects the exposure and density graph, or a gamma of 1.0. Using a low-contrast negative and a high-contrast print achieves this by multiplying their gammas: $0.65 \times 2.0 = 1.3$. Now, 1.3 isn't the same as the goal of 1.0, but it works out because that 1.3 takes into account aspects such as lens flare and ambient room light in the theater. This is why the final output contrast of the system is slightly higher than 1.0. When this slightly contrasty print is viewed in a darkened (not dead black) theater, the resulting appearance is that of a gamma of 1.0, or how the image would appear normally to our eyes.

## Why Not Use Normal Contrast Film to Begin With?

In some cases, normal contrast film is used from the start; it's called reversal film. There were films developed for newsgathering and sports study that upon processing yielded a higher contrast positive image. This was accomplished by turning the exposed film to silver, bleaching it out, and then exposing the remaining crystals to chemical "light" in the processor before the final fix was applied. The problem inherent in reversal films is that there is a much narrower latitude, so the exposure has to be hit dead on, and when making a print, there isn't much room to correct the exposure for color or density. Reversal is great for home movie film, but it is cumbersome in a regular production environment.

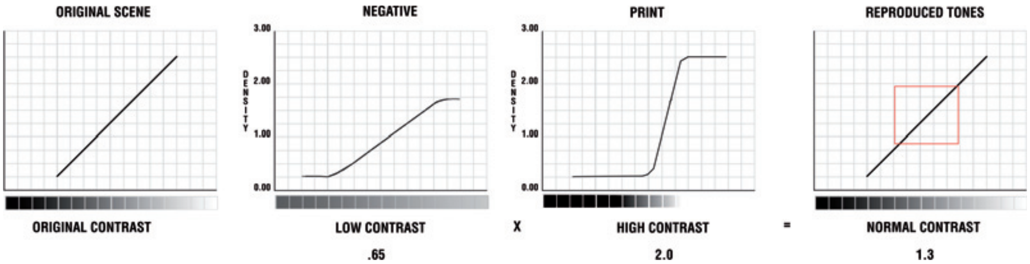


**Figure 5.11:** *Pipeline of tone reproduction in film. The red box on the last graph indicates that portion of the original scene that is reproduced for viewing. If the film was printed brighter or darker, the red box would move higher or lower along the tone line, allowing the highlights or the shadows of the original scene to be favored.*

## Color

To generate color, three thin emulsion layers that are sensitive to red, green, and blue light, respectively, are placed atop one another. Each of these color layers will have a separate curve showing its response to light, as shown in Figure 5.8. When a print is made, dyes are produced chemically in the film emulsion that render cyan, magenta, and yellow layers that represent the color in the scene. When these so-called subtractive colors are overlapped, they combine subtractively to reproduce the colors in the scene.

An issue comes up with color rendition, however, in that the sensitivity of the emulsion is balanced to a certain mix of red, green, and blue light. To explain more about this, we need to take a look at the electromagnetic spectrum.

## Light

Visible light is composed of a range of wavelengths between infrared and ultraviolet. A rainbow or prism can separate these wavelengths so that they appear as bands of color showing the component parts of white light, red, green, and blue. As with paint blends, there can be a warm white and a cool white. It is still white, but it has different proportions of the red, green, and blue mixture.

Film color sensitivity is expressed in color temperature. Heating a black body radiator to a high temperature until it glows white-hot derives the color temperature. When the light source matches the black body in color, it is said to have a color temperature equal to the temperature to which the black body was heated. The temperature scale is in degrees Kelvin (K). At different Kelvin temperatures the black body radiates different percentages of red, green, and blue light. For film, it was decided to formulate a color emulsion that would render a gray card illuminated with 3200 K light as gray. This film is called tungsten film; it was named after the filament used in tungsten movie lights. Daylight, on the other hand, is rated on average at 5500 K and is a much bluer white light than tungsten. This can be seen very easily if a tungsten lamp is lit

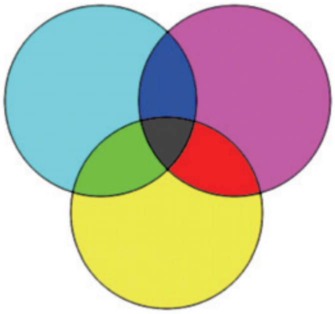


**Figure 5.12:** *Subtractive color reproduction. When the secondary color dyes overlap, they reproduce the primary colors of red, green, and blue. The combinations of various densities of the cyan, magenta, and yellow dye can produce an enormous range of colors.*

near a window during the day. The lamp appears very reddish in comparison to the light outside. At night, when the room is illuminated only by tungsten light, your brain compensates and adjusts to make the tungsten light appear white. Film does not have this built-in perceptual adjustment, however, so different emulsions are formulated for the different Kelvin temperatures. Daylight film is balanced for 5500 K and is much less sensitive to blue light. Tungsten film is made to be more sensitive to blue light since there is less of it under this 3200 K illumination.

Film emulsions are balanced to render a gray card as gray when lit with a specific color temperature. Daylight film is "balanced" for 5500 K so that a gray card shot outside will reproduce as gray. If tungsten film was taken outside and shot, the resulting image would be awash with blue and would need to be color corrected. The opposite is true of daylight film. Tungsten film can be used outside with the aid of an 85 filter.

The 85 is an orange filter designed to correct the daylight color temperature to tungsten. Since the filter will result in some light loss, Kodak recommends a change in film sensitivity when using this filter. The film label for Kodak 500 T 5218 indicates that it is tungsten-balanced stock (because of the T) and the speed of the film is 500. Below this label are two exposure indexes. When shooting with tungsten light, the film is rated at 500 ISO. When shooting outdoors using an 85 filter to correct the daylight to tungsten, the speed or sensitivity of the film drops to 320 ISO. In video cameras the color sensitivity is similarly adjusted by choosing either a lightbulb icon (for 3200 K tungsten light) or a sun icon (representing 5500 K sunlight). It is important to note that it was also decided that the 5500 K color temperature should

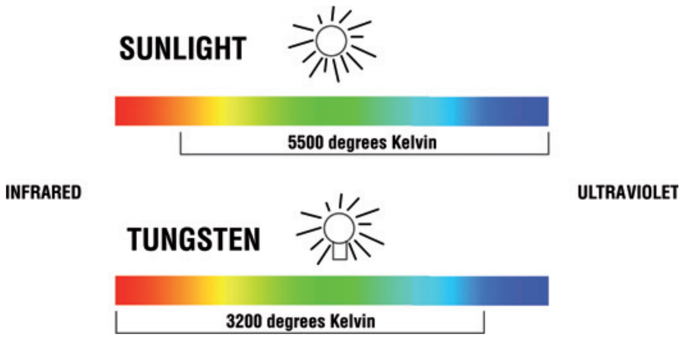


**Figure 5.13:** *Sunlight contains more blue light than tungsten light.*

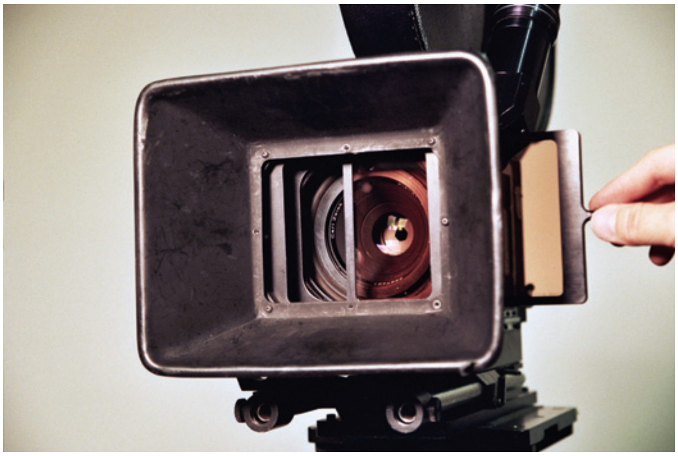

**Figure 5.14:** *An orange 85 filter is placed into a film camera's matte box to color correct the bluer daylight color temperature to the tungsten color temperature. With this filter added, tungsten film can be used outdoors. Since any color filter will absorb light, the film's sensitivity will have to be adjusted to make up for the light loss.*

also be the color of the light when viewing movie film on a light box or projection. When film print is evaluated for color over light boxes, the bulbs illuminating the table must be 5500 K.

## Shooting Raw

A new trend is to shoot with no filtration and correct everything later on in post. The Kodak Vision2 HD color scan film, for example, is designed to expose at 500 ISO with either tungsten or daylight. When exposing using daylight, a postprocess digital corrector is applied to correct the color. While this works and can be a boon for filmmakers in a rush who don't want to bother with filters, this shortcut comes at a price. This film is balanced for tungsten, and when shooting in daylight, some layers will be underexposed in relationship to others. When color correction is applied in post, the underexposed layers will be artificially brought up and will create an increase in noise or grain. The system works, but it is a compromise. In all fairness, the difference in quality between shooting with a filter and without may be minimal (depending on the judge), but you will always be better off shooting with a compensating filter.

The other issue that may come up occurs when shooting in a multiple color temperature setting. For example, if you light an interior with tungsten light and have windows revealing the outside daylight, the post process will give either correct color for the windows or correct color for the interior. This situation might seem to be a good argument for the "power window" controls in the digital color correction laboratory, where a matte is placed around the window so it can be corrected by itself to bring both color temperatures in balance. This doesn't seem like a big deal until one of the actors gets up and walks in front of the window. Now you need a hand drawn animation matte to keep the actor the same color. The Digital Intermediate suites (digital laboratory) are very expensive, and the power window mattes are only good for simple shapes or easy matte extractions. If your star needs matte work, it will mean taking the shot outside of the real-time suite and sending it to a visual effects house to laboriously create hand drawn mattes to create a color correction composite. This is an example of how ignoring filtration can lead to a senselessly expensive fix later on. To avoid this scenario, you could shoot the interior with daylight lamps or filter the outside windows with 85 gels to correct the daylight if shooting the interior with tungsten.

## How Does This Relate to Digital?

In the race to replace film, the high-definition and video worlds have followed the same pathway that film took. For a long time, video took the route of reversal film, generating instantly usable images at the sacrifice of latitude. Standard video can only capture five stops of light, so it is normally relegated to relatively low-contrast situations. Anything above or below this range will top out at maximum white or maximum black and thus will contain no detail. An example is shooting a dimly lit interior next to a bright window. If the interior is exposed well on video, the window will be "blown out" at maximum white and will be a solid white tone with no detail. As Figure 5.8 shows, five stops are pretty much only enough to cover the gray card range. Film negative gives you at least two stops above and three below to capture many more gradations of light. Recently, digital systems have become available that are similar to the film system. Digital cinema cameras record a much wider range of light that is then selectively corrected to yield a viewable image.

## Film Reproduction and the Optical Process

The goal of film reproduction is to copy the film so that it matches the original as much as possible. Two things happen in the analog world when film is copied. It gains contrast and increases the grain. Kodak devised a reproduction system that minimized these two issues by creating an intermediate film that has ultra fine grain and a low-contrast gamma of 1.0 that reduced the contrast increase by being neutral in the reproduction equation. The process was to copy the original negative onto the intermediate film to create an interpositive. This interpositive was then printed to the intermediate film again, where it became an internegative that could be intercut with the original negative without a loss in quality. In mathematical terms, the reproduction equation was an extension of the negative and print. Original negative gamma 0.65 × interpositive gamma 1.0 × internegative gamma 1.0 × print gamma 2.0 = gamma 1.3 overall reproduction. In practice, this scheme does not totally eliminate contrast buildup, but in the majority of cases the duplicate is imperceptible from the original.

In rear projection composites, contrast was a big problem because a high-contrast print was projected behind the actors and it was shot onto negative so the result yielded a higher contrast rear projection image: rear projection plate 2.0 × 0.65 camera negative = 1.3 on the camera negative. When this was printed, it increased the rear projection contrast even further, by ×2, so the final contrast of the rear projection plate was a whopping 2.6! As a result, rear projection composites that used regular prints looked terrible due to this contrast increase. To remedy this contrast buildup, rear projection plates were made low contrast. The simplest low-contrast method was to shoot on raw stock that had a slight flash or overall fog put on it by the lab before photography. This meant that absolute black could never be shot, because there was always a slight density on the negative film. After the plate was shot, a special rear projection print was made off the negative and the print film was given a slight flash so that there was always a bit of density in the highlight areas. On the negative, the highlights would be very dense and prevent light from exposing the print. By flashing the print on a second pass, a little light would be added in the highlight areas, giving them a little density instead of just being clear film on the print. As a result, the blacks would be gray and the highlights would be light gray, resulting in an overall low-contrast print. When this print was copied it yielded a more normal contrast image in the composite that matched with the foreground subject.

You can experiment with this idea using Photoshop and a copy machine. Create two different-contrast photographs using Photoshop, one at normal contrast and one at a low-contrast setting, and print them out on a photo-quality printer. When you copy these photos on a copy machine you will find that the low-contrast photo will copy better in that its contrast will increase to a pleasing result. The normal-contrast photo will gain in contrast and look poor in comparison. This is a great trick to use to produce attractive yet inexpensive flyers on a copy machine.

## The Optical Printer

The optical printer was the primary effects camera used for 90 percent of all film effects work. The printer consists of a movie camera pointing at a projector. More sophisticated systems have a secondary projector and lens that image a picture atop the picture in the main projector head. This is known as an aerial image printer. There are no screens on which the image is projected; instead, it is more like macro photography, in which the camera takes a picture of the actual film itself atop a light source. The device is an editor's dream for its ability to copy images and at the same time alter speed, zoom in, zoom out, change color, make tilts, recompose, make fades, dissolves, and wipes, and generally put in all the punctuation marks of cinema. Aside from creating these and other exotic effects such as blue screen, the optical printer is the instrument that put together all the titles for the movies. What follows are all the steps that were used to create a typical title sequence for a film. The technology is not as important as the organizational steps involved to create something that has to be delivered in a timely manner without flaws.

## A Typical Optical Main Title

The most important step in any effects process is the creation of the road map. A lineup person is given "counts" from the editing room that indicate the duration of the titles and the length of the fade-in and fade-out. The editing room also gives the

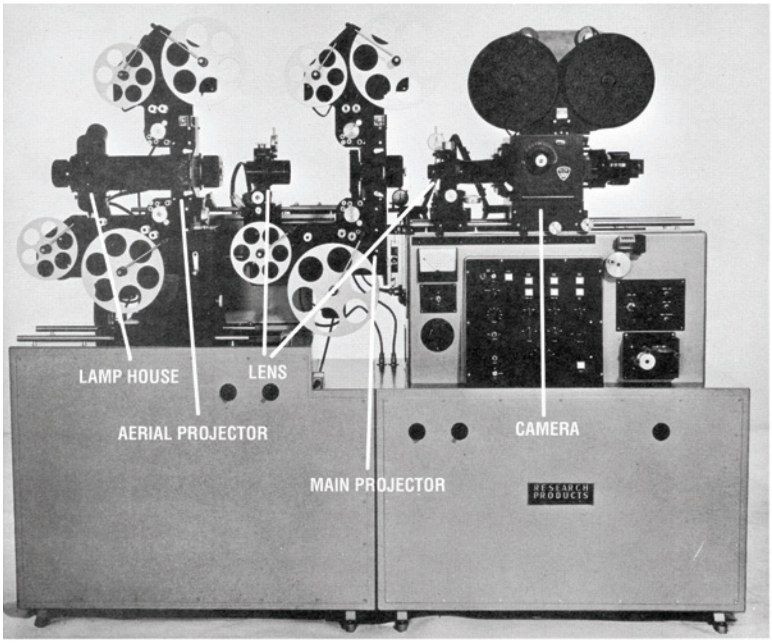


**Figure 5.15:** *An aerial image optical printer.*

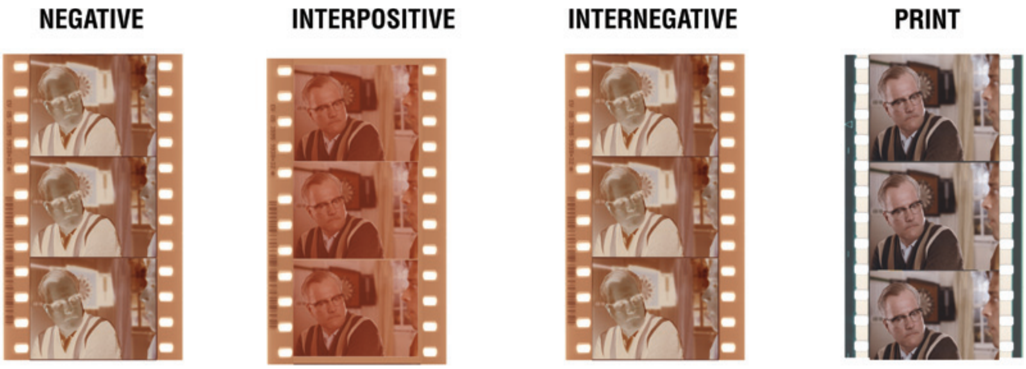


**Figure 5.16:** *The intermediate process of film duplication. Both the interpositive (IP) and the internegative (IN) are made using the same intermediate raw stock 5242. An IP is made from the original negative as a contact print. This IP is then put into one of the projectors of the optical printer and duplicated with various effects to produce the IN, which is then cut into the picture to make the final prints.*

key numbers of the negative that are to be used for the background imagery. Key numbers are numbers that are printed by Kodak at the edge of every roll of raw stock they sell that create a unique designation for each frame of film that is shot on a movie. When this information is collected from editorial, the different rolls of negative are pulled from the storage facility and spliced together in the order that they will be shot. The title cards are also ordered from another facility that creates art cards designed to be backlit on an animation stand. This facility checks with the legal department of the studio to make sure that the spelling is correct and the size of the relative names are correct as well. All the sizes of the type are negotiated by agents and lawyers and are relative to the size of the main title.

## The Animation Stand and Field Chart

The animation stand is set up to shoot the correct format to which the title art is aligned. Usually the art is made to what is called twelve-field center. Twelve-field refers to a master standardized chart that is 12 inches wide with a height of 8.75 inches, creating a 1.37 aspect ratio that matches the ratio of the Academy camera aperture. The chart has hole punches at the bottom that allow it to be registered on pegs, enabling it to provide a standard reference for the camera. The ratio is reduced upon itself in 1 inch increments to create a series of fields that denote 12 distinct frame sizes.

For example, referring to Figure 5.18, if the operator was told to shoot the art at a six-field center, the camera would be lowered to shoot a 1.37 ratio area on the field chart that was 6 inches wide. If the operator was then told to shoot the art three fields south, then the art would be moved so that the crosshairs of the camera aligned

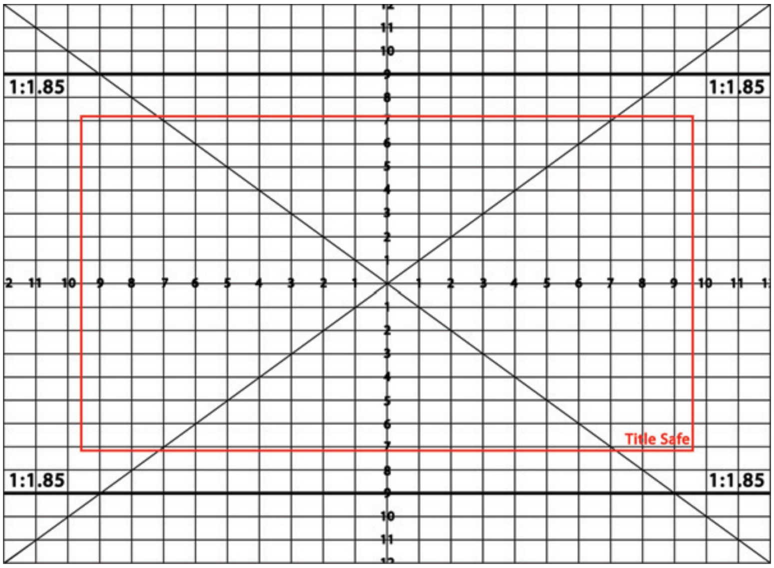


**Figure 5.17:** *A twelve-field chart used for title alignment for both optical and digital processes.*

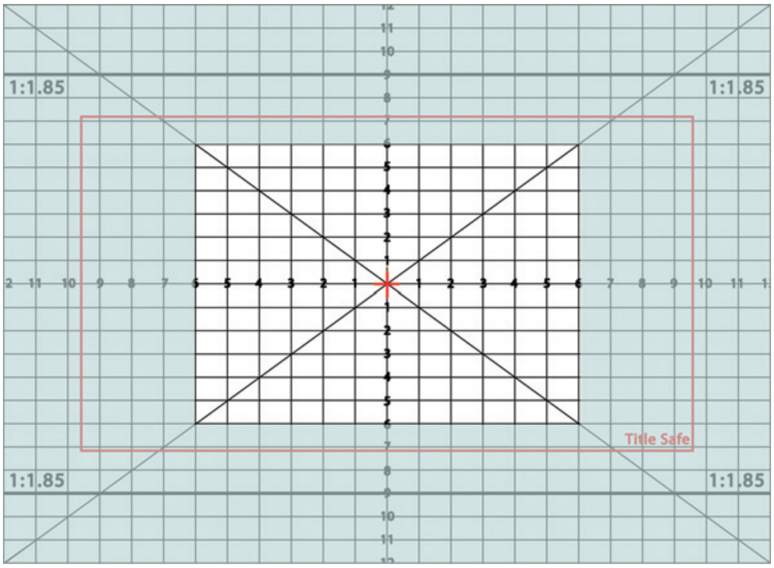


**Figure 5.18:** *The frame area of six-field center. In order to shoot this, the animation camera would be brought this much closer to the art.*

with the intersection of the three-field south line and the center line, as shown in Figure 5.19. Titles are usually shot at twelve-field center and the intersections used for aligning titles and positioning them using north, south, east, and west Cartesian coordinates. In the example in Figure 5.20, the Mr. Buckley title is positioned at six fields south.

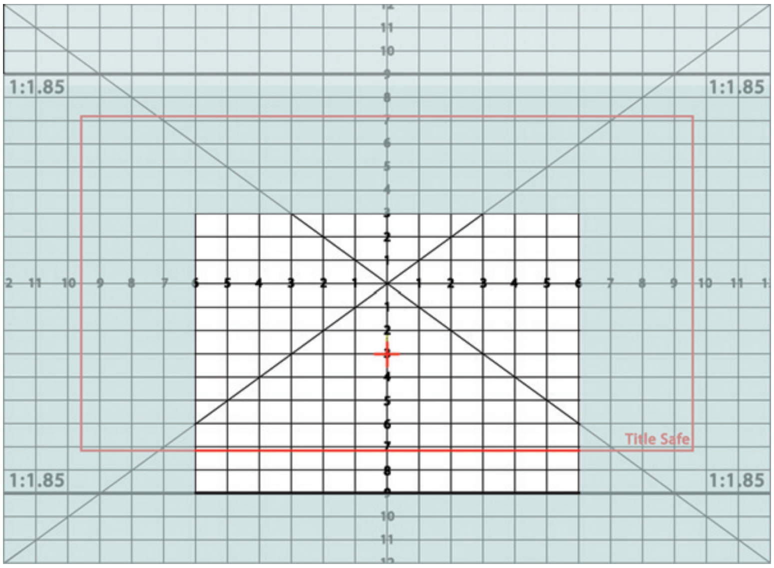


**Figure 5.19:** *Shooting a six-field area three fields south, keeping the east–west at center.*

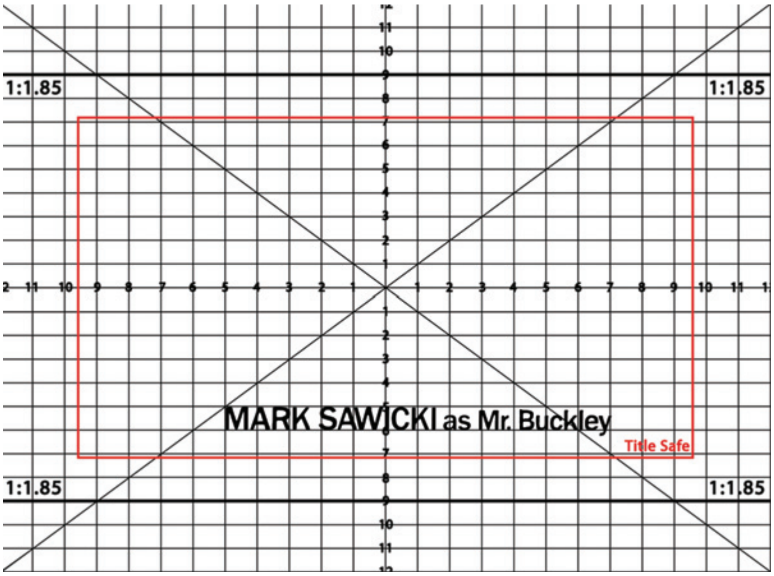


**Figure 5.20:** *Title positioned at six fields south.*

The field chart also has markings indicating 1.85 composition and the TV extraction, which is smaller than twelve-field with a 1.33 aspect ratio. It is smaller to make sure that the important image information is protected against the unexpected cutoffs that might occur in the distribution chain as the film is transferred to video and subsequently broadcast. The Buckley title in Figure 5.20 is well inside 1.85. The field chart is very useful for universally denoting problem areas on an image. Very often a film clip will be examined over a light box placed atop register pins against another film clip of a field chart. The juxtaposed clips are examined through a magnifier and you can see with absolute certainty if a microphone boom is below 1.85 or can note exact instructions, such as "Move the image up two fields to avoid the boom." These instructions are a much better translation of the requests made by a director in a screening room, where you might be told to move the image up a "squanch" (whatever that is).

Before the title art is photographed, a clip of film containing an image of a field chart is placed in the animation stand camera and projected down through the lens atop a field chart captured on animation pegs. The camera and the art bed are adjusted until the image of the chart projected on top of the chart aligns perfectly. Now a perfect twelve-field is being shot, so all the art will be positioned accurately on the film, as it was prepared over a twelve-field chart for position. After this alignment the camera is loaded with black-and-white high-contrast film and the title cards are shot in order according to the lineup sheet. The cards are transparent letters on black that are backlit to obtain a very clean image. For this operation the pattern is usually a 10 frame burst of a card, then 10 frames of black as a separation, then on to the next card. After shooting, the roll of film is sent to the processing lab for developing and printing in a registered contact printer.

## Drop Shadow Process

When the print of the title roll comes back, it is placed on what used to be called a "shaker camera." This camera is a simple optical printer set to duplicate the film exactly, or one to one. It was called a shaker because it has a moving diopter lens positioned between the camera lens and the projector. This lens is on a slider attached to a motor that moves the lens rapidly back and forth at an angle. This ferocious lens movement creates a directional blur when photographing the title print. In a way it is a form of "streak photography" in which the light is displaced during the exposure time. When a title is placed in the projector and photographed with the moving lens, an offset streak is made of the title that creates a matte with an offset drop shadow. After the shaking process, this new film is developed and printed.

## The Interpositive

After the negative roll is spliced together, it is sent to the color lab to make a color timed interpositive (IP) based on the timing used for the daily work print. The word timing means color correction; it was probably coined from the process of changing color filters in the printers over time as the film was printed. When the interpositive comes back to the lineup person, it is placed in a device called a synchronizer, which has several sprocketed wheels ganged together that allow a print to be run alongside

**Figure 5.21:** *The appearance of a low-contrast interpositive. It is orange-colored, just like a negative. The orange compensates for dye imperfections enabling good color reproduction.*

an interpositive or other element in mechanical synchronization. The device is able to read out frames and feet using a dial and a counter. The lineup person would have a marked work print supplied by the editing room that was spliced in the order of the image for the main title with grease pencil indications on the film for dissolves and where the titles should appear. The lineup person then generates a count sheet that tells the camera operator where to start and stop copying the interpositive so as to match the cut work print.

To avoid damaging the precious negative, the entire take is used for making the roll of interpositive and the operator does photographic "cutting" to reproduce the editor's wishes. This system is not unlike the Digital Intermediate process of today in which whole takes are scanned and only select files are "cut" digitally; this also preserves the integrity of the negative should changes be needed (each time you physically splice film, you destroy a frame in the process). During the lineup process, the lineup person also scribes or scratches onto the edge of the interpositive in the unused sound track area at each of the "cut" points. These marks act as a fail-safe double-check in case a number is written down incorrectly. The marks can easily be seen in the optical camera's eyepiece. Once a main title composite is started, it is often 400 feet of continuous imagery and titles that have to be executed perfectly or you have to start over. These scribe marks were good insurance for the operator. Occasionally, you can do "pickups," isolated shots that can be spliced in, but on average most titles are one dissolve after another with no easy place to cut or pick up. The first lineup sheet gives counts for shooting color wedges of each scene.

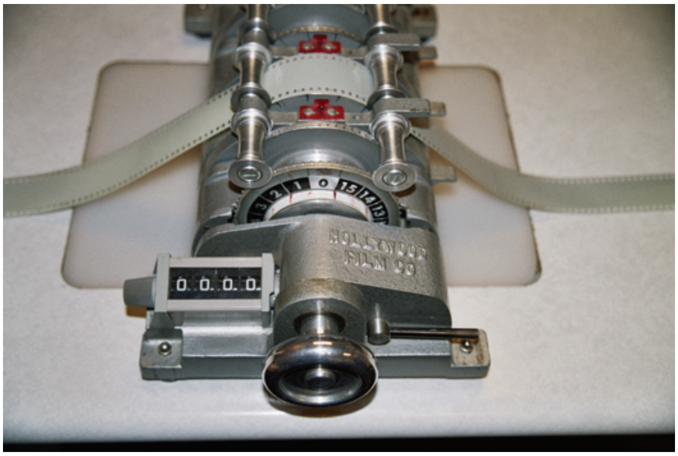


**Figure 5.22:** *The synchronizer is a mechanical device used to obtain frame "counts" off the film. The counter reads in feet and the wheel reads off frames. There are 16 pictures per foot in 35 mm 4-perf formats.*

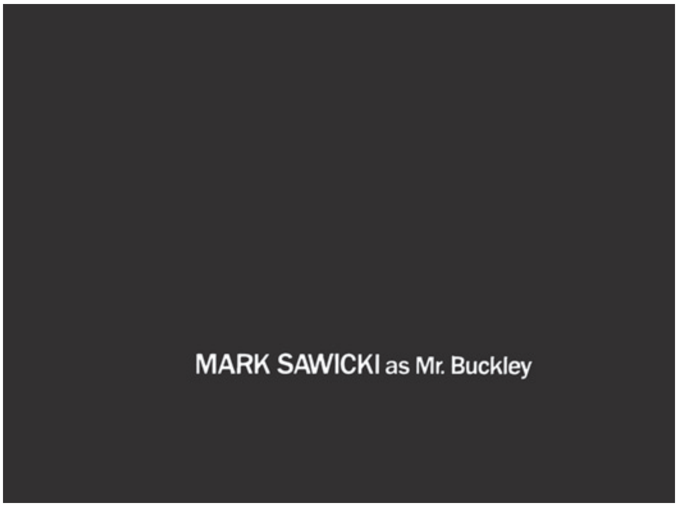


**Figure 5.23:** *The title photographed off the animation stand before the shaker process.*

## Wedging and Color Control

Before the composite, a series of color tests are made of the interpositive. Canceling two clips of the same field chart against each other aligns the printer. One clip is placed in the camera and one in the projector. When the lens is zoomed and positioned to cancel the grids so that they appear as one, the camera is making an exact duplicate. This operation was called putting the printer at one to one. The cameraperson uses a right angle prism to view the clips through the back of the film movement. After alignment, the lamp is turned up to 90 volts (a lower voltage than the line of 110 volts to save on the life of the bulb) and a light meter reading is taken at the film plane by

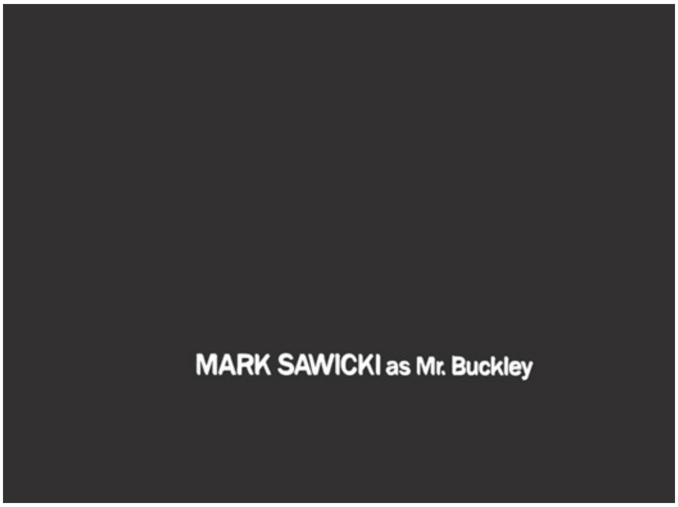


**Figure 5.24:** *The same title after optical shaking to produce a drop shadow.*


**Figure 5.25:** *A Kodak girl head control. The gray box in the lower left hand corner should read red 1.00, green 1.45, and blue 1.55 on the internegative of this image. The readings are taken on a densitometer. Keeping gray as a pure gray is a system that holds over into the digital age.*

removing the camera movement and inserting the light probe. When the light value is obtained, filters are placed in the lamp house to eliminate the infrared and ultraviolet spectrum and allow only a balanced, color-corrected light to expose the film. The first thing to photograph is a control girl head. A girl head is a strip of film containing an image of a girl along with a white, gray, and black box.

This control is known as a LAD (laboratory aim density) patch. It is the main control used for keeping film on track, and it uses the gray card system mentioned earlier. The theory is that if a gray card is exposed to absolute specifications on color negative film, it results in three densities for the cyan, magenta, and yellow dyes that make up the film. When a properly exposed negative of a gray card is read on a densitometer, the ideal readings are red 0.80, green 1.20, and blue 1.60, so the cyan dye would have a 0.80 density value, impeding the red light from going through the film. When this ideal negative is printed onto an ideal interpositive, the following numbers are obtained on the gray card: red 1.15, green 1.60, and blue 1.70. In practice, a short eight frame clip of the ideal interpositive girl head is made and kept as a control. This girl head is the first thing to be photographed using the basic color pack along with a neutral density filter to obtain an ideal internegative with the readings red 1.00, green 1.45, and blue 1.55.

> You may note that these internegative readings are not identical to the original negative gray card readings, as you might expect. Kodak makes them slightly higher to account for the unavoidable fog level that comes up when film is duplicated. So they lift the densities slightly higher to get above this system noise.

This control girl is very important and is shot every day. When the optical is shot on the camera, the film is sent to the lab for development and a print is made to specific printing lights. At the lab are continuous contact printers that have additive lighthouses that combine red, green, and blue light through a series of vanes or gates that can be opened in increments between 0 and 50. The combination of these openings for red, green, and blue makes the color correction for the print. A typical print light might be 35, 33, 21, representing the proportion of red, green, and blue light, respectively, that exposes the print. These numbers are obtained by printing the ideal gray card negative onto an ideal gray card print that should look like a 1.00 neutral density filter. In practice, the lights are adjusted to make a pleasing compromise between the gray card and the girl's skin tone. Once the effects company arrives at the girl head "look," they keep those lights as a standard. These print lights are always the same, and the way the girl head is photographed is always the same.

This control is very important because if the daily comes back all blue, and the girl head and the shot is blue, then it indicates a misprint at the film laboratory. If the girl head looks good and the shot looks blue, then the camera operator put in the wrong filter or the color filtration was indicated incorrectly. This is a great quality verification system. The only variables to constantly watch for are fading filters and a fading girl head. As the control is exposed to light day after day, the color dyes will fade and the ideal control readings of 1.15, 1.60, and 1.70 on the girl head will change over time, creating an out-of-control situation. This would not matter much if you were executing a shot over two days and would never see it again. A problem arises when six months go by and you are asked to do the same shot again. This is not an uncommon occurrence. If you were in control, then the same color corrections would still hold true.

The next item to photograph is a high-contrast focus chart. This is a control that ensures that the optical printer is in focus. Very often an out-of-focus shot is rephotographed; and to verify that the original footage is soft, a focus chart is shot. Next comes the slate, a strip of film containing the company name with space to scribe in the shot number and the date. After the slate, the IP roll is threaded up and the projector is run to the proper frame number for wedging. At this point, the neutral density or gray filter is removed from the light box. A color wheel containing a variety of filters is placed between the lens and the projector, and each filter is positioned in front of the IP for one frame. After one rotation of the wheel, a low-density gray filter is placed in the light box to dim the light a bit; this is usually a 0.10 neutral density filter. The wheel is run again to shoot another 19 frames of varying colors, stopped, and then the next darkest ND filter is put in, that is, the 0.10 is replaced with a 0.20. The process continues until the full spectrum of color filters is shot through the densities 0, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, and 1.00. Keep in mind that 0.30 neutral density is the equivalent of one stop of light attenuation, so the exposure run is over three stops in increments of one-third of a stop. The color filters are for the optical printer's subtractive lamp house, which controls the light by subtracting color using cyan, magenta, and yellow filters as opposed to adding red, green, and blue together. The typical color wheel corrections were

no_correction, 10y, 10c, 10m, 10y + 10m, 10y + 10c, 10c + 10m, 20y, 20c, 20m, 20y + 20m, 20y + 20c, 20c + 20m, 20c + 10y, 20m + 10y, 20m + 10y, 20m + 10c

When the yellow and magenta filters are added, they form a red filter; yellow and cyan make green; and magenta plus cyan makes blue. The 10 and 20 designations refer to the saturation of the color. This color wedge is run over each scene to be used in the main title sequence. The term wedge may have come from early forms of this type of color test in which the different filters were mechanically inserted over the film in a continuous printer. The space limitations of the design led to the color correction appearing as a wedge of exposure over the film frame, probably due to the wheel radius in an early device.

## Color Timing

After the film comes back from the lab, the girl head is checked for consistency and the negative LAD patch is read on a densitometer to ensure that the three magical

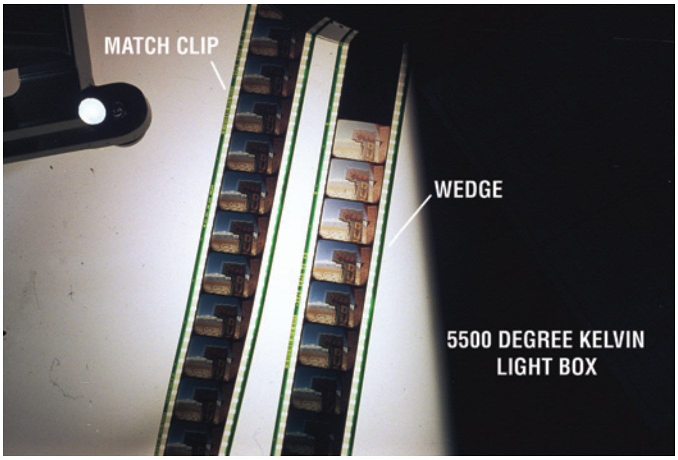


**Figure 5.26:** *Picking the wedge.*

LAD numbers were hit. The film is then taken to a color correct light box (5500 K) along with film "match" clips supplied by the editing room. These clips are what the optical house uses as a standard for color matching. The wedge of the scene is placed next to the film clip and moved up and down the wedge range until a good match to the color is obtained.

Once the color is matched, the filter and density are noted on the master count sheet for the composite. So shot number one may have a color correction of 10 cyan with a 0.40 neutral density in order to match the clip. This wedging is done for every shot and element in the main title composite, including the color of the title itself.

## The Master Hold-Out Matte

By this time, the print from the shaker camera effect has come back, and this roll is lined up to generate a final matte that will hold out the background in the area that the titles will occupy. The titles have to fade in and fade out over the background. In order to avoid any possibility of exposure dip, the fades are made on the matte stock itself. In other words, on a roll of clear matte film with a title, the title slowly fades in from clear to a dense black and then back to clear. This eliminates the possibility of exposure pops in the middle of scenes, which might occur if you use a shutter to dissolve the titles in and out. To accomplish this, the shaker print is threaded into the projector, rolled down to the first title, and held as a freeze frame. To ensure that the matte is clean, tape is placed over any areas of film black that have pinholes due to insufficient processing. This guarantees there are no black specks photographed into the final matte. Before the shot starts, a burst of a few frames of the title is made at the very head that act as an "alignment clip" (more on this later). After this, the titles are shot with the appropriate fades to create a clean final matte. This roll is then sent in for processing and cleaning.

## The Final Composite

Cleanliness is of utmost importance in optical printing. A very tiny frame of film is being rephotographed in the open air, and any small speck of dust will show up as a black speck on the film. To provide a sterile environment, the optical rooms have filtered air, sticky mattes on the floor to clean shoes, and humidity controlled at 50 percent. In high humidity, moisture tends to weigh down the dust so it falls. The film also lies flat and doesn't curl, as it does on dry days. Rainy days are the best days to shoot an optical. The basic procedure for doing a main title is as follows:

1. Shoot the girl head, focus control, and slate.
2. Thread the master hold-out matte in the rear projector and the master burn-in (the first print off the animation stand) roll in the main projector.
3. Sight through the eyepiece, and using the alignment clip mentioned earlier at the head of the master hold-out, cancel the hold-out and burn-in title so that there is an even glow around the perimeter of the title. Too little of a glow and a black matte line appears around the title; too much of a glow and the title double-exposes over the background. With white titles, err on the double-exposure side.
4. After "fitting" the mattes, remove the master burn-in and then thread up the IP.
5. Keeping the master hold-out in sync with the raw stock, run to the start of the IP to be copied, verify the start with the scribe mark, insert the correct color filters, and shoot the specified number of frames.
6. Roll down to the next shot; execute fades and dissolves until the entire background sequence is laid in.
7. Close the shutter, cap the lens, and roll back the raw stock to the beginning.
8. Unthread the IP and the master hold-out and rethread the master burn-in of the titles.
9. Go to each of the titles, hold frame them, tape off pinholes, and then shoot them with the same fades that were present on the matte. Since the gamma of the high-contrast film is higher than the color film, the fades used in the matte have to be twice as long in order for the composite to fade properly. In other words, for a 24 frame fade on the color film, shoot a 48 frame fade on the matte film, whose higher contrast turns it into a 24 frame fade.
10. At the end of this composite, unthread the camera and take the film to the lab.

The entire main title shoot could last anywhere from 4 to 8 hours of constant concentration. If you hit a wrong frame or put in a wrong color it could be disastrous.


**Figure 5.27:** *In pass number one, the interpositive is shot with the title hold-out matte that has the drop shadow included. For clarity, the background image is made normal. Through the camera you would see black type against a low-contrast orange-colored IP.*

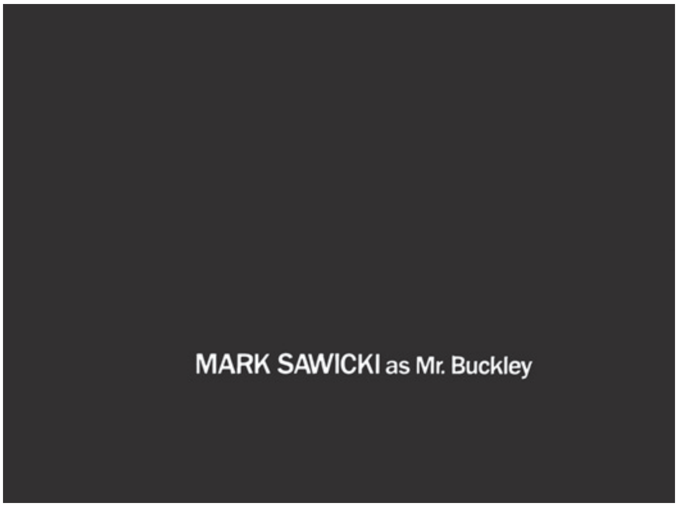


**Figure 5.28:** *After pass number one, the camera is wound back with the lens cap in place to the start frame. Pass number two "burns-in" the white type in the area left unexposed by the hold-out matte. Alignment of the hold-out and burn-in mattes is critical.*

If you were lucky, you might be able to complete the shot and then go back and "pick up" the mistake at the end of the roll at a place where the editor could make convenient cut points.

This was the basic way that the bread-and-butter main titles were done on an optical printer for most of cinema history. The tools are now different, but the underlying


**Figure 5.29:** *The final title composite. Note that the addition of the drop shadow helps the type stand out from the image. Title composited by Stewart Motion Picture Services.*

principles and elements that make up this task remain the same, as we will see with an examination of the film to digital system in Chapter 6.

> For those who would like to see a glimpse of the optical craft, I have authored a video presentation called "Twilight Cameraman" available from First Light Video Publishing (www.firstlightvideo.com). The program documents the workday of an optical cameraman. It was shot just days before the great workhorse cameras were retired and replaced with digital workstations.

I would like to pause to mention independent filmmaker Josh Becker, who generously allowed me to use an image from his film *If I Had a Hammer* in the illustrations of the film and title process. Josh is an author as well and has written an excellent book called *The Complete Guide to Low-Budget Feature Filmmaking*, published by Wildside Press, which I highly recommend. It is sometimes difficult to obtain permission from major studios to use pictures from their films, and I am very grateful to Josh for allowing me to use the photo of Mr. Buckley. Surprisingly, I had no problem getting permission from the actor.

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# Chapter 6
## Film to Digital

Around 1992 I took a digital class through Weynand Training courtesy of Camera Local 600. At that time the class focused on an early image processor for video called the Harry. When the class finished, the digital video instructor and I were asked by Weynand Training and Kodak to develop course material for the Cineon digital film system. The Cineon system was a process by which film was scanned into the computer, digitally manipulated, and recorded back out to film. I leaped at this terrific opportunity to enter the high-tech world of tomorrow and learned a great deal from the experience. I remember distinctly this great turning point in technology. My co-teacher and I were given a demonstration of the Cineon by an engineer. At that time, the digital room easily cost over a million dollars. I remember riding in the elevator after the demonstration and taking note that the video pro thought that the system was slow as snails, while I thought it was fast as lightning. To her it was slow because she was used to manipulating 1-megabyte video frames in real time on the Harry. For me it was lightning-fast because although it dealt slowly with 40-megabyte frames, I could see the results of the work without lab processing and print time for mattes and color, as discussed in the previous chapter. The Cineon system was a historic blending of two worlds, film and digital, in which people of many disciplines came together to create a new way of working. While the Cineon software itself is gone, the procedures that Kodak established remain. What follows is an introduction of the film to digital process.

### Scanning

Movie footage is shot on film using traditional methods. A print can be made if desired, but when it comes to duplication, the original negative is scanned rather than contact printed onto an intermediate film to make an interpositive (IP). A scanner can be thought of as a finely focused densitometer that measures thousands of points in a film frame and gives a red, green, and blue value to each of them. Each of these points forms a pixel or picture element. There were several methods developed for scanning. The Kodak system registers the film on pins and moves each frame past a linear array of 4096 sensors to generate the digital information. This linear array concept is also used in flatbed scanners and photocopiers, in which a wand of sensors is dragged past the picture being scanned.

The amount of information that is scanned can vary and is expressed by the number of pixels that exist horizontally and vertically across the picture frame. These pixel numbers vary with the film format and the amount of detail that is captured. Through exhaustive study, the Kodak engineers determined that for digital to match the amount of information that exists in a full aperture Academy frame, the frame must be scanned at a resolution of 4096 pixels horizontal by 3112 pixels vertical. The drawback is that this results in 40 megabytes of information per frame. Even today this amount of information is enormous to deal with. Moving these large files is like sucking a really thick milkshake through a tiny straw. These 4096 × 3112 or 4K scans wound up being so unwieldy that most people opted to scan at 2K, or 2048 × 1556, since a 2K scan takes up only 12,474K of space. The scan can be made even smaller, to 1828 × 1332, if the sensor information outside of the Academy frame is subtracted. In practice, it is customary to scan at 2048 × 1556 to get an image that is smaller yet oversampled enough to allow movement within the frame for simple repositions, as with the optical printer.

A 2K resolution is just fine for 90 percent of the subject matter being photographed. The difference between 2K and 4K only becomes apparent with images that contain extremely fine detail, almost like a test pattern. When a movie is shot using the Super 35 process, some cinematographers prefer to scan in 4K to offset what they perceive is a resolution loss due to the anamorphic process at the tail end of print production. In my experience, the decision to scan 4K instead of 2K has more to do with fickle than with fact. A 4K resolution is undisputedly better, but you should consider whether the monetary outlay for scanning and increased processing time is worth the slight improvement in quality. If you're making *Lawrence of Arabia* and can afford it, go with 4K. If you're making *Smog Monster 4*, I recommend sticking with 2K.

## Bit Depth

What I have just outlined is the linear resolution of the film, or how many square pixels will make up each frame of film. The other issue is how many shades of gray can be resolved in each of those pixels. A common digital image is recorded in 8-bit linear color space. The term 8-bit refers to the number of placeholders binary code can be put into. The basic binary language of the computer is built upon yes or no,

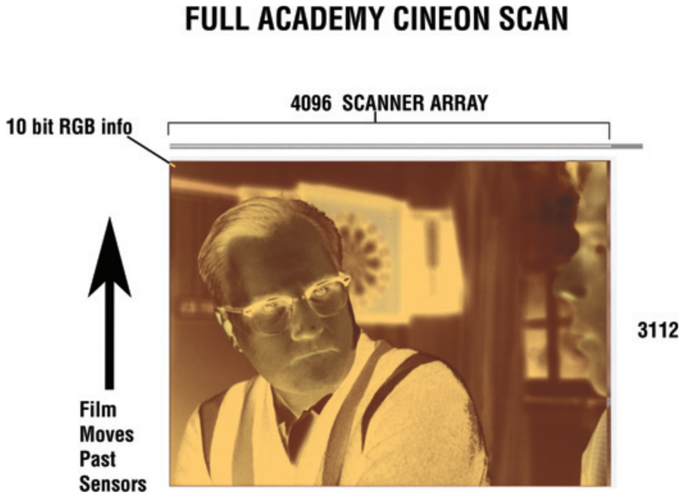


**Figure 6.1:** *How linear resolution is derived from a scanned film negative.*

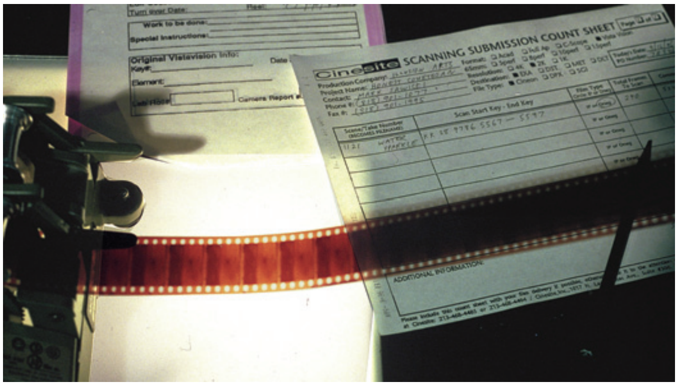

**Figure 6.2:** *Preparing the negative for scanning by indicating key numbers. The process uses a synchronizer and is similar to ordering an interpositive.*

on or off, or numerically a one or a zero. When there are eight spaces to put a one or a zero combination, they will form a binary "word" that will represent a value for the pixel. For example, if all eight spaces are zeroes, 00000000, that binary word represents a zero value for the pixel. The next word, 00000001, represents a value of one for the pixel. If all the combinations of ones and zeroes within eight spaces are used, or the number 2 taken to the eighth power (2 × 2 × 2 × 2 × 2 × 2 × 2 × 2 = 256), there are enough binary "words" to create 256 variations of tone, so we have 256 values representing the brightness range of a pixel. This is called the bit depth. Now, 256 doesn't seem like many values, but that number represents only one of the color channels. In other words, on most video displays there are 8 bits of red plus 8 bits of green plus 8 bits of blue, making 24 bits of color. If the variations are multiplied, we get 256 × 256 × 256 = 16,777,216 different combinations of red, green, and blue, or more than 16 million different colors. In practice, another 8 bits is added to the mix that will contain 256 variations of tone for an alpha or matte channel. This is sometimes called 32-bit color, but this term is a misnomer in that only the first 24 bits are used for color information.

This might seem like more color than you would ever need, but it is only a fraction of what is contained in the film emulsion. Some have addressed a need to record the extended range of tones in film by using 16-bit data to create a range of 65,535 code values per color. The problem is that film is not a linear medium, so doubling the amount of data doesn't really capture the 1000 to 1 dynamic range of film. 16-bit is great for blacks through the midtones but then starts to be unevenly distributed in the high light regions. Kodak solved this issue by creating the Cineon 10-bit log format. It essentially redistributes the numbers so that the huge dynamic range of the film can be put into a mathematical format that fits very nicely into 10 bits per color. This file format essentially encodes in the same way that D–log E curves graph the film's response using logarithmic math. The important thing to remember is that the standard file information for film is 2048 × 1556 with 10-bit log data. Later I will demonstrate how manipulating the linear resolution on the scanner can be an aid in certain effects chores.

## Storage

In the past, the data would be archived on a storage medium such as a data tape and was also transferred to a more quickly accessible hard drive. As solid state storage becomes more robust and file transfer over fiber becomes faster, the storage paradigm will likely shift to something else. The important thing is that the film has been converted to a whole lot of digital numbers that are ready for the computer.

## Compositing Software

The original Cineon system developed compositing software that was based on the optical process. Each operation that the optical operator would perform was distilled into a node. A node was a little box along the pipeline of the operation that would perform a single function, such as color correction. Another node might flop the image by reordering the data numbers. Another node might pull a matte and create a blue screen composite. This system blossomed into the standard logic layout of much of the software used today.

One thing that flustered many early film compositors who were used to working on video was that the raw Cineon file looked weird and flat when brought up on the monitor. They thought something was wrong with the file, when in fact, nothing was wrong. It was merely displaying a log representation of the film, exactly the same type of image that you would see if you looked at an interpositive in the optical printer. The only difference was that there was no orange coloring to compensate for dye imperfection because there was no dye, only data. The flat positive image of a raw Cineon file is the same that you would see if you took the low-contrast (gamma 0.65) negative and turned it into a positive. It contains the full dynamic range of the film and gives the compositor tremendous latitude to color correct the image.

In order for the operators to work with the images and see what they are doing, another node such as a log to linear converter is used that moves the numbers around to a more "printlike" viewable condition. It is as if at the tail end of the composite you made a preview print in the software to see what the image would look like on film. It is important to remember that this "viewer" must be behind the "saver" that outputs the final composite. As in the optical printer, you start with intermediate and end with intermediate; the contrast only comes up when a print is made. So a typical node flow would proceed from file to color node to density node to flop node to save data node and then to the print preview node. Whenever possible, it's best to work with 10-bit log files for film. Debates came up in the old days over which file format was better, 8-bit or 10-bit. It was a frustrating debate because the two file formats, when placed side by side in a print comparison, looked exactly the same. What you gain in 10-bit is the range and latitude needed to make big changes in the color and density of the film. An image could be reproduced in 8-bit, but there would be virtually no room to make big corrections. If you wanted to see into the shadows in 8-bit, for example, you would find that the black had no further data and couldn't be lightened. In 10-bit, however, you could brighten the exposure and begin to see


**Figure 6.3:** *An 8-bit linear scan, while looking acceptable at one setting, such as reversal film or video, does not have a wide range for adjustment. If the file is brightened, there is no information in the dark interior, and if the file is darkened, the bright sky will go dull.*

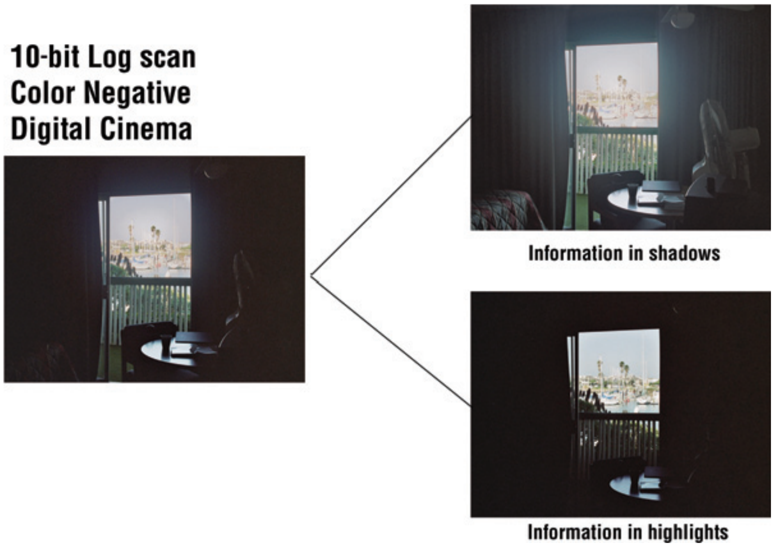


**Figure 6.4:** *A 10-bit log scan contains all the information in the negative. As the file is brightened, the hidden details of the dark room begin to reveal themselves. As the file is darkened, the sky remains bright and details in the daylit harbor scene can be seen.*

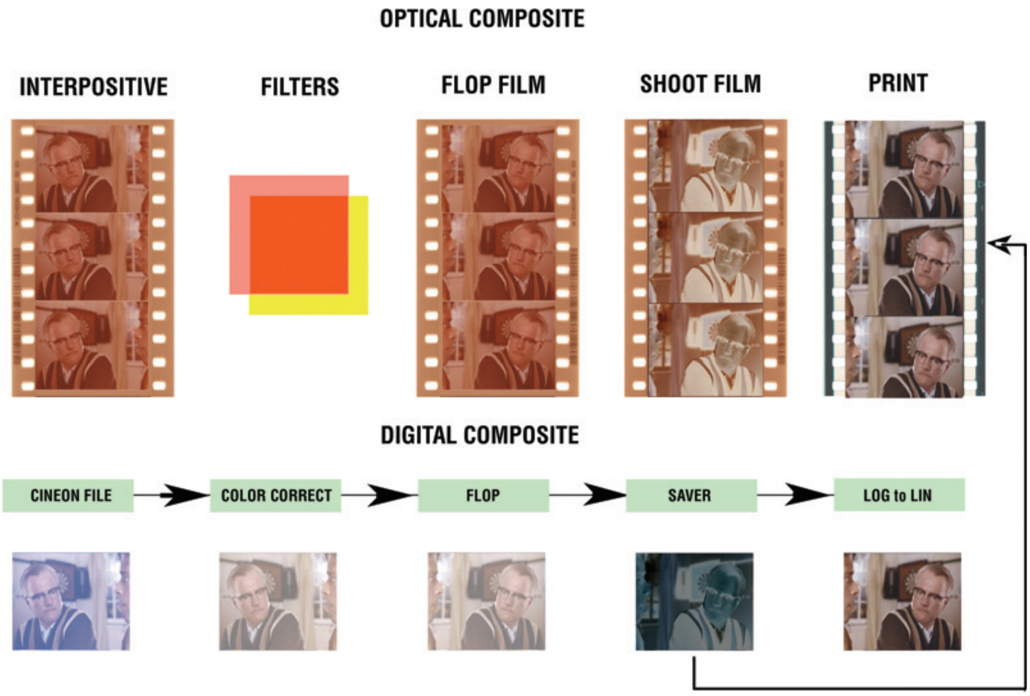


**Figure 6.5:** *A comparison between the traditional optical process and a node-based digital compositing system. Each traditional operation is contained within a node represented by the labeled blue boxes. Many compositing systems such as Digital Fusion display a layout that allows digital compositors to create an effect by calling up, connecting, and adjusting nodes.*

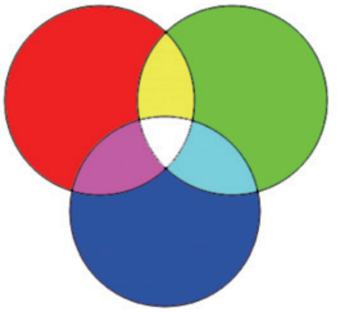


**Figure 6.6:** *The additive mix system for generating color as used in electronic display devices such as cathode ray tubes.*

branches under the dark bush and the dark rabbit hole in the ground. All this data is still there in 10-bit.

## Laser Recording

When the shot is completed in the software, it is saved on a hard drive and sent to the film-out facility. As on the optical printer, a slate is shot along with a girl head. When the data files get to the film-out shop, they are loaded onto a laser recorder, and three narrow beams of red, green, and blue laser light are focused on the raw stock emulsion of the intermediate film, and the data files are written onto the film. The quality is exceptional. Unlike the optical printer, where lights are "called," the film is sent to the lab for processing, and a print is timed to hit the LAD aim of red 1.10, green 1.10, and blue 1.10 in the gray patch area (this is slightly different from the 1.09, 1.06, and 1.03 aim in optical and a bit easier to remember). The fluctuations are taken out of the system by timing the print to the same value each day. It is a brilliant closed loop system for film going in and out of the digital universe.

## The Digital Intermediate and Beyond

Today the process of how movies are made is in a state of rapid change. The vexing aspect of the Cineon stepping stone was the difficulty in evaluating the work. Though the workstation was a great miracle machine, the image on the monitor was decidedly different than what ended up on film. The main reason for this was the fact that film is a plastic ribbon with images made up of cyan, magenta, and yellow dyes that subtract the color of the white light emanating from a projector bulb. The color monitors used in compositing were glowing phosphors that emit red, green, and blue light to create an additive light display. The contrast of print film was much greater than what could easily be obtained on a monitor. Essentially the image was being evaluated on two completely different display systems. Filmmakers would often edit their films on Avids and see their movie only in the electronic format. When their movie was finally taken to film, they would be shocked at how different it looked. To save money, film dailies went by the wayside and all film was instantly scanned, so the real print appearance was not seen until the end. The traditional film wedge became more important than ever to really see what was going to be on the final medium in the theaters. There were issues concerning color space as well, meaning that film dyes could recreate certain colors that the television monitor could not produce, and vice versa. These colors would be out of gamut between the displays. As a result, a visual effect might look great on film, but the elements would start pulling apart when it went to television.

Today, movie theaters are in the process of being converted to digital projection. These projectors create images by reflecting high-intensity light off chips containing millions of fluctuating mirrors that reflect precise amounts of red, green, and blue light to create all the colored pixels for each picture. This development means that display systems are all becoming additive and universal. The new Digital Intermediate houses use these digital light processing (DLP) projectors in their color timing rooms. If the data are distributed to identical DLP projectors, it would mean that the film makers and the audience would see the exact same image as what we enjoyed when we only had the medium of film. Unfortunately, it will never be that simple again, as movies are now shot with film, high-definition, mini DV, video, and anything else that can take a picture. They are also being distributed on film, TV, high-def, cell phones, the Internet, and whatever else comes up. Each medium has different resolutions, bit depth, color gamut, etc. Pandora's box has been opened, and huge facilities have been built to accommodate this cacophony of data. While this is daunting for the effects professional, it can be dealt with a bit at a time using the traditional skills of evaluation and testing. The high resolution of film can always act as a guide to shoot for. All other mediums can be evaluated against film to determine whether their particular qualities are suited to the shot at hand. One example is a scene containing a TV monitor shot on film; the objective is to put an image onto that TV monitor. Suppose the filmmaker wants a gritty crime recreation image and wants to shoot this footage on video resolution with poor color fidelity. That would be perfectly fine as long as the filmmaker commits to that idea. If at some point down the road, however, the filmmaker wants that footage to have the same quality as the film, then there is trouble. If possible, you should shoot on the same high-quality medium throughout and degrade when desired. You can always make something look terrible, but you can't resurrect the dead.

# Chapter 7

## Digital Cinema

### Digital Cinema Cameras

We are in the dawn of the age of digital cinema. All the things I write about in this book regarding dynamic range and high resolution in film are now available in the digital cinema environment. As of this writing, there are several cameras competing for use in professional motion picture imaging: the ARRI D-20, the Dalsa Origin, the Thompson Viper, the Panavision Genesis camera, and the RED digital cinema camera. This rapid adoption of digital technology into the motion picture field is exhilarating, confusing, and difficult.

### What's the Best Camera to Use?

The vague question "What's the best camera?" is one constantly asked by students. The answer is never simple. The response must be yet another question, "What are you going to use it for?" I can't say that I blame students for wanting an easy answer when they are deluged with data and advertising. In my experience, finding the best camera often, embarrassingly, boils down to finding out what other teams have used. The production pipeline has gotten extremely complex, and now many people are involved in the process of choosing equipment to buy or rent. A large corporation may have an entire technical staff spend months doing research before acquiring equipment. For a small shop or an individual, finding the right equipment becomes a very daunting proposition. At the National Association of Broadcasting (NAB) convention, which is a showcase for media technology, it seems that the sales force for every single product on the floor will tell you that their product will turn lead into gold and prove it by blinding you with science. For someone who has the responsibility for making a substantial financial commitment and who isn't a rocket scientist, choosing equipment can seem like the seventh circle of hell. Many motion picture personnel, myself included, have a difficult time absorbing this constantly changing stream of data, especially if they are fortunate enough to be working constantly.

I typically head to the NAB after having exhaustively worked on several motion pictures and have to catch up with what's new in a very short span of time. My simple method of picking out what is important in a camera product is to find the common denominators in the advertising of competing products. I try to learn a bit about those details and then make an educated guess about which is the best product for me after getting input from several digital professionals from the shop that will have to deal with the material down the line. The sales force of a camera manufacturer will have spent a great deal of time researching what is very important to cinematographers and will highlight that information when promoting their cameras, and that becomes a clue (of sorts) as to what to look for. Some of the more important common factors for digital cinema cameras are progressive image capture (the camera takes pictures in a manner similar to a movie camera), image resolution (how many pixels the image has), sensitivity to light, the dynamic range (how many stops of light the camera can capture), the size of the sensor behind the lens, and the color sampling. I will attempt to outline briefly each of these features as a simple introduction to these amazing new cameras. Before getting to that, I will outline some digital concepts in a simplified manner. While digital cinema cameras are not "souped-up" video cameras, I find that illustrating some very basic video concepts goes a long way toward helping the artist understand the remarkable features of this amazing technology.

## Mechanical Television

It is hard to believe that television, the electronic miracle of today, had mechanical roots. The great thing about the early mechanical television is that it is easy to understand and thus illustrates the concepts of scanning, pixels, resolution, and sampling. A German student by the name of Paul Nipkow patented the first mechanical television in 1884—yes, that's right, in the nineteenth century. His ideas laid the foundation for the development of the first practical mechanical television by Scottish inventor John Logie Baird in the 1920s. It was a brilliant system. The original television made use of a light sensor (photocell) that would vary its voltage output by the amount of light to which it was exposed. A light was connected to this sensor. The more light the photocell saw, the brighter the bulb would glow. The changing voltage traveling through the wire became the first television signal. In order to create an image, the device needed to break down the picture into discrete components, thereby encoding them, and then decode them on the receiving end. In order to do this, two identical wheels were constructed that had holes arranged in a spiral leading downward toward the center of the wheels. These were called Nipkow discs. The two discs were attached to a common shaft of a motor so that the holes were aligned and the disks could spin together. Behind one of the discs was the photocell sensor, about the size of a piece of film. In front of the disc was a lens that focused an image onto the cell through the holes in the wheel. Behind the other disc was the light, whose intensity was varied by the photocell. The motor was turned on, and the two discs revolved very rapidly in synchronization. As the hole passed by the photocell, its output voltage would vary depending on the amount of light that came through the hole focused by the lens. In the case of a white subject (such as a white card), the hole would allow white light to hit the photocell when it revealed the white background. The cell would output high voltage and the bulb on the receiving end would be bright, lighting up the hole on the receiving wheel as it passed by. After the first hole cleared the photocell, the second hole (which was slightly lower) began scanning the second line. If the hole passed in front of an image that was black, no light would come through the hole, the photocell voltage would drop to zero, and the lamp would go out. If the hole passed by a gradation of tones, then the voltage would vary up and

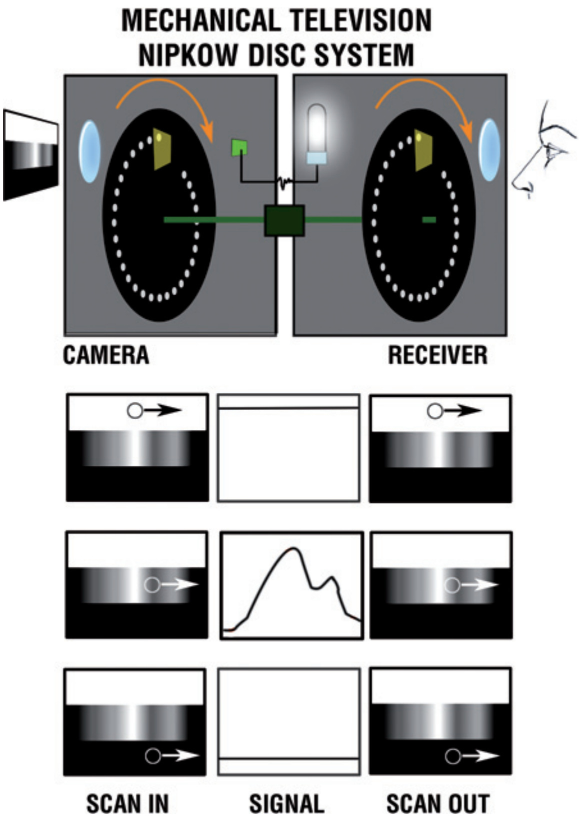


**Figure 7.1:** *The mechanical television system.*

down as each different light value was revealed by the hole as it scanned the image line. As the photocell scanned, the viewer would look at the other disc spinning rapidly in front of their eyes and the lightbulb behind would turn on or off or dim depending on the voltage transmitted by the photocell. In this way the image was faithfully recreated by selectively illuminating the spinning holes. This became the origin of scan lines and the idea of a rasterized image.

The more holes on the wheel, the more scan lines were possible and the higher the resolution of the image. The signal produced was an analog signal, meaning a continuously variable signal. Another form of an analog system is the traditional clock with its sweep hands. The information is constantly changing with time. In a digital clock, those moments in time are captured and displayed as discrete components. The long and short hand pointing to the number 12 on an analog clock would be captured at that moment in time in a digital system and become the digital display of 12:00. The second hand on an analog clock can sweep to 15 seconds after 12 o'clock, but the digital clock can display only 1-minute increments, and so it will not change until 12:01 comes around. In the mechanical television, if the information at one instant of time when the hole was passing in front of the image was captured, it would create a pixel or picture element. This pixel would have a certain value. If white was 1 volt and black was zero volts, then the pixel would contain that information when it sensed white or black light. As with the digital clock, the more often the analog signal is sampled, the clearer the image. Instead of sampling the analog clock every minute, it could be sampled every second to increase the resolution of the time data. Depending on how often the hills and valleys of the analog television signal are sampled, it can result in a higher or lower resolution of the image.

Figure 7.2 shows an analog signal forming a rounded hill down a soft curve to a smaller bump graphed along a line segmented into seven steps. If each step is sampled, it results in a pretty good reproduction of the signal. If it was sampled four times as often in the same amount of time (28 samples), the fidelity of the reproduction would be even better and the digital signal would resemble the original analog signal even more. If only three steps were sampled instead of seven, as in the chrominance samples, the digital reproduction forms a low-resolution digital copy of the analog original, or a picture that doesn't resemble the original very closely at all. This is the basic idea behind scan lines becoming pixels and sampled brightness range becoming an important component of a digital image. The ordering of these little pockets of information enables untold miracles in visual effects. Think of what would happen should one of the Nipkow wheels be rotated 180 degrees out of alignment with the other wheel. The image would appear upside down, because the top scan line would be capturing but the bottom scan line would be displaying.

With the mechanical television system in mind, I will now discuss those sales points I mentioned that are so often used for digital cinema cameras.

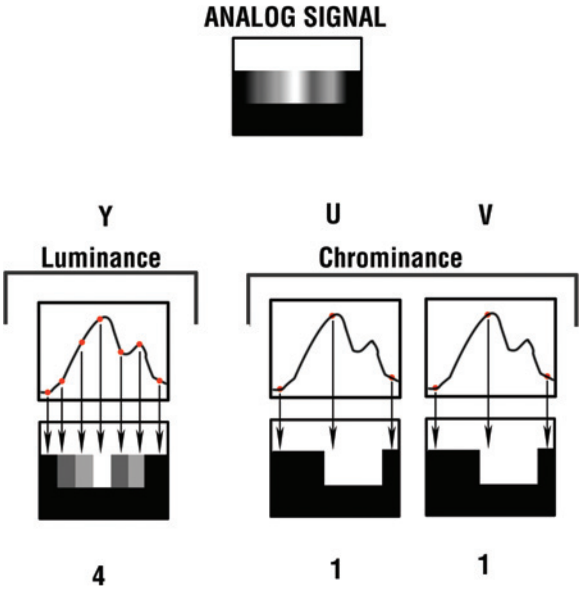


**Figure 7.2:** *A graphic display of the problems inherent with low sampling rates. The digital reproduction on the left resembles the analog image due to the higher number of samples, while the two digital reproductions on the right look nothing like the analog image due to insufficient sampling.*

## Interlace or Progressive

As television developed as an electronic medium in the United States, the frame rate eventually became 30 frames per second. The system was based on the U.S. power supply, which is 110 volts, 60 cycles per second alternating current. Thirty frames per second was considered a convenient subdivision of 60 cycles. In Britain, the power is 50 cycles per second; that is why the frame rate of their video system is 25 frames per second. In the United States, it was originally decided to go with 60 frames per second, but it was discovered that there was not enough bandwidth in analog transmission to carry that frame rate. In addition, the television sets of that day were not able to image 60 frames per second, while they could transmit 30 frames per second. However, to preserve the persistence of vision phenomenon (discussed in Chapter 5), a method of presenting the images at a rate faster than 30 frames per second had to be developed to prevent flicker. To accomplish this, unlike the film system, which flashed each frame two times on the screen through the use of a double-bladed shutter, the video systems broke the image into two fields of alternate scan lines of even and odd lines. The two fields flashed by the eye very rapidly to blend into one image in a process referred to as interlaced imagery. An interlaced image most often differs from a film frame during subject or camera movement, when the two fields will not have the image line up in the same place.

For example, in the right hand picture of Figure 7.3 I panned using a camera shooting with interlace. The telephone pole appears jagged because the two different

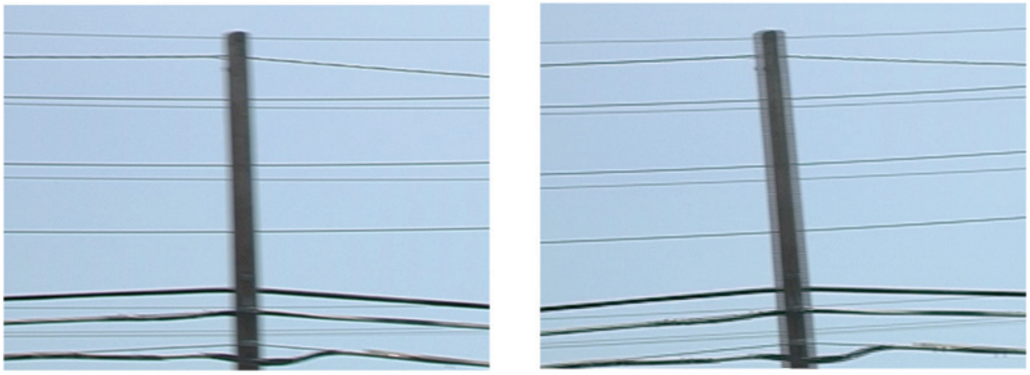


**Figure 7.3:** *The visual difference between progressive and interlace imagery.*

positions of the pole were captured alternatively by field one and field two and don't align. When the term progressive is used to describe a digital camera it means that there is no interlace and so the image captured is one complete image, much like a single frame of film. The image on the left in Figure 7.3 is the same pole shot with a digital camera shooting in 30 frames per second progressive. As you can see, there is no tearing of the image. Because digital cinema cameras with progressive image capture recreate the way a film camera captures whole images, that feature is considered a plus. For motion picture work, a camera that shoots 24P, or 24 progressive images per second, would be used to match movie film.

From an artistic standpoint, video in the United States runs at 30 frames per second, but from a purely technical view, this isn't exactly correct. Steve Wright, in his book *Digital Compositing for Film and Video*, states the issue eloquently: "NTSC (National Television Systems committee) video runs at 30 frames per second (fps), consisting of 60 interlaced fields per second. Well, sort of. Like all things video, there is more to it than that. It really runs at 29.97 frames per second. The reason for the slight discrepancy is that when TV went color in 1953, signal timings had to be juggled a bit to make things come out even, and 29.97 frames per second is the result. What effect does this have on you? Usually, none. However, you might want to know about drop frame time code, just in case you trip over it one day" (p. 217). For those who desire to learn more about digital compositing in depth, I highly recommend this book.

## Image Resolution

While film has the benefit of three extremely thin color-sensitive emulsion layers laid on top of one another that allow the different wavelengths to pass through and expose

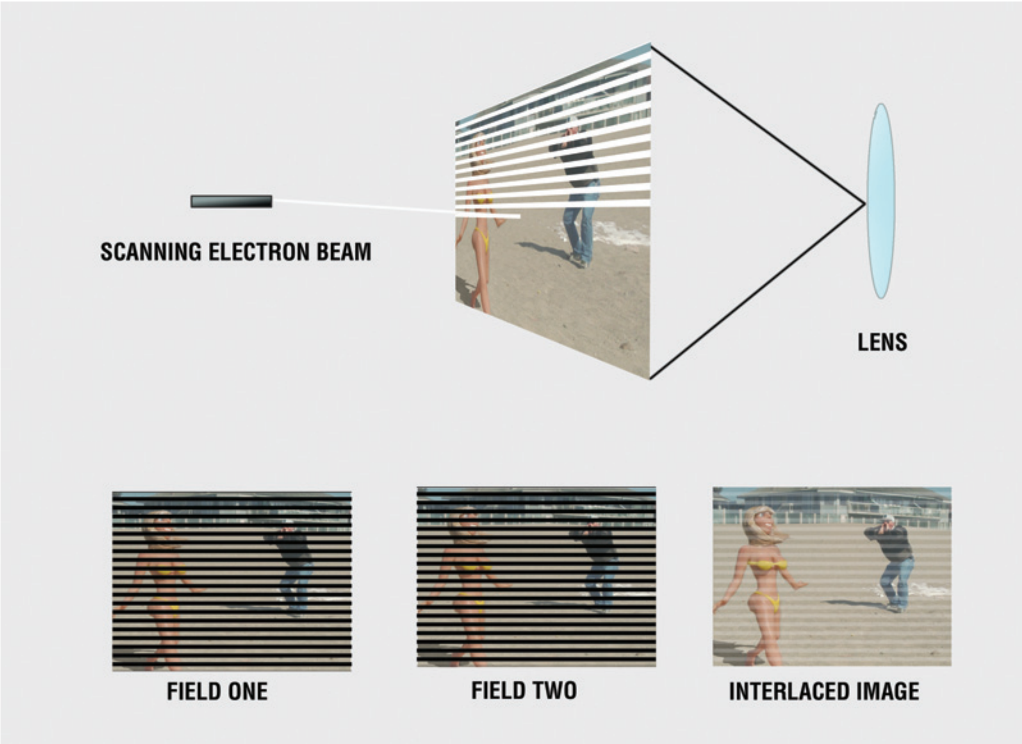


**Figure 7.4:** *An early form of video capture in which an electron beam scanned an image formed by a lens to create odd lines of an image for one field and even lines for another field to create an interlaced image. The size of the scan lines is grossly exaggerated for illustration purposes.*

each accordingly, digital capture chips are opaque and don't allow light to pass through. Due to this limitation, two schemes have been developed for capturing color in a digital camera. One system uses a special prism that splits the image focused by the lens into three identical pictures that pass through red, green, and blue filters, respectively, onto three CCD chips. CCD stands for charge-coupled device, which basically means that the chip has an array of sensors that convert light into electrical energy. This method is used in the Viper camera. The second system, which seems to be gaining in popularity, is the use of a single sensor that has an array of red, green, and blue filters in front of the chip, sometimes known as a Bayer pattern.

Evaluating these cameras for resolution can be a bit tricky, as the data sheet may express that the camera has a 4K chip. Keep in mind that the capture chips are color blind and the color data come from the light passing through red, green, and blue filter arrays. In a single chip camera, each red, green, and blue sensor is mathematically combined to create one color pixel that results in a resolution loss of about 30 percent. The Dalsa Digital Cinema website has an excellent white paper on the subject that states:

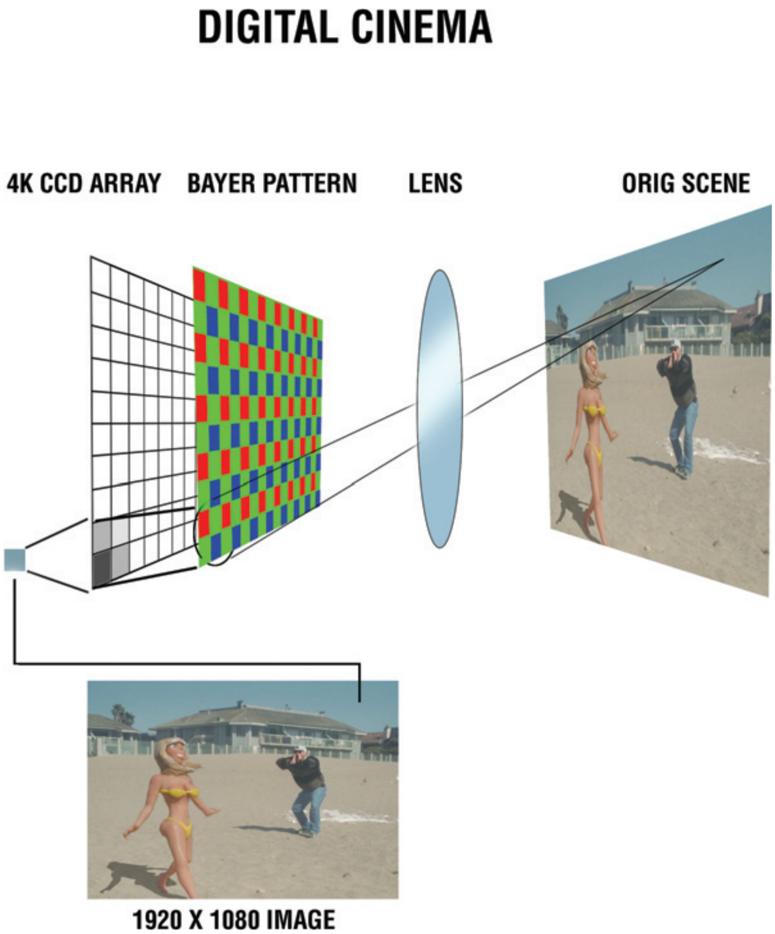


**Figure 7.5:** *How a digital cinema camera works. The black-and-white sensor array gathers the red, green, and blue information from a pattern of red, green, and blue filters and interpolates that information into a variety of resolutions. 1920 × 1080 is a common resolution, but the pixel count can be higher or lower depending on how the signal is manipulated.*

> A color filter array (CFA) mosaic such as a Bayer pattern allows the use of a single sensor. Each pixel is covered with an individual filter, either through a cover glass on the chip package (hybrid filter) or directly on the silicon (monolithic filter). Each pixel captures only one color (usually red, green, or blue), and full color values for each pixel must be interpolated by reference to surrounding pixels. Compared to a monochrome sensor with the same pixel count and dimensions, the mosaic filter approach lowers the spatial resolution available by roughly 30%, and it requires interpolation calculations to reconstruct the color values for each pixel (3-70-00218-01; www.dalsa.com).

So in evaluating a single chip that has 4000 horizontal pixels that are sensing over a pattern of red, green, and blue filters, we must realize that a great deal of mathematics is used to derive various resolutions using this capture method. A resolution of 4K can be obtained by interpolating the sensed values, but it is not directly captured this way to start with. What it boils down to is that as long as a substantial amount of data is captured, mathematics can be used to interpolate the information to generate sufficient resolution for theatrical presentation.

It is wise to test a digital cinema camera at a variety of desired resolutions and take the images all the way through the process to final film print and make an evaluation based on the final product. It will be up to the filmmaker to decide on the quality. Panavision states that its Genesis camera does not use a Beyer pattern but nonetheless uses a filter array in front of sensors to generate a signal. As far as I'm concerned, the images for the film *Look Out* (which I had the pleasure of being associated with), shot on the Panavision Genesis camera at a resolution of 1920 × 1080, looked spectacular.

## Light Sensitivity

In order to accommodate the market, the digital cinema manufacturers have (happily for me) rated their cameras with ISO values as well. The Viper camera, for example, is rated with an ISO of 320. This can give a handle on what to expect in relation to film emulsions. Even here, though, it gets a bit tricky, as film can be balanced for either daylight or tungsten. As it turns out (with the Viper system, at any rate) the chip isn't balanced the same way. The new philosophy seems to be correcting for color temperature in post rather than filtration at the camera. What follows is an explanation adapted from Viper's website.

One aspect of the working method that may change is that using filters at the time of imaging to correct the color temperature may move into postproduction in order to have more light sensitivity at the time of capture. The Viper Film Stream camera can be balanced for daylight by using a CC60M (magenta) and a CC81B (blue) filter for a good balance, though it will cut the light sensitivity by two stops. For tungsten light, Viper recommends a CC60M and a CC80C, though this cuts the light by three stops. Though these corrections can be performed in post, it will come with a price. If the wavelengths captured are out of balance due to shooting without a correction filter, then the underexposed portions of the digital image, just as with a film image, will have to be brought up later to compensate and can increase the noise level in the image. I suspect that the greater speed and convenience of not using filtration may become popular even though the data are slightly compromised. Three stops of sensitivity is a great deal of loss; if I had a choice, I would probably correct in post rather than scramble for more lights. While the current trend in digital cinema is to capture imagery without color correction, it is a viable alternative only with high-end cameras that capture an enormous amount of data. When using a standard or high-definition video camera, I always color correct or white balance the image at the start, as there isn't as much range to correct the color later on in post.

## Dynamic Range or Latitude

While the Viper loses a great deal of light when using filtration, it makes up for it by having a range of sensitivity settings. These higher settings (gain) usually result in a higher noise level, just as you would get with film if you "pushed" the processing and had the film sit in the developer longer. Pushing film can artificially raise the sensitivity, but it creates a grainier image. It should be noted that while the sensitivity of digital cameras can be changed by setting different ISO ratings, this is not the same as using different film stocks at different ratings. In order for the sensitivity change on a digital camera to mimic film stock, the capture chip would have to be physically replaced. When the ISO in a digital cinema camera is changed, it changes the proportion of stops over and under the gray card point. The Arriflex Corporation distributes an exposure wheel developed by Director of Photography Tom Fahrmann for their D-20 digital cinema camera that illustrates the point. At an ISO rating of 200, the D-20 will give five stops above gray and four stops below gray for a total of about 10 stops. Above and below these regions, the white and black will clip to a fixed value. If the D-20 is set to ISO 25, it will give only two stops above gray but seven stops below gray, resulting in the same range but allowing more detail in underexposed areas. When rated at ISO 400, it changes the scale so that it now gives six stops above middle gray and three stops below middle gray. With film, the different sensitivities always yield a similar exposure curve that is about five stops over and four stops under mid-gray. This range exists for shooting in bright light with ISO 25 or dim light with ISO 500 rated film.

## Size of the Chip

Another plus that is commonly touted by digital cinema cameras (except for the Viper) is that the sensor chip has dimensions similar to those of a frame of movie film. This allows the use of standard film camera lenses on digital cinema cameras. Cinematographers can enjoy the same depth of field and field of view that they have with film. Electronic cameras have frustrated many cinematographers because the capture chips are varied and small. Having a chip the same size as a film frame allows cinematographers to work with motion picture lenses and plan out shots just like they always have. The inconsistency of sensor sizes in different video cameras also made it difficult to correlate between different cameras. For example, a 50 mm lens will have a different viewing angle depending on the camera and the chip. The field of view shot from a 50 mm lens with a camera that had a 1/2 inch chip would be different from that from a 50 mm lens imaging onto a 1/4 inch chip. The cameras could be in the same place with the same lens but the picture would be different because of the size of the sensor. Camera operators have had to use charts and calculators to compensate

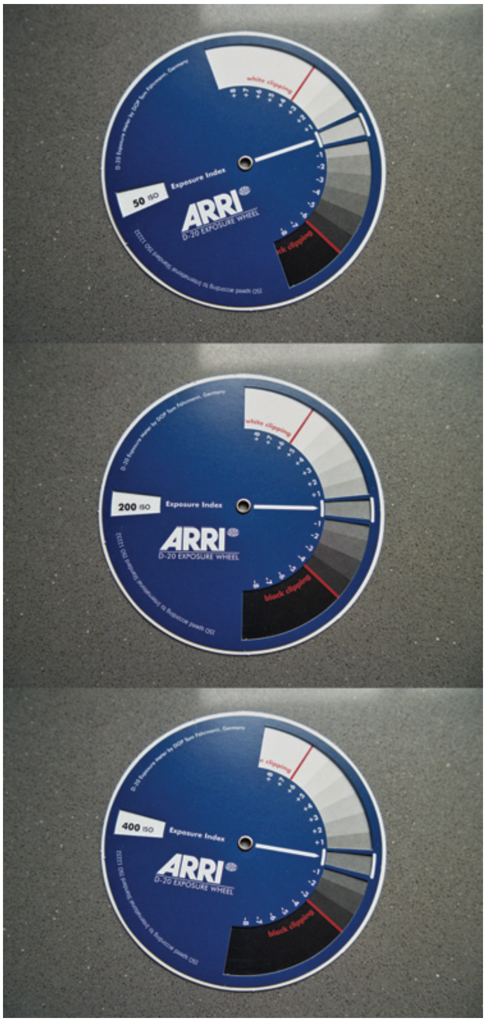


**Figure 7.6:** *Director of Photography Tom Fahrmann's brilliant calculator. Courtesy of the Arriflex Corporation.*

for this issue. When the digital cinema sensors are the same size as movie film, however, lens angles start matching again. Chapter 13 describes an example of planning a shot using two video cameras with different sized chips.

## Color Sampling

This next topic, color sampling, is a bit of a challenge in that I will subject myself to the pitfalls of generalized nomenclature in order to make a very complex subject palatable for the technologically challenged filmmaker. I provide this information as a very rough guide and invite those who want more exacting information to consult more technical books on this fascinating subject. For this topic I need to revisit the prior discussion of mechanical television and sampling the analog signal. As I mentioned before, the original image comes in to the camera through a Bayer or other pattern of red, green, and blue filters producing a red, green, blue (RGB) signal. When this signal is processed it can be converted into another type of signal called YUV, which is a method of compressing the information into a smaller space for ease of processing. Instead of sampling the full color data for all colors, only the brightness range, or luminance, is recorded in full, represented by the number 4, and less space is given for the color information, or chroma. The reason this works is stated eloquently by Charles Poynton in his paper "Converting between RGB and 4 : 2 : 2: The human visual system has poor color acuity. If R'G'B is transformed into luma and chroma, then color detail can be discarded without the viewer noticing. This enables a substantial saving in data capacity." The information is converted from RGB to YUV.

> Bear with me as I use the term YUV as a catchall for all its variations, such as YIQ, YprPb, and YcrCb, representing the many systems from different countries, analog and digital, or others I may have missed. The important thing for the non-tech artist to remember is the basic concept of the storage scheme for color and brightness. Once again, I lean upon Steve Wright to explain (p. 291, second edition): "Nomenclature disclaimer. The truth is that for NTSC the correct signal name is YIQ, and for PAL it is YUV. However, in computer-land, the label YUV has been misapplied to NTSC so often that it has stuck. Rather than confusing everybody by insisting on using the correct term, we will go with the flow and refer to it as YUV, but you and I know wherein lies the truth." Thank you, Steve.

The Y stands for luminance, or luma (brightness). The U and the V represent chrominance, or chroma (color), channels that contain the hue and saturation for orange-cyan colors (R-Y) and yellow-green-purple colors (B-Y), respectively. The sampling rate shows the amount of compression that goes on with this scheme. At times it is referred to as 4 : 2 : 2, which means that there are two samples of color for every four samples of luminance. These three numbers as applied to digital video cameras can be 4 : 4 : 4, which is equal sampling for all components of luminance and color, down to 4 : 1 : 1, which has one sample of color for every four samples of luminance. For effects work requiring blue or green screen, the amount of color information becomes very important. So, in a nutshell, for blue or green screen 4 : 4 : 4 is much better than 4 : 1 : 1. Figure 7.2 shows an exaggerated illustration of how tonal ranges get truncated with a lower sampling rate. The Y that has four samples shows a gradation of grays, while the lower samples to the right display only two tones. In a digital cinema camera, the 4 : 4 : 4 refers to full sampling of red, green, and blue. The output of these cameras only undergoes the luma chroma compression when the data is converted to 4 : 2 : 2.

> ### What Does This Number 4 Mean, Anyway?
>
> Marcus Weise in his book *Video Theory and Operations* gives a very succinct explanation of the number 4 (p. 111): "The specific sampling rate developed for digital television was based on multiples of the subcarrier frequency. The subcarrier frequency was used as a reference because it is the main synchronizing signal for the television system. The current sampling rate most commonly used is four times the subcarrier frequency for the luminance signal, and two times the subcarrier frequency for R-Y and B-Y components. Simple mathematics of multiplying 3.58 megahertz (color subcarrier frequency) times 4 will give a sampling rate of 14.3 megahertz. In other words, readings of the signal are taken over fourteen million times a second." In my book, that's pretty darn fast.

## What Camera Did You Get?

Well, currently, if I need high-resolution imagery it is easier and more economical for me to rent a less expensive film camera and have the film scanned. However,

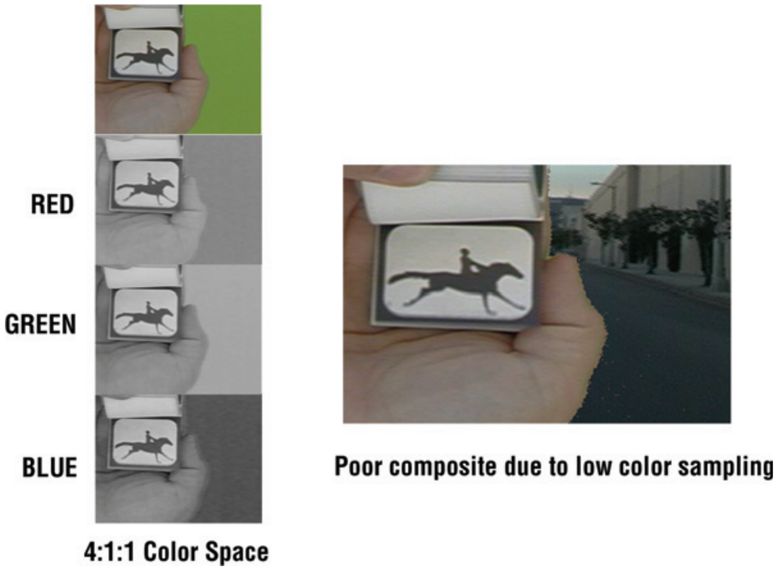


**Figure 7.7:** *Some compositing software can have a difficult time dealing with 4 : 1 : 1 color space elements. It is always best to start with as much information as possible to give the compositors a fighting chance. Note the jagged edges of this green screen composite due to low color sampling. A work-around for this problem is discussed in Chapter 12.*

there have been occasions when I've rented a relatively inexpensive high-definition camera to do certain element work for motion pictures. It is not my intention to write an exhaustive review of all the different low-cost high-definition cameras out there, as this book is mostly about camera placement, lighting, and lenses. My highlighting of a particular camera can be viewed as a research starting point for those

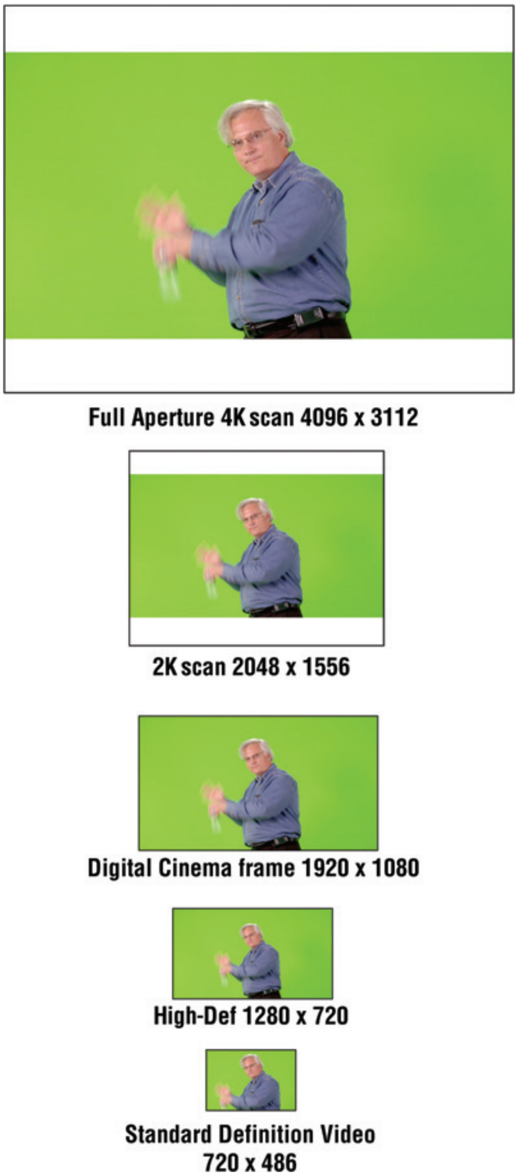


**Figure 7.8:** *A sampling of resolution sizes. The first two boxes are scans off motion picture film, while the last three are from electronic cameras. While I list the digital cinema frame as 1920 × 1080 (used on the film Lookout), these new cameras can have a resolution as high as the 4K scan seen at the top. 4K is not used that often because each frame becomes a huge, unwieldy chunk of data to work with in post.*

wanting a low-cost instrument to execute effects work in the high-definition 24P world.

In the case I'm highlighting, my choice was to use a high-definition Panasonic AG-HVX200 camera. I chose this camera because it shot progressive images and could achieve the 1280 × 720 resolution that I needed for my element to fit within a 2K film frame. Even though the HVX200 has a much smaller latitude range than the 10 stops available with the digital cinema cameras, I found that it wasn't a limitation in this situation. I was shooting on a set under controlled conditions, so I could adjust the contrast of the lighting and put it within range of this camera's sensitivity and latitude. The size of the chip did not matter, as I could play back the background plate I was matching to and do a video blend of the output from the camera and the background using a video switcher. In other words, I was able to match by eye rather than by focal length, which (as usual) was unknown. The color sampling of this camera when recording its data onto its solid-state storage device, called a P2 card, is 4 : 2 : 2, which made it a lot easier to pull the green screen matte off the element that I was shooting. Now, this being said, I was fortunate to be able to shoot the element (consisting of a sheet on top of a green screen manipulated from underneath) performing twice as slow. I needed to do this to match the delicate performance, which involved matting a sheet on top of two naked actors in a bed. (It is often a requirement to tone down nudity in shots when a feature film is distributed in certain markets.) I played back the background plate at half speed so I would have an easier time matching the movement of the sheet with the actors' performance. This methodology proved useful in more ways than performance, as the digital department wound up averaging the frames during the time compression (the half speed performance needed to be brought back to real time), which helped alleviate noise in the electronic image that became apparent as we combined the sheet over the film plate. I am confident that this was a temporary limitation of the camera that only became an issue for this particularly demanding shot. Placing a high-definition image on top of a film image invites a direct side-by-side comparison and can be quite a challenge for the compositor. The shot was very successful and was executed on a budget that precluded the use of the high-end digital cameras mentioned previously. I was quite impressed by the Panasonic and believe that its technology is moving in a smart direction. In my opinion, this camera would be ideal to use in the teaching environment and for independent work. The thing to remember is to always record onto the P2 cards if you are shooting green screen in order to take full advantage of the 4 : 2 : 2 sampling. My cameraman for this project was Jarred Land. His website, www.dvxuser.com, is a valuable resource that features the HVX and a host of other products used for digital filmmaking.

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# Chapter 8

## The Moving Camera

Motion pictures are a remarkable simulation of how we experience the world. A big component of that experience involves movement. For a good deal of the time our mind steadies out rough movements so that either the world appears still or we appear to be moving smoothly through it. This smoothness was initially accomplished in movies by putting cameras on tripods and using pan and tilt heads or using a dolly or crane to obtain smooth, dreamlike motion. Later, the development of the Steadicam allowed for smooth movement from a camera that was essentially handheld.

The effects industry has always had to catch up with this need for movement. The problem is that every single element in a shot involving movement needs to have identical movement if they are to composite properly. While the camera can have pan and tilt movement on the nodal point, as demonstrated in Chapter 1, this trick will not work for dolly, crane, or handheld moves. Effects such as the foreground miniature illustration, while allowing movement, had the impediment of having to be done on set. As movies became an industry, the rapid pace of production did not favor doing elaborate effects on set. There have been notable exceptions, such as Disney's *Darby O'Gill and the Little People* (1959) and, most recently, the remarkable *Lord of the Rings* trilogy, which used both on set and digital postproduction effects. For many years, however, effects shots such as matte paintings became "locked-down" shots, as described in Chapter 2. All the needed elements were shot at different times with the same lens, station point, and perspective. The elements would hold together in the shot, but the composition was static. What follows is a rough progression of various techniques for imparting motion to effects shots in postproduction.

## Rear Projection

In a projection composite in which an image is projected behind the subject, a certain degree of movement can be created during the composite. If the camera goes too far off axis of the projector, there could be issues with the rear projected image darkening, but for the most part very naturalistic moves can be simulated in this way. For matte painting shots, the plate is usually shot full frame and then is projected into a small aperture cut out of the painting, allowing for extreme pullbacks. An excellent example of this method is the final shot of *The Hunchback of Notre Dame* (1939) with Charles Laughton. The figure of the hunchback is rear-projected into a matte painting. The composite camera started shooting the projection full frame and then pulled back to reveal the painted cathedral.

## Lock-Off and Pan and Scan

An early idea for allowing freedom of movement for the camera was to shoot a lock-off shot on a larger negative and then rephotograph the image in an optical printer to create a pan or tilt within the finished composite. For a latent image matte painting requiring a tilt, this was typically done by shooting a lock-off latent image onto VistaVision film on its side where the image was taller than it was wide. The footage was then taken back to the studio and combined with a matte painting to create a composite using the methods outlined in Chapter 2. When the shot was finished, an interpositive was made of this VistaVision composite and then put into an optical printer, where a small portion of the plate was rephotographed. The optical camera

**Figure 8.1:** *An example of a rear projection matte painting composite. The black region in the middle of the painting is clear glass with black velvet behind. In front of the painting we see a forced perspective foreground miniature. The taking camera was on a repeatable motion control rig that allowed the camera to pull away from the painting. This was the matte painting pass. On the second pass, the lights were extinguished on the painting and the rear projection element was exposed. Painting by Robert Stromberg. Courtesy of Illusion Arts.*

**Figure 8.2:** *The third pass was a pull away on the foreground miniature only. Black velvet was dropped to obscure the painting. Note the simple use of two blue-gelled lights bouncing off foam core to provide skylight and a yellow gel over the hard directional lamp to simulate sunlight. Lynn Ledgerwood is seen detailing his model. The perspective is "forced" by having different scaled cars in close proximity to each other, providing a sense of depth. This setup was used for the final shot in the film* From Dusk till Dawn. *Courtesy of Illusion Arts.*

photographed the top half of the VistaVision plate, copying one-half of the frame. There was no image degradation, because one-half of a VistaVision frame equals one whole Academy frame, so no image blowup was necessary (refer to Figure 4.8). As the image was copied, the optical printer lens was moved frame by frame to create a tilt-down move over the matte painting effect. This same idea can be found in digital when the background plate is placed within a higher resolution matte painting frame. As long as the digital sampling of this larger frame stays within the final digital output resolution, there will be no loss of quality.

Most pans and tilts easily fit within the larger aperture of the VistaVision frame. If a longer event (such as a long pan) was desired, the method was to physically pan the camera and then stop at the lock-off point where the matte would align with the background. Before the camera came to rest at the lock-off point, the blend of the matte painting and the live action would not match, but this would never be seen, as the printer would only be copying the portion of the image outside the matte painting area. As the pan came to a stop, the optical printer lens "hooked up" to the live action pan and continued the move onto the matte painting, which by then had a perfect blend since the camera had come to its stopping point. This method was a brilliant way to preserve quality while bringing back controlled movement after the fact. The main drawback with the lock-off method, as with the on-set nodal pan, was that all effects elements remained locked and had no perspective shift. In a real situation, the taking camera pans not about the nodal but about the center of the camera. As a result, an object closer to the camera moves past it faster than objects


**Figure 8.3:** *An example of a tilt-up move within a high-resolution image. In this case, the 1.85 composition has a final output resolution of 1828 × 988. If the matte painting is considerably larger than this, we can pan about without fear of losing quality because we never "blow up" the image. In this case, the large matte painting has a resolution of 2996 × 3136. When we pan up to the smaller frame the extraction is exactly 1828 × 988. If we zoomed in closer we would begin to get a softer image because we would be enlarging the pixel data.*

in the middle ground or background, imparting a sense of depth. To address this issue, a method of repeating an actual camera move had to be created.

## Motion Control

Motion control is a method by which stepper motors are attached to all the moving axes of a camera and are controlled by signals generated by a computer. The beauty of this idea is that the movement of the camera can be finely controlled and is exactly repeatable. It is interesting to note that this motion control camera technique was used as early as 1948 in the "Fifth Avenue" shot in the film *Easter Parade*. Motors that derived their instructions from signals recorded on film controlled the camera; it was called the Dupy Duplicator. Olin Dupy of the MGM sound department was the inventor.

Modern motion control didn't come into widespread use until the dawn of affordable computers with the film *Star Wars* (1977). The biggest advance was the ability to

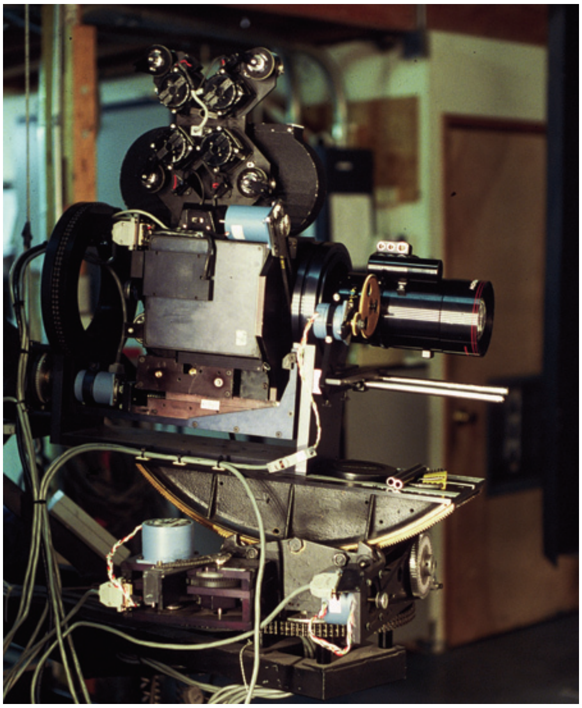

**Figure 8.4:** *A motion control stage camera with computer-controlled motors for every conceivable axis. Note that the lens is positioned on horizontal and vertical nodal in this rig. Courtesy of Illusion Arts.*

rethink movement and accomplish great, sweeping moves with an economy of effort. In the past, to photograph a spaceship coming from the distance and flying right over the camera, the method was to suspend the ship from wires and light the entire distance the ship had to travel. Needless to say, this was an elaborate setup that required a lot of rigging and many lights. The method used in *Star Wars*, supervised by John Dykstra of ILM, was to place the spaceship in a fixed position save for localized movement, so that only a few lights were needed to illuminate it. All that was needed to achieve the appearance of vast expanses of movement was to move the camera toward the model. On a black field there was no visual difference between a model moving past the camera and the camera moving past the model. This method saved a tremendous amount of elaborate rigging and allowed scores of flying spaceships to be photographed in a timely manner. The model was placed in front of a blue screen so that a background with its independent movement could be combined later, creating a dynamic effect. The ability to program the move was invaluable, and the ability to repeat the move exactly allowed for highly controlled lighting embellishments. For example, in a series of passes, in the first, the light could be taken off the subject and only the blue screen would be lit to generate a matte pass separately. The next pass would have the blue screen turned off and a black velvet background placed behind the model to generate a "beauty pass" of the model against black. A third pass could

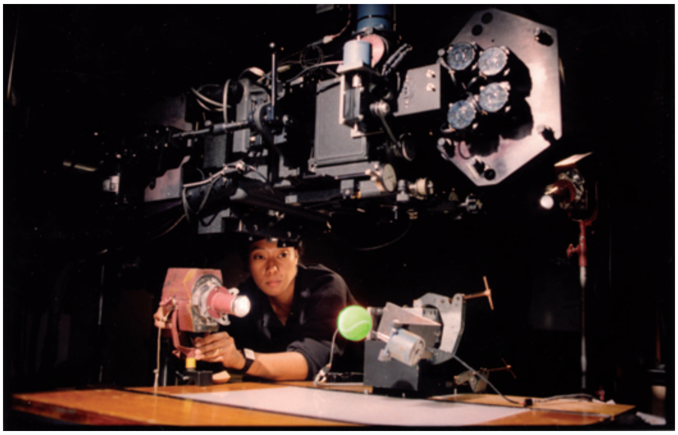

**Figure 8.5:** *A tennis ball attached to a motorized model mount on a motion-controlled animation stand. Operator Juniko Moody is adjusting the lights for the "beauty pass."*

be a double exposure on top of the beauty pass in which the main lights for the model were turned off and internal engine lights were turned on. At this point, the exposure of the camera could be increased dramatically, to perhaps 2 seconds per frame, and a diffusion filter could be added to "blow out" the exposure of the bulbs at the end of the engines, so they would appear to be white-hot exhaust. The use of motion control in a stage setting was a tremendous advancement that allowed for precise control of movement and lighting during effects photography.

## Streak and Slit Scan Photography

One effect that came to fruition at the dawn of computerized motion control was the ability to animate streaks of light. You may have seen an effect shot of a freeway at night that showed streaks of light as the cars moved across the frame during a long exposure interval. Motion control allowed this phenomenon to be animated frame by frame. During the 1970s, the streak effect was all the rage for titles; it was done in the following manner. A backlit piece of art was placed on the light box of the animation stand along with a colored gel. The camera would begin to move from 13 fields downward, essentially moving in on the artwork. When the camera came up to a constant speed, the shutter was opened at twelve-field and then closed at eleven-field to expose one frame of film. The camera returned to thirteen-field, and the next frame was shot using the same movement. The camera moved down, the shutter opened at twelve-field, then this time closed at ten-field. The length of the streak could thus be animated depending upon when the shutter was closed. These shots would take hours to shoot and put great wear and tear on the cameras, but created a magical effect.

Slit scan was a variation on this technique. During the long exposure time, rigs were used to move a slit past the artwork scanning the material, similar to the linear array film scanner. During the time that the slit revealed the image, the art could be moved as well, introducing controlled distortions of the image. You can create a slit scan effect yourself by placing some art on a photocopy machine and moving it about on the glass as the scanner wand passes by. You can turn a circle into an oval by simply moving the circle to keep up with the scanning wand in the middle of its move. A great example of slit scan can be found in the classic *2001*: *A Space Odyssey* during the Star Gate sequence. These effects are largely defunct now but are a great example of the ability to think of an effect in a four-dimensional construct in which time and space are manipulated simultaneously.

## Motion Control on Set

The use of motion-controlled cameras on set has been a great boon for actor duplication and interaction. In such scenes, the lighting is exactly the same for each take, and the two performances can be choreographed to precisely interact. A great example of this type of work can be found in the *Back to the Future* films, where two performances by the same actor in differing-age makeup are composited together with camera movement. Another example is the film *The Lord of the Rings,* in which actors of different scales, meaning same size actors made to look like giants or dwarves, interact with one another. The use of deeply integrated motion control within a movie is very effective when it is used on a regular basis with equipment owned by the effects company. Unfortunately for one-of-a-kind shots, the cumbersome nature of the exotic equipment needed tends to be off-putting to production companies even though it is a fabulous tool. In a typical scenario, technicians on location with the big motion control rig get it to work flawlessly on several test tries. Everyone feels confident, and the word comes down that the big star is 5 minutes away. The technicians stand ready and the report comes in that the big star is 2 minutes away—that is usually the time when the motion control computer crashes and everyone runs about screaming. I've never been present at a complete meltdown, as the problem usually is solved within those 2 minutes, but this type of occurrence has made people feel a bit suspicious about using motion control on location. This is unfortunate, because when used properly there is nothing like motion control for creating a completely convincing shot. The move can be done on location and then the same move can be scaled to shoot a miniature on a stage so that it blends perfectly. The use of motion control with miniatures still remains popular for the spectacle productions such as *King Kong*.

## Motion Control and Computer-Generated Imagery (CGI)

A motion control move can be shot and the movement data saved to manipulate a virtual camera in a CGI world. While this is a very workable idea, the reverse does not always hold true. A virtual camera can do absolutely anything, unhindered by gravity and inertia. A great previsualized CGI move might be created that everybody loves, and the camera data will be transferred to a motion control system only to have the physical motors stall out because the laws of physics won't allow a real camera to move that fast. In cases in which a miniature is being shot, the move can be matched by slowing down the frame rate in order to capture extreme motion. When people are involved, that option probably won't be available. One early failure of previsualization was an elaborate spaceship shot done in CGI whose move was transferred to a motion control camera in order to shoot a real model. In this case, the motion could be captured perfectly, but the previz did not take into account the myriad C-stands, flags, and lights that were placed about the stage to light the model. When the go button was pushed, the camera proceeded to knock down all the stands and lights, leading to untold amusement for all.

## Two-Dimensional Motion Tracking

This method uses high-contrast parts of the plate as "targets" to discern after the fact how the camera moved. This information is then used within software to match move imagery after the fact to composite into the plate. The targets are usually corners of doors or other architectural features, or, if placed by the effects crew, tape in the shape of crosses. Two-dimensional (2-D) tracking is very useful to stabilize a shot that has slight movement. A target is located as a reference on one frame and the software repositions all the subsequent frames so that their targets align with the reference target. Another typical example of the use of targets is to insert imagery into TV monitors. To avoid spill and flicker problems, monitors on the set are usually turned off, leaving black screens that may capture some reflections that can be used later. To get tracking information, I usually place four crosses of white tape at each corner of the screen. As the camera executes simple moves about the set, these four reference points can be used to record the position and perspective key stoning of the monitor screen. Later, the targets can be used to track and distort the image that is matted into the monitor. The matte will remove the tape marks and another matte may be pulled from the monitor glass to add its natural reflection over the image insert (cutting out the targets). Two-dimensional tracking can be very successful for many motion match chores such as TV monitor inserts. It is perfect for placing things within a shot so that they seem to be attached to an object within the scene. One case where this can fail is a green screen shot in which there are many targets on the screen and the objective is to matte the foreground over a background representing a far distant object at infinity. An example would be a green screen of an astronaut where we want to put the distant earth into the background. If the compositor slavishly used the tracking targets to "nail" the background onto the screen, the result would look like the earth was a painted flat 10 feet behind the astronaut. If we dollied in, the earth would get too big too fast, just like a painted flat. If it was in true perspective, a dolly in would enlarge only the astronaut and leave the distant earth

**Figure 8.6:** *It would have been impossible to physically stabilize this platform, as it swung in the wind 80 feet in the air. Large black crosses on white foam core were placed on the ground and were used as tracking targets to make the image rock steady. I am up in the basket, more than a little nervous. If you have a fear of heights, the trick is to focus on what you're doing and don't look down. Courtesy of Illusion Arts.*

unchanged in size. In this case, the tracking targets would be used to match certain motions that would affect both elements such as a pan but leave out the *z* axis on the background, meaning the in-and-out movement of the camera.

## Three-Dimensional Tracking

A very popular solution now is to use software programs such as Boujou to analyze clusters of target points within an image and derive an exact backward-engineered movement of the camera along with lens information. These data can be directly transferred to CGI programs such as Maya or Lightwave to move the internal virtual camera shooting the CGI element in the same way as the live action camera.

This is a tremendous improvement over what was needed to get this same information in the past. Wally Gentleman wrote a marvelous thesis on obtaining lens and camera position information from previously photographed footage, a method that was used quite extensively for static shots. The highlights of Gentleman's technique

**Figure 8.7:** *A blue screen stage with tracking targets attached to the screen to extrapolate camera move information after the fact. From* Rescue Rocket X-5. *Courtesy of sheerforceofwill.com.*

**Figure 8.8:** *On location, tennis balls laid on the ground or affixed to a "monster stick" (a stand-in for a digital monster) can be used to gather tracking info. From* Rescue Rocket X-5. *Courtesy of sheerforceofwill.com.*

can be found in David Samuelson's *"Hands On" Manual for Cinematographers*. If you don't have Boujou and don't have the time or inclination to do the Gentleman method, you can use CGI software along with some assumptions about the background plate to empirically derive camera information after the fact. This down and dirty method is only useful for lock-off shots, but it illustrates what goes on inside move data extrapolation software. I once worked on a picture in which a street scene shot in Canada needed a dialog change. Because the crew could not go back to Canada, the dialog was recorded in front of a green screen with actors standing in front of a piece of architecture that needed to be aligned with a building in the background plate. Shots like these are some of the most difficult effects shots to accomplish because they cannot "hide behind" being effects shots. The shot has to be absolutely real without calling attention to itself because it is the replacement of a real production shot. For the plate we used the empty background before the main characters entered the scene. No notes about how the plate was shot had been taken, so I had to deduce the information after the fact. I called this shot into CGI software and created some very simple planes to represent the sidewalk and the side projecting wall of a building. I could get a pretty good estimate of the width of the sidewalk and the wall by judging them against extras within the plate. I then took these two planes at right angles to each other and positioned them so that they coincided with the image of the sidewalk and the wall. I moved the virtual camera back and forth


**Figure 8.9:** *Deducing camera position by alignment method. Two planes are created that are at right angles to each other and superimposed over the background plate in computer graphic software. By manipulation of the virtual camera's focal length and position, the original camera station point can eventually be arrived at. In this case, the photograph was taken with a still film camera that has an aperture size similar to VistaVision. I shot the photograph with a 28 mm lens, and sure enough the "sweet spot" wound up being 28 mm in the camera attributes window. Other windows show the camera height and tilt.*

and up and down, changed the lens angle, and so on, until I found a sweet spot in which the vanishing points of these elements lined up. I could then look up the camera information and tell the green screen crew what the height, lens, tilt, etc., of the green screen camera should be. Many CGI artists use similar techniques to align computer graphic models with live action elements. If you don't have access to software such as Boujou, this method can be a viable alternative to the drafting table methods of Gentleman's era.

As a side note, when doing seamless shots, like the previous dialog replacement example, it is important to scan all the foreground elements at the same time. In the dialog replacement shot, the editor had us scan two shots and then added a third shot a few days later. This necessitated going back and scanning all three shots on the same scanner at the same time. There are subtle differences between scanners; even the time that a scan is done can have an effect on color reproduction. If two of the shots had been scanned on one brand of scanner on one day and the third shot scanned on another make of scanner on the following day, it might have been impossible to match all three scans for color. In the case of a green screen there will already be subtle color changes due to the color extraction process. In this case, color was critical, as the green screen shots involved closeups of the star. Always scan all shots that repeat in a sequence at the same time on the same scanner.

## Sticky Front Projection

Motion tracking works very well in situations in which live action camera movement is matched with a complete CGI environment. It also works well for placing artwork or a CGI element into a moving live action background. It is of questionable use when taking a live action background plate made with one move and another live action element with another move and attempting to justify them so they fit. A shot comes to mind in which the production did an elaborate boom up from the actor's lap in a moving convertible to over the shoulder of the driver. The car and principals were shot against a green screen. The production also provided the background plate of the road with a simple tilt up from the roadbed to the horizon. It was impossible to track both moves and have them marry up in a convincing manner. The first few attempts looked like a scene from *Flubber* (a movie about a flying car). The solution was to scan the tail end of the shot where the background plate camera stayed in place. That footage was then mapped onto a curved L-shaped polygon on which the sky and horizon were on the back plane and the road was mapped on the ground plane (like the real environment). This mapping is called sticky front projection because the projected background image is stuck, like wallpaper, on the polygonal surface, turning it into a crude dimensional model. A CGI camera was used to mimic the boom move and replicate it shooting the background off the polygon map. This system can work well for subtle or quick moves. If the move goes too far such as an extreme push in, the effect can be given away, as the background can become unusually distorted.

## Matting Actors into Unstable Stock Footage

It is best to take movement data from a plate and attach it to a lock-off of a foreground figure on a green screen to match movement in a composite. A common technique for placing actors into historical settings, used in *Forrest Gump* and *Zelig*, is to take the historic moving background plate and stabilize it so that it is static. A green screen element is shot static to match and composited into this stabilized frame. Once the two elements are locked together, a move is added that is the opposite of the stabilization data and the original camera move is imparted back upon the composite, affecting both the foreground and background equally.

## Encoded Motion Interactive Playback

If the production is well planned and the composite will involve live actors interacting in a CGI environment, it is possible to create low-resolution versions of the CGI set and have that data imaged by a virtual camera slaved to a real camera system with encoders. If the performer is on a blue screen set being photographed by a film camera on a boom arm, then the video tap off the film camera can be put through a real-time compositing system that will combine the video tap image with the low-resolution real-time video render of the CGI set. If the real boom arm tilts up, the encoder will send signals to the CGI system that will tell the virtual camera to tilt up at the same speed with the same number of degrees. On the video tap monitor, a crude composite can be seen of the actor performing in a low-resolution virtual set, with the real camera and the virtual camera moves locked in synchronization. This method is a clever way to move previsualization into on-set visualization so that the final camera move can be locked in a visually tangible way. The film footage can be linked to the video tap playback and the CGI camera data can be used to create moves using the final high-resolution CGI set. The final composite will be a high-quality version of the previz shot seen on the set.

## Environment Maps

To accommodate a situation in which there is no definite decision about how a number of background plates will be shot, a method called environmental mapping can be used. On location, the background is shot from a variety of angles that will cover a wide field of view, much like the Disney Circle-Vision rides, in which multiple cameras are used to shoot a 360 degree perimeter of the scene. If a wide expanse of coverage is shot in this manner and the shots are seamlessly stitched together and mapped onto a curved polygon in CGI software, a virtual environment can be created for the virtual camera. The camera can be moved in the green screen shoot and that move data transferred to the virtual camera so that the background will be shot in the correct orientation for the composite, as if the actor was placed within a giant curved screen playing the background image. This method can work fairly painlessly if the shot is in the sky, at the top of a mountain, or in another setting in which all of the background is at infinity. When mimicking a Steadicam shot in a busy environment, extra care must be taken to multiplane the background plate to mimic the parallax displacement of the various elements. Figure 8.15, for example, shows how different foreground elements pull apart as the camera dollies to the left. If the actress is shot against a blue screen with tracking targets to mark the motion of the Steadicam, this same movement can be applied to a CGI camera to have it shoot an artificial environment pieced together from photos taken on set. Since a still background is not dimensional, the various planes such as the background and mid-ground have to be cut out from the picture and the holes left behind in each cutout have to be painted in. In Figure 8.15, for example, if the sky was cut out from one of the stills, the area where the pole and the trees were would have to be painted to create an even expanse of sky as is seen in Figure 8.14. This has to be done for each image plane created from a still or moving picture.

As pictorial elements within the shot get closer to the camera, the perspective shift becomes so great that there is no recourse but to build a fully dimensional computer model. The usual rule of thumb for creating false dimensional sets is for the elements closest to the camera to be full CGI, because they will show the most perspective change. Elements farther away would be simple polygonal forms that have photographic texture maps on them to allow for a slight perspective shift. The third most


**Figure 8.10:** *Shooting several stills at a variety of angles to create a seamless environment map to be rephotographed with a moving virtual camera.*

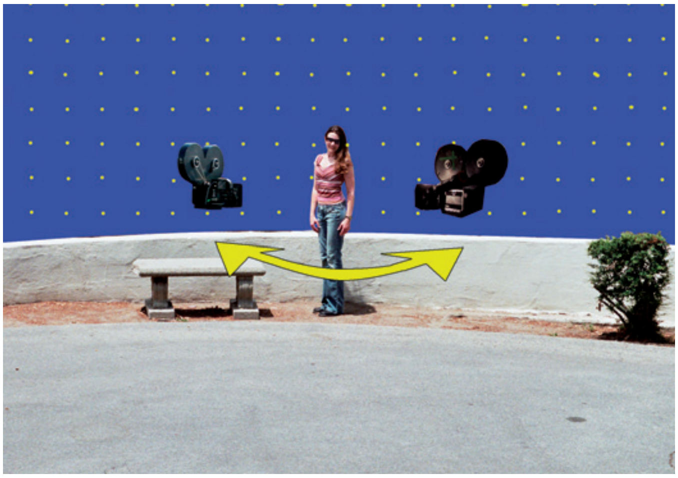

**Figure 8.11:** *Live action subject on a partial set with blue backing and tracking targets. The live action camera moves about the subject, recording the performer and the tracking targets.*

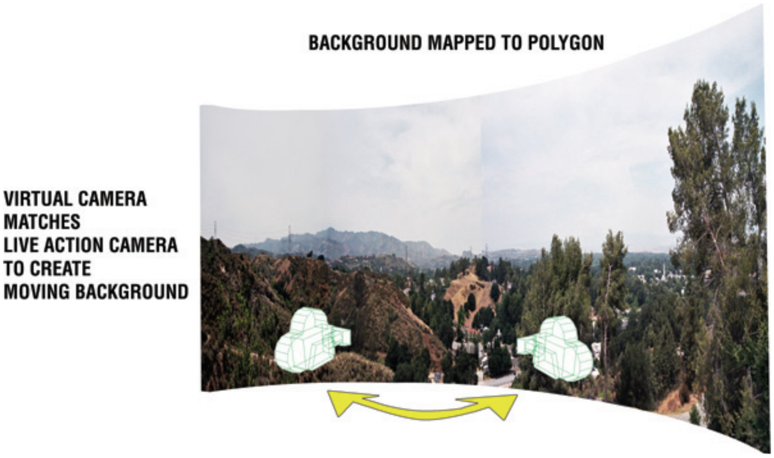


**Figure 8.12:** *Three-dimensional tracking uses the tracking targets to recreate the live action camera move in the computer graphic world. A virtual camera photographs the large environment map placed on a curved polygon to create a moving background that will match the live action blue screen footage.*

distant plane would be a flat polygon with cutout buildings in the distance, and the final layer would consist of a flat plane of the world at infinity consisting of distant mountains and sky.

## LIDAR

LIDAR stands for light detection and ranging. With this system, laser light can be used to scan real environments and create CGI models that mimic the real world. These rough models need to have the proper textures and detailing added to achieve

**BLUE SCREEN COMPOSITE OVER VIRTUAL BACKGROUND USING 3-D TRACKING**

**Figure 8.13:** *If the background is far enough away, a single plane environment map can be used for a dynamically changing background. There will be no perspective shift between elements in the background.*

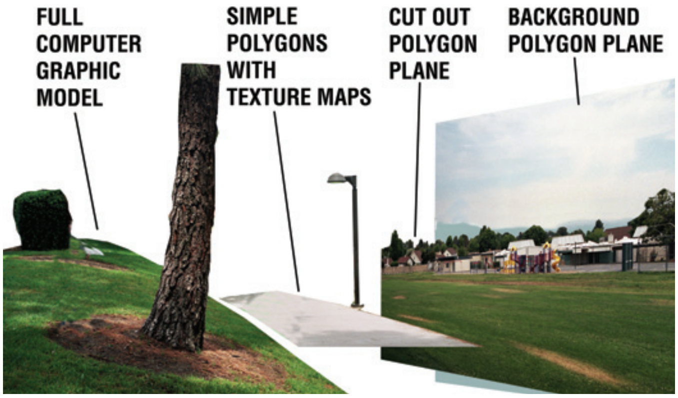


**Figure 8.14:** *To obtain perspective shift, the objects closest to the performer have to be fully realized computer graphic models. For objects farther away, simple computer models "wallpapered" with photographic texture maps will do. The layer beyond that can be a cutout of the far mid-ground, and the most distant layer can be the world at infinity, that is, sky and the distant horizon. Recreating extreme moves after the fact is quite an involved challenge.*

**MANY PERSPECTIVE CHANGES HAPPEN EVEN IN THE SIMPLEST OF MOVES**

**Figure 8.15:** *The simplest dolly move can show the tremendous amount of subtle changes that the background undergoes. Take note of the light pole and the slight perspective shift it undergoes along with the intersection of the pole against the bush. This is why it is a good policy to shoot as much real background as possible. It would be easier to merely replace the sky, for example, than to fabricate the entire location.*

photo reality, but the distance and size relationships will be provided automatically with the scan. Typically, the scans are done by a unit mounted in an aircraft that flies overhead and is calibrated using a global positioning system.

## CGI Actors to Accommodate Moving Backgrounds

A system similar to LIDAR can be used to scan the full body of a performer to provide an accurate model of the actor. This digital model will have to be extensively reworked to include the armature and smooth "break points" for the model's joints. Once achieved, this digital puppet can be texture-mapped with photographic imagery of the real actor.

To have CGI actors that mimic real actors working within a changing light environment, a different type of scan that was developed by Paul Debevec and used by Sony Imageworks for *Spider-Man 2* (see www.imageworks.com) can be used. For this scan, called the Light Stage system, the actor is placed in a stationary position and is photographed by four motion picture cameras as a series of strobe lights flashes and rotates around the performer. In an 8 second pass, each camera photographs the actor's face under 480 different lighting positions, which, multiplied by four cameras, yields 1920 differently lit faces that could be mixed and matched to the changing lighting patterns encountered by the CGI figure as it is composited within the live action background plate. This is the digital equivalent of the replacement head technique of the early stop motion era, as illustrated in Chapter 3. In this case, there are many more replacement heads, as the same head is lit from the front in one series of scans from the four cameras and lit from the back in another series of scans, as if the light effect was painted on the replacement heads instead of using real light. For the animation of the character's face, about 80 different facial expressions are captured and used as key poses. This method is much like producing a robotic voice by stitching together various words to form sentences. If done skillfully enough, the voice can sound very natural. The stitching and animating of the huge selection of face photos and poses gave a remarkably realistic image of Alfred Molina's face on the CGI figure of Doctor Octopus used in *Spider-Man 2*. The method is a brute force technique for matching lighting in which a huge number of poses and lighting conditions are oversampled on a subject, which allows you to light by menu choice after the fact. Needless to say, only a very well-heeled production can afford to use this strategy.

## The Future

Many amazing camera moves are done today by blending a variety of techniques, such as having a Steadicam operator ride a cable cam into a set from a far distance, jump off the cable car, walk through the set following the action, jump on a boom arm to move down two stories, jump off again to further follow the action, etc. These shots can be spectacularly dreamlike but a complete nightmare for the effects person if it is necessary to matte in another actor or other elements into a dynamic shot like this. Entire sets can be created in CGI for complete flexibility but, as was mentioned before, will require just as much if not more effort as creating a full miniature. If you take this approach and have limited resources, you run the risk of having the actor perform in what looks like a "cartooniverse." After speaking to robotics engineer Rich Petras from JPL who was one of the engineers responsible for driving the Mars Exploration Rovers about the surface of the red planet, I obtained an insight into a technology that might be used in the next generation of effects. Since the Mars lander is being manipulated from such a vast distance, it behooves the engineers to have a very exacting layout of the land before moving the vehicle (to avoid hitting rocks or getting stuck in craters). They get this layout by scanning the environment with a 3-D camera (two cameras side by side with matched lenses offset by a known amount). A 360 degree pan made with this camera creates many left eye, right eye pictures whose parallax difference enable the relative positions of objects in space to be seen. An object 4 feet in front of a 3-D camera will be displaced more than an object that is 8 feet away, and by computing those displacements, each pixel that makes up an image can be given not only RGB data but also *x, y,* and *z* coordinates. If the 360 degree pan scan is performed at several locations in the environment, clusters of pixel data can be captured that can be used to create CGI set pieces out of photographed imagery, as opposed to polygonal structures with multimapping strategy.

To record an environment in motion, the scanning device must be a collection of motion cameras that shoot off mirrors to simultaneously record from several different scan positions. The process is similar to the environment map idea except that instead of flat planes, each object, tree, chair, rock, etc., would be a true 3-D model created from pictures. The advantage to this process is that a set or location can be scanned and captured as a virtual set and the performers can move freely about a green screen set photographed with a camera linked to its virtual camera counterpart. It is like being able to do what we do today with CGI models without having to build CGI models (unless a fantastic setting is being created, in which case a real set and a CGI set could be integrated in the same 3-D space). This process captures reality in two places separated by time and allows them to be integrated seamlessly with no constraints on movement. The number crunching needed to accomplish this task is staggering, but, as with all things digital, it may be accessible in the not-too-distant future.

## The Blessing and Curse of Movement

While it is a great achievement to accommodate the moving camera when executing a visual effect, it is also important to note that these accommodations can be expensive and are often compromises. Giving a filmmaker complete freedom of movement with the thought that it will be relatively easy to track in and composite numerous elements into dynamically moving shots couldn't be further from the truth. As can be seen from the case studies, none of this is easy. The other aesthetic issue that comes up is that extreme camera movement, while exciting, calls attention to the camera work and thus moves the movie away from a simulation of our perception of reality. If I look up at a building, for example, I merely look up at a building; this viewpoint is simulated with a simple tilt of a camera. As a human being I don't suddenly jump 300 feet in the air and circle the building to see every angle. When stories are depicted in this manner, the experience becomes more like a video game than a movie. The other issue with extreme movement is that it is aesthetically limiting in terms of the lighting. Most films use a single-camera technique, and as a result the lighting is adjusted to work perfectly for a limited angle. The more you move the camera, the more you have to light like a multicamera television show if you want a readable image from all those different positions. I think of movies as an expression of the human experience, and not all of that is a fireworks display of movement. Since this book is addressed to the student and independent filmmaker with limited resources, I think this may be a point to ponder.

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# Chapter 9

## Blue and Green Screen

The color difference system used to separate an image from a colored screen and composite it over a background image has become one of the most common effects techniques used today. It is relatively fast to execute and doesn't appear to need much preplanning. The myth behind this technique is that you can put anything up against any kind of color and "they'll make it work later." As a result, digital compositors on the front line have lost a great deal of hair dealing with poorly executed color screen elements. To provide some guidelines, I'll trace a bit of the history and demonstrate some methods for shooting a blue or green screen element.

### Blue Screen

As I mentioned in an earlier chapter, the blue screen process was used as early as the silent period for generating high-quality composites on black-and-white film using the Dunning Pomeroy process. As the years progressed and color film came into being, many effects artists adapted the idea of using a blue screen to isolate an element photographically to create color composites. One of the early examples of the process was that developed by Lawrence Butler for Alexander Korda's *The Thief of Baghdad* in 1940. The color blue was first used for the simple reason that there is very little blue in skin tones. The blue wavelength can be isolated while still getting a fairly acceptable color rendition for faces. The process made use of black-and-white separations. A separation is a black-and-white film that contains only one of the color components. It is made by placing the color negative in contact with black-and-white film and exposing it with a primary color. This process was done three times to create red, green, and blue color records on black-and-white film. The black-and-white color records were exactly the same as the color channels now used in digital processes. In the early blue screen process, the red and green "seps" rendered the blue backing black, while the blue separation rendered the blue area clear on the positive film. The matte was created by bipacking the color negative on top of the positive blue separation (bipacking, as you recall, is a process of placing one film on top of another in contact while being held in place by registration pins in a camera or projector). The negative and positive image of the figure would cancel out, leaving the subject black, yet the blue screen area in both the negative and positive would be transparent to light. When this bipack combination was copied using red light, a silhouette of the subject was obtained that would move with the action, creating a traveling matte.

The drawback of the early system was that it made use of all three separations to render the color. Any slight mismatch of mattes led to a blazing blue fire around the blue screen elements (this was essentially the screen showing through). This problem can be seen on films such as *The Greatest Show on Earth* with Charlton Heston and, not unexpectedly, on early video chroma key composites for TV weather announcers. In *The Greatest Show on Earth*, an early editorial "fix" to address this issue can be seen. In one sequence showing circus performers parading under the big top, there was a closeup of a woman wearing a feathered headdress that was ablaze with blue fringe. To

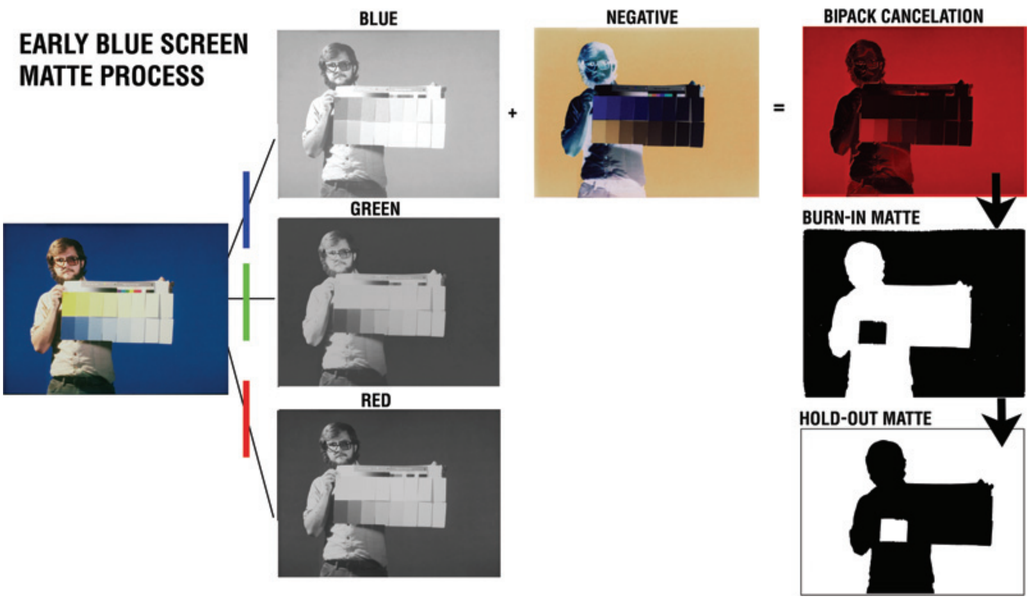


**Figure 9.1:** *The basic idea behind the blue backing process is to cancel a positive and negative image against each other while the common area of the screen is clear for both. This is accomplished by placing a black-and-white record of the blue information on top of the negative image and shining red light through the pair. This creates a burn-in matte that we then print back to obtain a hold-out matte.*

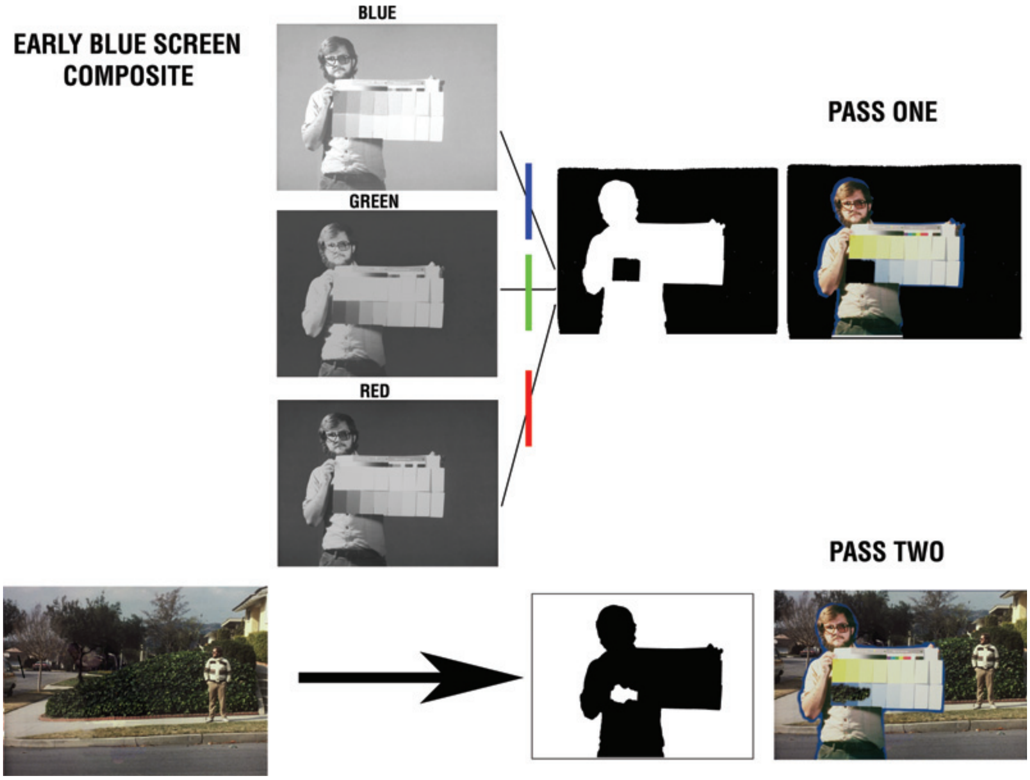


**Figure 9.2:** *In early blue screen process, all three records were used to reinstate the color.*

**Figure 9.3:** *The problem with early blue screen. If the mattes did not cancel perfectly, the blue backing would show through, creating a blue fire around the figure. If the figure contained any blue, such as the blue patch on the chart, the subject would become transparent unless a "helper" rotoscope matte was used to fill in that area.*

justify this weird image, the editor cut in a shot just before it of one of the circus roustabouts swinging a big blue light around to seemingly point at the offscreen woman; this then became the reason that the woman's headdress had a blue highlight.

It wasn't until the mid-1950s that a brilliant inventor named Petro Vlahos perfected the system and created the color difference process. Vlahos devised a way to create a synthetic blue record from the green record (where the blue screen was dark) that effectively eliminated the blue halo. Vlahos discovered that the green and blue separations were essentially equivalent except for blue and yellow colors. This meant that when the blue screen element was composited, instead of putting in the red separation and exposing it with red light, then backwinding and exposing the green separation with green light and the blue separation with blue light, the green separation could be used twice and exposed with both green and blue light. If the subject did not

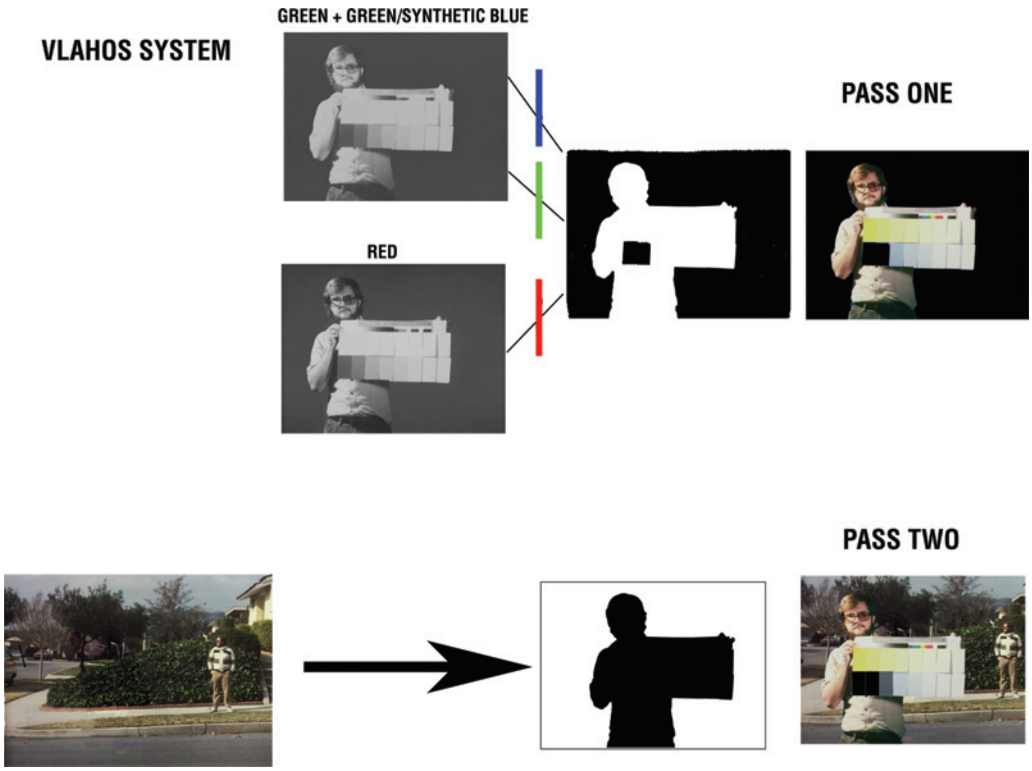


**Figure 9.4:** *The Vlahos process reproduces color without the use of the blue separation. It can render all colors except for the blue backing without getting the blue fire. In this figure, I'm holding a chart recommended by the original U.S. patent #3,158,477 to check color reproduction. The black box on the chart was originally blue and needed a supplementary hand drawn matte to keep the background from showing through. Pass one consists of three separate color exposures of red, green, and blue through the appropriate black-and-white records.*

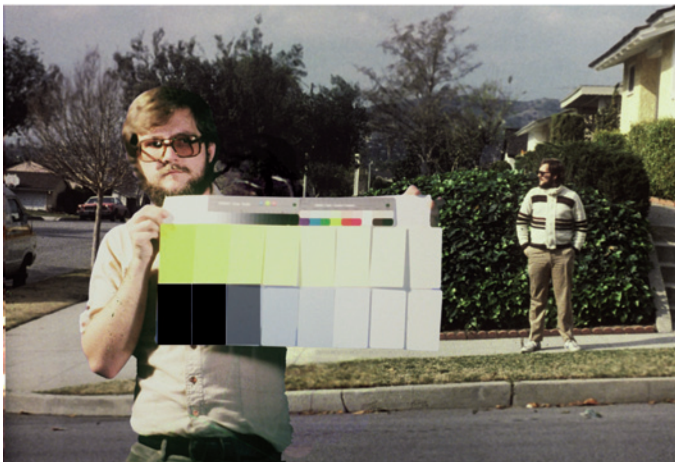

**Figure 9.5:** *A blue screen composite using the Petro Vlahos method now incorporated in Ultimatte software. The yellow box on the chart stays yellow due to the use of the synthetic blue separation derived from the green. If only the green separation was used for both the green and blue pass, the yellow box would become white.*

have blue (it shouldn't, for blue screen) or yellow, all colors could be rendered accurately. Yellow will become white, as a yellow object will be clear on a red and green sep but black on a blue sep. If the green is used twice, then the yellow object will be printed with red, green, and blue light equally, rendering it as white. To overcome this problem, Vlahos devised a way to create a synthetic blue separation from the green by adding density in the yellow areas of the image onto the green record. This synthetic blue became a match for the blue separation with the exception that the blue screen area was dark, thereby avoiding the problem of blue fringe. The Vlahos system was so successful that effects artists used the system for all the blue screen effects from the mid-1950s to the age of digital. Remarkably, Vlahos went on to create the electronic equivalent of his system with Ultimatte. Ultimatte is the video and digital equivalent of the color difference system and has been used as the primary software tool for color difference shots on many major motion pictures.

## Color Screens

The main objective when creating a color screen for compositing work is to obtain a color as pure as possible with an exposure that allows for easy matte extraction. One of the first screens developed for this use was the Stewart blue screen, a pure blue translucent screen that was lit from behind by hundreds of tungsten photo flood bulbs. The screen was extremely flat, bright, and brilliant blue but very expensive and wasteful energy-wise. A common alternative was to use deep blue paint on flats and increase the purity of the color by lighting with two intense blue gelled lights at angles to the screen of 45 degrees. This lighting scheme would render a very pure blue but at a tremendous cost in light output, as a deep blue filter in front of lights can remove 90 percent of the light output through absorption.

Today there are special paints formulated for this purpose that take a lot of the guess-work and testing out of the process. If the budget allows, the screen should be painted with paint specifically designed for the purpose, such as Ultimatte digital blue or green distributed by ROSCO. There are paints that are marketed under other names, such as chroma key paint, digital or video green, or some other variation. These paints have been formulated to emit wavelengths that are friendly for a particular medium, such as film or digital capture. I find that the differences are subtle, and any paint that is sold for color backing work can generally be used for all mediums. The important thing to note is that since these paints exist, make use of them. A pale green bedsheet is no substitute for a good green screen.

If you are stuck with using a less than pure blue or green paint, then the fallback is to return to the early method of lighting the screen with colored light to bring out the purity of color. For low-budget work, a good portable screen can be made by purchasing a small roll of the cheapest linoleum you can find and painting the color on the back. The painted linoleum can then be supported by two C-stands from above and draped at the bottom to form a fairly durable flooring as well. The most popular screens today are cloth screens that are extremely pure in coloration. Since they are fabric, they tend to avoid the glare issues that painted flats sometimes have. The most common screen for professional use is the Composite Components screen available from www.DigitalGreenScreen.com. It was developed by John Erland (formerly of Apogee) and is the result of extensive research in coordination with Ultimatte and Kodak. The screen is very popular because it provides excellent purity, brightness, and separation and has the wonderful side benefit of being able to be used outside in daylight without any special lighting apparatus.

## Setting the Screen Exposure

Blue screen exposure is the easiest to get right in that it can be done visually by eye. The screen is lit with two large soft lights on either side that are adjusted for an even field. The field is checked for evenness through the use of a spot meter or the use of zebras (more on this later). If the blue is not pure enough, deep blue filters can be added over the lights to increase the purity, or blue-emitting fluorescent tubes can be used to light the screen. For my own work, I tend to use a good screen fabric material such as the Composite Components screen and light with straight tungsten light. For me, this method seems to be the most flexible even though it is not optimal. While the blue tubes are the best light source, they only serve to light the screen and can't be called upon to do double duty. If you have the resources, by all means use them, but for tight budgets, tungsten light and a good screen are usually fine.


**Figure 9.6:** *The fastest way of balancing a blue screen is to view a white card against a blue screen through a deep blue filter. When the white card and screen match in intensity, you have the correct exposure.*

In order to balance the blue screen to obtain the correct exposure, the subject is lit as desired, then a gray card is placed at the subject and a spot reading is made to obtain the f-stop. If the stop is, say, f/5.6, the goal is to light the screen so that it will be well exposed at this setting. The next focus of attention is the white chip on the gray card that represents 90 percent white. Your handy 47B or 98 blue Wratten filter, which are pure blue filters developed by Kodak for color separation, is then held over one eye while the blue screen is brightened or darkened until it blends in with the white card. This ensures that the blue light level is right at the 90 percent mark. This is a good goal since it gives adequate exposure in the screen while still allowing fine detail, such as a wire fence, to be resolved without "pinching out" due to overexposure of the screen. This method can also be used for green screen with a 99 green filter. I find that it is a bit more difficult to find the blending point of the white with green, as it seems to blend over a wider range and is hard to nail down, but you can usually find a midpoint. When you don't have access to a 98 blue or 99 green filter (which will be always), you can create a substitute by selecting the deepest color filter in a sample filter booklet or by looking through several layers of the deepest color gel you have. The same blending can be seen using a video camera (without the use of filters) by viewing the screen and card on a black-and-white monitor displaying only the blue channel.

## Blue Screen or Green Screen?

The color blue dominated the effects arena for many years not only for color rendition issues but also because it was the easiest color to extract mattes from using the photochemical process. Green came into popularity when it was found that video systems liked it better, as it was closely linked to the luminance channel and had less noisy data associated with it. Other strange technical factors, like the fact that the detail generators of some video cameras didn't sense a change between the subject and the green so then would not create a detail spike along the edge, also played a part in the switch to green. Ultimatte recommends turning off detail generators on electronic cameras, as the "details" they generate are synthetic and create artificial matte lines before you even get to the compositing stage.

Even though green seems to be the color of choice in this work, the important thing to remember is that either green or blue can be used; the deciding factor is the color of the foreground subject. If the subject is wearing a color similar to the screen, they will disappear, much like the invisible man. This decision should be made in preproduction. If the subject is wearing blue jeans, shoot in front of a green screen. If he or she is holding a green apple, shoot in front of a blue screen. If he or she is wearing blue jeans and holding a green apple, pick the least problematic offender. In that case, I would choose blue—the apple is a fairly intense color, and the jeans tend to be darker or paler and a bit more subdued, so you have a fighting chance of pulling a matte. While these primary colors are obvious issues, some secondary colors will not be able to be reproduced if the subject has a great deal of screen spill (light bouncing off the screen onto the subject) that needs to be eliminated using spill suppression in compositing. For example, in blue screen photography, magenta colors will reproduce well as long as there is no blue spill. If there is unacceptable blue spill and it is cancelled out in post, then magenta colors tend to go red because you will be suppressing the blue component (red + blue = magenta). Hyperefficient colors such as red and yellow may produce dark outlines that will have to be corrected in post. In the case of green screen, saturated yellow will turn red if too much spill suppression is used. Pastel green and blue colors are fine for both processes.

The best approach is to plan and anticipate color reproduction issues. When a company hastily shoots a foreground in front of a screen that happens to be handy without considering color issues, the only solution may be to generate hand drawn mattes after the fact. This turns what should have been a simple push button solution into a labor-intensive operation in post. This is the drawback of proceeding without preplanning, and it happens far more often than it should. In some cases, however, it is unavoidable. In the film *Batman and Robin*, the character Mr. Freeze had an all-blue costume while the Poison Ivy character was dressed all in green. There was a composite shot in which they jumped out a window together, so there was a one or the other situation. In the best of all possible worlds, the blue subject would be shot in front of green and the green subject would be shot in front of blue, and they would be blended together. The reality, however, is that the time involved to take this "correct" approach would be far too time consuming and expensive under the circumstances, as it would add more elaborate setups; it would also lose the intimacy of both performers being in the same shot at the same time. The supervisor made the appropriate call and green screen won out, so Poison Ivy's mattes had a lot of hand drawn help from a digital artist.

## Shooting Green Screen Elements the Proper Way

### The Background Plate

I worked on a film, *The Glimmer Man*, that contained the classic shot of a man hanging from a window. What follows is a description of the traditional procedure used for this age-old effect, in this case supervised by Bill Taylor, ASC. The illustrations used are a recreation of the effect to avoid the permission complexities of a shot that involves an actor. The actual shot can be seen in the trailer for this film, which is available on the Internet.

A fair amount of preplanning was used to execute this effect. The shot was boarded, the location was worked out, and the camera equipment was prepared. The building we were to shoot from was in downtown Los Angeles. The production company rented an apartment in a tall building for the day so that they could shoot out of the window. For safety's sake, the camera was mounted on a dolly with a long boom that could project out of the window. The camera had a video tap so that the composition could be seen on a monitor. The camera head was locked off as various lenses and tilt angles were explored. With each change, the camera would be dollied back in the room so that the tilt, lens focus, f-stop, etc., could be adjusted and locked off safely and conveniently. Once the Director of Photography approved the composition, the boom arm was braced with wood to the frame of the window to further stabilize the camera and we shot the background plate.

Copious notes were taken regarding the details of the tilt of the camera, the lens, the stop, the focus, the height of the camera from the ledge below (which the actor was to dangle from), as well as the distance that the camera stuck out from the building.

**Figure 9.7:** *The background plate.*

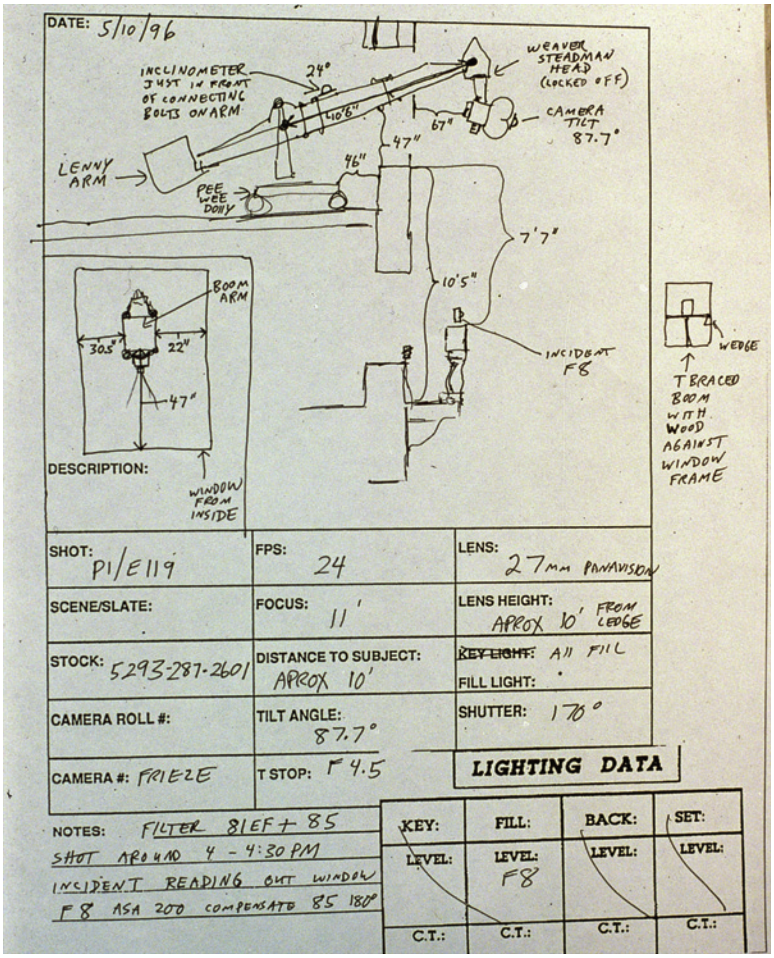


**Figure 9.8:** *The detailed notes regarding how the background plate was shot.*

> Please note that you don't measure how far a camera sticks out from a building by "leaning out there." You make a mark on the boom where the window ledge is, then pull the camera back into the room and measure from the camera to that mark; you then move the camera back. Never hurry or make stupid decisions like "leaning out there" when you're up high, as you could easily lose your life.

Notes were also taken about all aspects of the camera's position in relationship to the building, as well as the film stock, the camera speed, the time of day, and the light conditions. An incident meter reading was taken of the overall soft shadow light that was hitting the building and recorded. In addition, any special filters used by the Cinematographer were noted. Figure 9.8 shows the data sheet for this shot.

## The Green Screen Shoot

Whenever possible, green props or surfaces that the actor needs to interact with should be avoided. Aside from the problem of spill light from the screen material, it is very difficult to get clean, convincing shadows that don't buzz, let alone create the natural fill light that comes from a real object. For this film, a set piece was constructed that was the exact dimension of the actual building ledge. The camera was positioned on a secure scaffold above, resting on the same dolly used in the plate shoot. The camera was returned to the exact positions as indicated on the shot sheet and was placed at the same height above the set ledge as it was above the real ledge so that in the composite, the set ledge would obscure the real ledge. The green screen was placed on the floor about 15 feet below the actor atop a stunt bag in case the actor should fall. To further prevent an accident, the actor was secured by cable to the set piece. The use of the cable took the pressure off the actor hanging by his fingers but also required several takes to avoid the "hanging by a cable" look. Very often, digital compositors are asked to not only paint out cables but also take out the peculiar bunching up of clothing that happen with rigs like this. The actor was lit with the same quality and direction of light that existed in the plate; this included any subtle bounce light he would have gotten from the face of the building. When all was set, I remember looking about and checking for anything that might be problematic. I noticed that the scaffold was not entirely devoid of movement and decided as a precaution to place some white tape marks on the ledge set in the area of the sound track. I figured that if the shot needed to be stabilized, those marks in the track area could be used without having to roto out and hide the marks since they weren't in the frame.

## The Composite

The best takes were selected and key numbers sent to the effects house. The lineup specialist created an instruction sheet that informed the scanning facility to scan the

**Figure 9.9:** *The actor hangs from a set piece that matches the building. Actor contact with green set pieces should be avoided whenever possible. Note the tape tracking target on the left side of the ledge.*

correct frames on a roll of negative that coincided with the editor's wishes from a common hole punch on the film roll. The negative was cleaned and sent in for scanning and the files were returned on a hard drive and loaded on the database to be used by the compositor. The first thing to be done was to color correct the plate and the foreground element on the monitor to obtain a center; then a photographic wedge for both elements was run.

When the wedge came back, it was compared with film print clips made from the original negative and a color correction selection was made that would match the


**Figure 9.10:** *A wedge of the background plate. The numbers on each frame are an indication of the amount of red, green, and blue light used to color correct the image. The first image is red because it has one point more red light than the bottom image.*

**Figure 9.11:** *When elements are shot correctly, compositing is a breeze.*

clips. The color correction was added into the compositing software and the composite was made. In this case, the background was matched by wedge and the foreground was corrected to blend with the background. If the plates were shot correctly, the composite can be laid in and done in minutes. On the other hand, if the elements were shot haphazardly, the composite duties can take days or weeks to correct what would have taken a few extra minutes on the set.

## The Incoming Scramble Green Screen Shoot

Unfortunately, today, due to the compression of postproduction schedules, the preplanning of shots is sometimes nonexistent. An effect supervisor, Kevin Kutchaver, coined the phrase "postviz" to describe the process when filmmakers start making complex creative decisions after the film is shot. A director or editor may come up with an idea during editorial that will enhance the film and want to see it realized immediately. What follows is an actual scenario and my thoughts on how to shoot under these conditions.

### Your Mission

It's Friday afternoon. The effects shop is busy, and people are running about doing things. In the hallway, I'm stopped by the boss, who says, "We have to shoot some high-speed candy bars over green on Tuesday." I respond, "What kind of bars? What are they doing? What's the shot?" The boss says, "I don't know what kind of bars. THEY'RE FLOATING! That's all I know. Gotta go." The conversation, such as it is, ends and I'm left to prepare to shoot the unknown. This dialog might seem absurd, but a few moments before, the boss probably got the same terse request from the client. The client is not new to us—we have been working on many shots to finish his movie, and as a result we aren't that demanding of details at this point, but we have to be prepared to be flexible. The above conversation, as limited as it was, told me a few key things that I can work with.

1. Candy bars:
   This tells me the approximate size of the subject, so now I can work on selecting a lens that can frame the candy bar while at the same time giving me sufficient distance from the screen to avoid spill. I ponder the color of the candy for a moment. Lime-colored jaw breakers would be bad for a green screen, but I also know that the legal department hasn't gotten any rights or permissions for any particular product right now, so the issues of color can come up later when we have some legally cleared props. We can always order a screen switch once we see the props. It is interesting to note that nothing works in isolation on a movie. I imagine that there were many lawyers scrambling to call candy manufacturers for releases on this day.
2. They're floating:
   This tells me that a slow-moving effect might be desired for the motion. At this stage I don't know what the client has in mind, but I have to be prepared to use a fast film and have enough light to shoot comfortably at 48 to 96 frames per second. It also occurs to me that since the candy bars are "floating," they will probably be free-standing elements that don't directly interact with subjects in the background plate. I prepare to shoot the element large to allow the compositor to be able to resize, animate, and fine-tune the candy bar performance in post.

## Planning the Stage

Since we are already working on this film, I know that it is a 1.85 picture. This allows me to look up the lens angles for that format and use them to determine camera, prop, and screen placement. We had a stage that I measured to get the floor space and the height. The height can be tricky, as hanging light fixtures or air conditioning ducts have to be taken into account. Once I determined these dimensions, I could rent a screen slaving to the tallest dimension and have its length roughly correspond to the aspect ratio.

I then draw out the floor plan of the stage on a sheet of graph paper. I make each square on the graph paper represent a 1 foot square and in that way can draw and position the screen. If the screen is 16 feet wide, I draw a line that is 16 squares long. I now want to pick a lens that will give me sufficient distance from the screen to avoid spill and yet not force me to be backed up against the far wall. I find it handy to go to a table of lens angles for a variety of focal lengths and draw those angles on several sheets of clear acetate. One sheet would have the angle for an 18 mm lens, another for a 24 mm lens, and so on. With a collection of these acetate camera angles

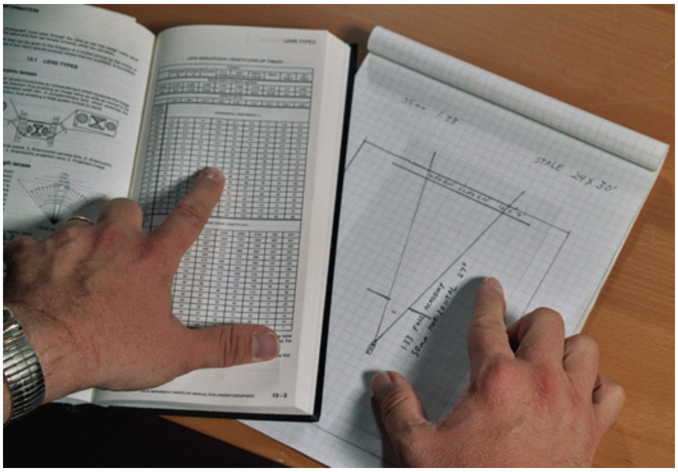

**Figure 9.12:** *Lens angles drawn on clear acetate sheets are a quick way to plan out camera position on graph paper. Each square represents 1 square foot. The small box in front of the camera represents the candy bar. By counting the squares it can be seen that the candy is 15 feet away from the screen. Lens angles for any focal length and format can be found by consulting camera manuals or making use of lens calculators. This table is shown in Figure 9.14.*

I can quickly place, position, and plan my shot before I rent my camera. In Figure 9.12, I am consulting the *"Hands-On" Manual for Cinematographers* by David Samuelson and have found that a 50 mm lens is ideal. It puts me far from the screen and still gives me ample working room. My finger is pointing to the horizontal lens angle of a 50 mm lens when shooting at full aperture. I discover that this angle is 27 degrees, and that is what is drawn on my clear acetate sheet as a planning guide.

I find that this lens angle will enable me to shoot both the screen and candy bar while allowing me to place the subject 15 feet away from the screen to avoid spill. This graph paper method is the technique used by old style effects veterans and production designers to previsualize the layout of a set before building or ordering anything. Today I often use computer graphic software to build a model of the stage and screen and use the CGI camera to see what the real camera will see. Doing previz this way can let me try all sorts of different angles quickly and do a bit of imagining. The paper and pencil method is still a great way to go, however—it's fast, it's extremely portable, and it doesn't require a software learning curve.

## The Problem of Spill Light

When light hits a blue or green screen it bounces back the color of the screen in all directions. The closer the subject is to the screen, the more the stray bounce light will hit the figure from the sides and "spill" colored light on him or her. Figure 9.15 shows that a subject who is closer to the screen will receive much more spill because he or she is within the angles of the bounce light. When the subject is 15–20 feet

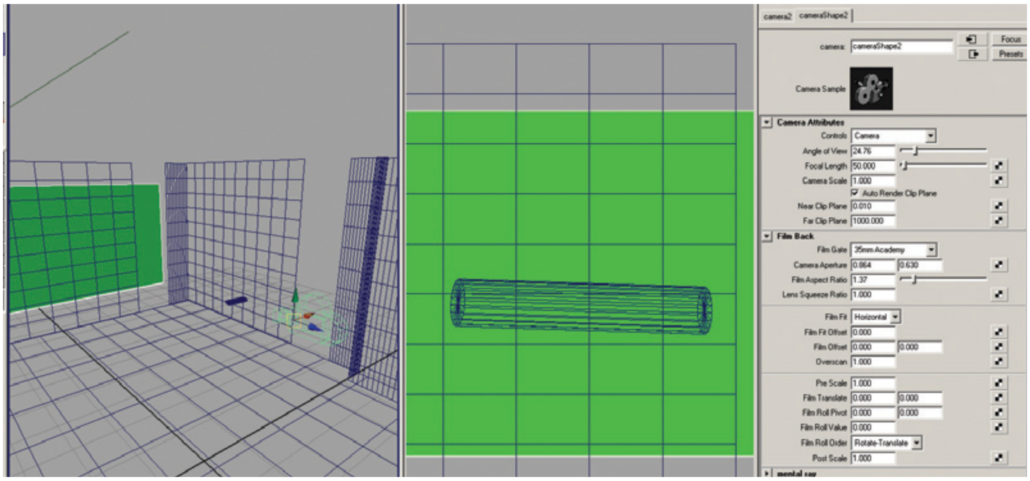


**Figure 9.13:** *A computer graphics program is a great aid in previsualizing camera placement. The view on the left shows the camera in relationship to the room, the candy, and the screen. The view on the right is what the camera sees using a 50 mm lens. This setup is for standard Academy and that is why the lens angle indicated is 24.76 instead of 27 degrees for full aperture.*

away, the bounce light will graze right past the figure, avoiding spill. It is very important to limit spill because it creates great problems in pulling mattes and resolving the true color of the figure. In extreme cases, the blue or green screen tool may fail altogether and hand drawn mattes will have to be used.

## The Screen

I mentioned earlier some methods for painting screens and using fabrics. For this project, I opt to not fool around and use a tried-and-true material, the Composite Components green fabric. I don't need to reinvent the wheel or be clever if I don't have to be. If I start out with a product like this, much of my struggle is over. There is a reason people make these screens, and you should build upon their efforts to make things easier all the way around.

## Lighting

For lighting I start by considering the film I'm going to shoot with. Though I would like to use fast film, I avoid super fast films for reasons of quality. Fast films can sometimes be grainy or not have the best matte pulling capabilities. For this job I decide to go down the middle of the road and choose 5293 200 ISO tungsten film. At the time, this stock was twice as fast as regular production stock, but not the fastest. Going down the middle is a safe bet, and, if need be, different film can be purchased pretty rapidly. I go to the Kodak website and look up this film stock's specification sheet. (Please note that this film is discontinued, but the thought process

| | FORMAT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | STANDRD 16 | SUPER 16 | ACADMY | FULL FRAME | ANA-MORPHIC | VISTA-VISION | 65 mm | 1/2″ VIDEO | 2/3″ VIDEO |
| IMAGE WIDTH (Projector aperture) | | | | | | | | | |
| Inches | 0.378 | 0.463 | 0.825 | 0.945 | 0.838 | 1.418 | 1.913 | 0.5 | 0.667 |
| mm | 9.6 | 11.76 | 20.96 | 24.0 | 21.29 | 36.01 | 48.59 | 12.7 | 16.93 |
| ASPECT RATIO | | | | | | | | | |
| | 1.33:1 | 1.66:1 | 1.37:1 | 1.33:1 | 2.35:1 | 1.5:1 | 2.2:1 | 1.33 : 1 | 1.33 : 1 |
| LENS FOCAL LENGTH (mm) | HORIZONTAL LENS ANGLE (′) | | | | | | | | |
| 400 | 1.4 | 1.7 | 3 | 3.4 | 6.1 | 5.2 | 7 | 1.8 | 2.4 |
| 250 | 2.2 | 2.7 | 4.8 | 5.5 | 9.8 | 8.2 | 11 | 2.9 | 3.9 |
| 200 | 2.7 | 3.4 | 6 | 6.9 | 12 | 10 | 14 | 3.6 | 4.8 |
| 150 | 3.7 | 4.5 | 8 | 9.1 | 16 | 14 | 18 | 4.8 | 6.5 |
| 135 | 4.1 | 5 | 8.9 | 10.2 | 18 | 15 | 20 | 5.4 | 7.2 |
| 100 | 5.5 | 6.7 | 12 | 14 | 24 | 20 | 27 | 7.3 | 9.7 |
| 85 | 6.5 | 7.9 | 14 | 16 | 29 | 24 | 32 | 8.5 | 11 |
| 75 | 7.3 | 9 | 16 | 18 | 32 | 27 | 36 | 10 | 13 |
| 50 | 11 | 13 | 24 | 27 | 48 | 40 | 52 | 14 | 19 |
| 40 | 14 | 17 | 29 | 33 | 60 | 48 | 63 | 18 | 24 |
| 35 | 16 | 19 | 33 | 38 | 68 | 54 | 70 | 21 | 27 |
| 30 | 18 | 22 | 39 | 44 | 78 | 62 | 78 | 24 | 32 |
| 27 | 20 | 25 | 42 | 48 | 86 | 67 | 84 | 26 | 35 |
| 25 | 22 | 26 | 45 | 51 | 92 | 72 | 88 | 29 | 37 |
| 20 | 27 | 33 | 55 | 62 | 112 | 84 | 101 | 35 | 46 |
| 17 | 32 | 38 | 63 | 70 | 128 | 93 | 110 | 41 | 53 |
| 14.5 | 37 | 44 | 72 | 79 | 145 | 102 | 118 | 47 | 61 |
| 10 | 51 | 61 | 93 | 100 | 187 | 122 | 135 | 65 | 80 |
| LENS ANGLE (′) | LENS FOCAL LENGTH (mm) | | | | | | | | |
| 1 | 550 | 674 | 1201 | 1375 | 2440 | 2063 | 2784 | 728 | 970 |
| 1.5 | 367 | 449 | 801 | 917 | 1628 | 1375 | 1856 | 485 | 647 |
| 2 | 275 | 337 | 600 | 687 | 1220 | 1032 | 1392 | 364 | 485 |
| 3 | 183 | 225 | 400 | 458 | 813 | 688 | 928 | 242 | 323 |
| 4 | 137 | 168 | 300 | 344 | 610 | 516 | 696 | 182 | 242 |
| 5 | 110 | 135 | 240 | 275 | 488 | 412 | 556 | 145 | 194 |
| 7 | 78 | 96 | 171 | 196 | 348 | 294 | 397 | 104 | 138 |
| 10 | 55 | 67 | 120 | 137 | 243 | 206 | 278 | 73 | 97 |
| 15 | 36 | 45 | 80 | 91 | 162 | 137 | 185 | 48 | 64 |
| 20 | 27 | 33 | 59 | 68 | 121 | 102 | 138 | 36 | 48 |
| 25 | 22 | 27 | 47 | 54 | 96 | 81 | 110 | 29 | 38 |
| 30 | 18 | 22 | 39 | 45 | 79 | 67 | 91 | 24 | 32 |
| 40 | 13 | 16 | 29 | 33 | 58 | 49 | 67 | 17 | 23 |
| 50 | 10 | 13 | 22 | 26 | 46 | 39 | 52 | 14 | 18 |
| 60 | 8 | 10 | 18 | 21 | 37 | 31 | 42 | 11 | 15 |
| 80 | 6 | 7 | 12 | 14 | 25 | 21 | 29 | 8 | 10 |
| 100 | 4 | 5 | 9 | 10 | 18 | 15 | 20 | 5 | 7 |

Notes: Given the film format and the horizontal lens angle the upper part of the table shows LENS FOCAL LENGTH. Given the lens focal length the lower part shows the HORIZONTAL LENS ANGLE.

To calculate the VERTICAL LENS ANGLE divide the horizontal lens angle by the first part of the aspect ratio (above).


**Figure 9.14:** *A chart showing lens angles for a variety of different lenses and formats.*

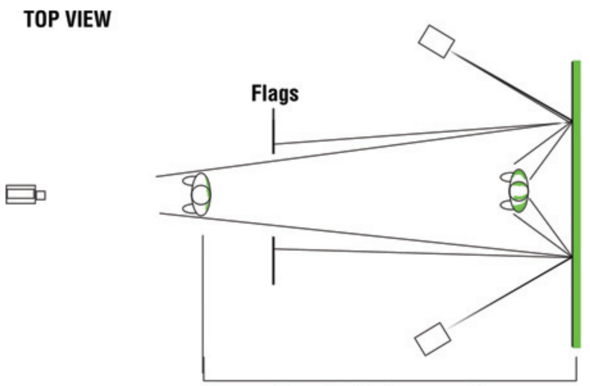


**Figure 9.15:** *The closer the figure is to the screen, the more spill he or she will receive. When the figure is far away, the green light never gets a chance to light the sides of the person and just zips past.*


**Figure 9.16:** *An early blue screen spill mistake made by the author. Yes, I make mistakes. In this case I did not consider the bounce off the floor and completely bathed the owl in blue light from the bottom. Fortunately, the owl did not move off his perch. The Illusion Arts traditional solution was to make the bottom of the bird and his perch a matte painting that blended in perfectly with the real bird. Painting by Syd Dutton. Courtesy of Illusion Arts.*

described here still applies to whatever the current product is. As of this writing I would use 5217.)

On the data sheet I find the exposure table for tungsten light and see that at 24 frames per second (fps) I can get an f/5.6 using 200 footcandles of light. That is a healthy stop right in the middle of the range, so I'll shoot for that amount of light. Next I go to a movie lighting rental company website, such as Mole Richardson (www.mole.com), and pick a light that I think would be appropriate to light the screen, looking for coverage and intensity of light. I select a 2000 watt Junior Fresnel light and look

**Table 9.1:** *5293 Exposure Table for Tungsten Light at 24 fps, 170 Degree Shutter Opening*

| Lens Aperture | f/1.4 | f/2 | f/2.8 | f/4 | f/5.6 | f/8 | f/11 | f/16 |
|---|---|---|---|---|---|---|---|---|
| Footcandles required | 12.5 | 25 | 50 | 100 | 200 | 400 | 800 | 1600 |

**Table 9.2:** *Performance Data for a 2000 Watt Junior Fresnel Light*

| | Light Intensity (Footcandles) | | Beam Diameter (Feet) | |
|---|---|---|---|---|
| **Distance (Feet)** | **Max. Flood** | **Min. Spot** | **Max. Flood** | **Min. Spot** |
| 10 | 490 | 3920 | 8.8 | 1.6 |
| 15 | 220 | 1745 | 13.1 | 2.5 |
| 20 | 130 | 1000 | 17.4 | 3.4 |
| 25 | 80 | 640 | 21.8 | 4.3 |
| 30 | 55 | 445 | 26.1 | 5.1 |
| 35 | 40 | 330 | 30.5 | 6.0 |
| 40 | 30 | 250 | 34.8 | 6.8 |

at its spec sheet. It is a light with a lens that allows the light to be focused as a hot spot or defocused and flooded for maximum spread.

The performance data tell me that at 15 feet, this light will have a beam diameter of 13 feet at maximum flood with 220 footcandles of light. This is more than enough to give me my f-stop of 5.6 and illuminate half the screen. So, I order two of those with a selection of scrims to dim the light if need be. A scrim is nothing more than a wire mesh that is put in front of the light to decrease its intensity. A full scrim is equal to one stop and a half scrim is one half stop of light attenuation. This takes care of the screen and the lights, so now I order a basic lighting package that should handle just about any candy bar. The lights for the candy don't have to be intense, as the size of the subject is so small. So I can order a simple three- or four-light kit that contains stands, cables, scrims, and extra bulbs. I also order about six C-stands and sand bags to match. The C-stand is one of the most useful grip devices made for the movies. It is a stand with a myriad of clamps at the end of poles that can be configured to hold just about anything, such as flags, nets, props, and lights. Now, before I order this stuff I want to make sure that my stage has enough power to handle these lights. To that end, I use two of the Ohm's law formulas for electric power. The first is $E \times I = W$, where E stands for volts, I for amps, and W for watts. If I look in my breaker box and see that my plug circuit has a 50 amp breaker, I can use this formula: 110 volts × 50 amps = 5500 watts, which is more than enough for my two Juniors. The other formula is W/E, used to get amps. In this case, 2 × 2000 watt Juniors = 4000 watts divided by 110 volts = 36 amps, which, of course, is rounded up to 40 or 50 amps to be on the safe side. I also use these formulas to check to see whether I have enough power for my small light kit as well.

I chose Junior Fresnel lights in the candy bar example for their intensity of illumination since I was anticipating shooting at high speed. I also felt that the performance data for this light made a good illustration for this chapter. In practice it is preferable to use soft fill lights, open face nook lights, or banks of fluorescents, as these instruments make it much easier to obtain an evenly lit screen. I am using 2K soft lights to light the screen in Figure 9.18.

## The Camera

For my camera I decide to rent an instrument I was familiar with from an effects company that was known to me. For film, an effects camera is likely to be a modernized Mitchell Fries camera that yields a rock steady image. The Mitchell cameras were standard production cameras in Hollywood throughout the 1950s and 1960s. They were updated by the Fries Company to embody modern through-the-lens viewing and the ability to hold film reference clips in the viewing system. The motor was also enabled to run at high camera speeds. The Mitchell cameras are inappropriate for sound work unless they are heavily blimped, as they are quite noisy (the tradeoff for being steady). The standard requirement for effects photography is any camera that carries good registration pins. Photography of elements with a steady camera ensures that the disparate images don't weave against each other. In the past this was essential, as there was seldom a way of "steadying" the image after the fact. Today, even though an image can be digitally steadied, there will usually be a loss of resolution as the digital solution involves the averaging of pixels to obtain a fixed image. The best policy is to shoot the steadiest image possible, otherwise there is a compromise from the very start. If the plate has inherent camera movement then steadiness is not as critical, but for anything that is locked off, like this green screen example, it is essential. When renting from an unknown source, time must be set aside to perform scratch, focus, and steady tests with the rental camera before the shoot.

### Scratch Test

The first thing to do when testing a rental camera is to check whether it scratches or damages film. The camera is set up on sticks and head and is threaded up with raw stock. A short 20 foot burst is run through the camera at the desired speed (usually 24 fps; higher if using high speed is anticipated). The camera is stopped and the film is removed from the take-up side of the magazine and examined on both sides for any signs of scratches. The perforation holes are also examined to see whether they are distorted in any way. This test is a good procedure to follow on the shoot day as well, as it can detect a misthread of the camera.

### Focus Test

In a focus test, a focus chart is set in front of the camera at various distances and measured to check that the markings on the lens match the actual distance measured. For example, a chart could be placed 10 feet from the camera film plane as measured with tape. The 10 foot focus mark on the lens is set, and the chart is viewed through the viewfinder to check that it is sharp to the eye. This establishes agreement with the ground glass and the lens. A film test is shot with perhaps two known distances for each lens in the package. The resulting film will verify lens sharpness and eyepiece agreement. It is good practice to shoot focus tests with the lens wide open to preclude the advantage of depth of field.

### Steady Test

In the steady test, the camera is locked off and pointed at a chart of white lines against a black field. The center markings of the chart are canceled against the crosshairs of the ground glass. Footage at the start is noted, and then 60 feet of film of the chart is run off. The lens is then capped and the camera runs the film in reverse to get back to the start point. The lens is uncovered and the camera is slightly panned and tilted about three line widths askew as measured by eye in relation to the crosshairs and then locked off. Now a second exposure of the grid is shot over itself in this new position. This double-exposure test is viewed on a projector to see whether the grid lines move or weave in relation to each other. On a steady camera, the lines will be rock steady; an unsteady camera will instantly be given away by the lines moving toward and away from each other.

These few tests are not by any means exhaustive, but they do point out the primary things to look for in a film camera. By renting from a known source I was able to save myself the effort of testing until the pre-light day.

## The Pre-Light Day

The material arrives, and I go about setting up the green screen and the camera. For the green screen I assemble what is called speed rail—light aluminum tubing that is

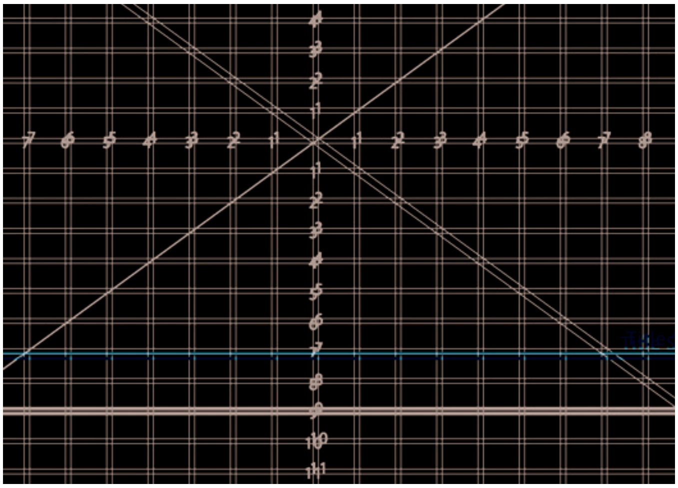

**Figure 9.17:** *A closeup of two charts superimposed upon each other to check the steadiness of a camera. If the lines weave toward and away from each other, the camera is unsteady.*

assembled with connectors that are tightened in place with bolts and hex keys. After the frame is assembled, the green screen is tied into place and affixed to the rails with cord ties. I position the green screen as far as possible from the subject, which ideally is at least 15 feet away (25 feet is even better). I set two lights to hit the screen at a 45 degree angle to provide even illumination. To check the evenness I scan all areas of the screen that will be photographed with a spot meter and adjust the lights till I get a very flat screen, to within perhaps one-quarter to one-third of a stop or better.

Once the screen is even, I set up foam core sheets that are black on one side using C-stands to block off extraneous unused portions of the green screen. All that is needed is enough green screen to surround the subject and capture any movement the subject performs. It is acceptable to include the black foam core in the shot, as that will be easily matted out using simple garbage mattes in post.

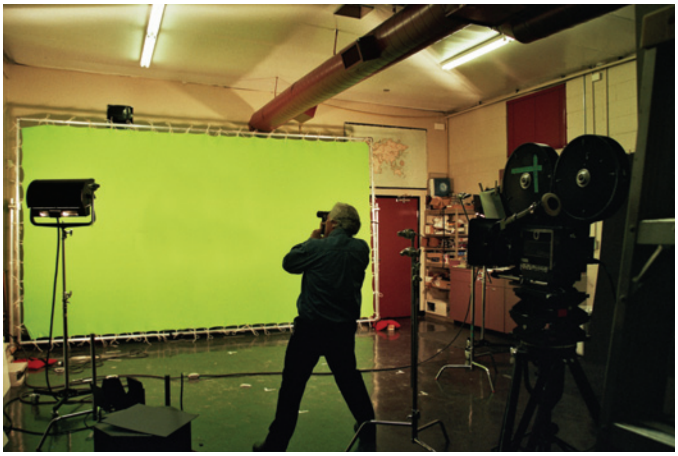

**Figure 9.18:** *Reading the screen with a spot meter.*

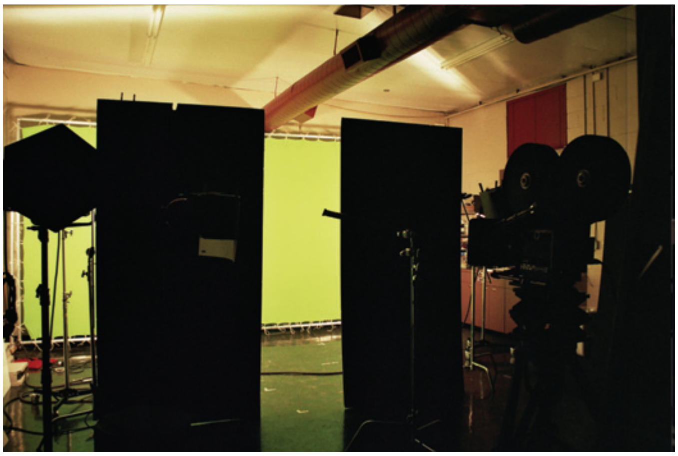

**Figure 9.19:** *With the candy in position, we block off sides of the green screen to avoid spill on the subject.*

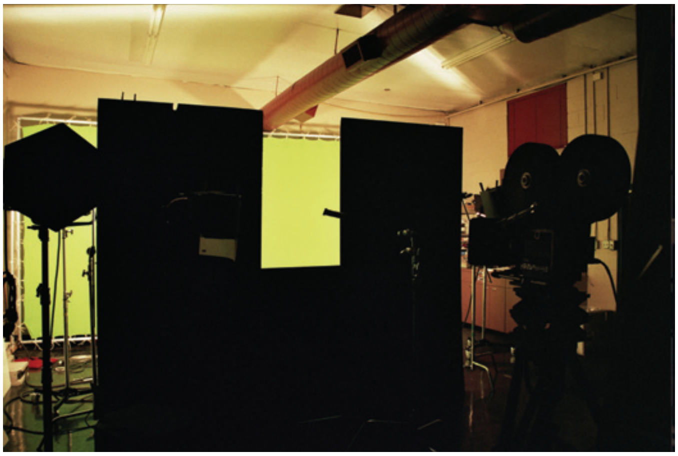

**Figure 9.20:** *Don't forget to mask the bottom of the screen.*

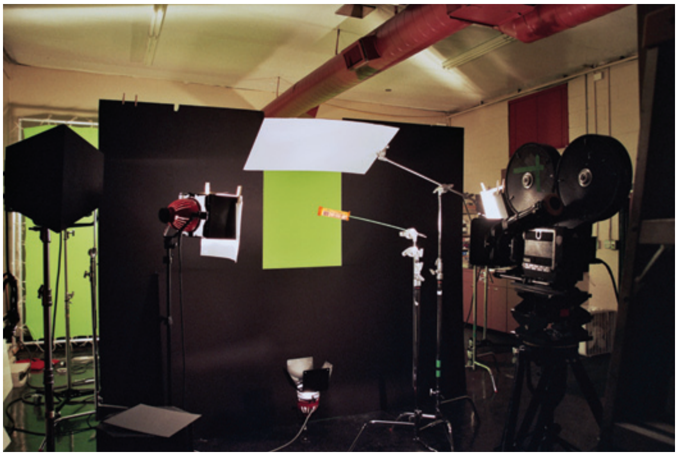

**Figure 9.21:** *The final lighting setup using soft even lights all around to match the original plate photography. Remember that the green screen is not a light source, so you must light the edges of the subject.*

**Figure 9.22:** *The properly lit green screen element with no green spill. The elimination of spill will allow us to reproduce the yellow of the candy wrapper because we will not have to suppress the green in the subject. Suppressing the green would make the yellow go red.*

### A Word on Tracking Targets

You may notice that in this example I'm not using the standard "tracking targets" that are so commonplace in the behind-the-scenes shots of effects films. I didn't use them for this shoot because there was nothing to track. The camera was locked off shooting subjects that undulated in space. The *x*, *y*, *z* movement was added later during compositing through animation.

On many shoots, things are overthought and more is assumed to be better. I can imagine a panicked production coordinator thinking that there must be tracking targets but having no idea of how many, what color, the spacing, etc. So he or she guesses and makes a huge patchwork quilt of tracking targets on the screen that may never be needed and indeed may cause extra work in compositing. If the targets were white tape, for example, and the image of the object happened to coincide with the tape, at that point the object and the tape combine and, as far as the computer knows, are the same object. As a result, a lot of delicate hand rotoscoping needs to be done to get rid of the white tape when it starts to meet the image of the subject. It is a relatively simple fix, but annoyingly unnecessary. It is best to use the targets when they are needed and lose them when they are not. Whenever possible, I use tape that is the same color as the backing, only darker, to provide some contrast. Another idea is to use blue tape on top of green screen so that the compositor can do two matte pull passes. They first pull out the green, which leaves the performer and the blue tape in front of the background, and then, on another pass, they use blue screen to matte out the blue tape. The compositor can always add contrast to the image for tracking purposes while at the same time giving them a fighting chance of getting rid of the targets using the matting software instead of rotoscoping.

Another problem compositors run into is out-of-focus targets. When shooting performers this is sometimes unavoidable in closeups, but if possible the screen and targets should be kept relatively sharp. In the composite, the in-focus screen will be eliminated and the background can be made very soft for the intended look of the closeup. If the depth of field is so shallow that the performer's hair is slightly soft, then it is better to leave the focus as is to preserve the original photographic intent; if not, use a fairly deep stop to give the trackers a fighting chance.

By this time, the effects company has more tangible information about the scene. I discover that the floating candy bars are to appear in front of a woman standing in a garden. I view the background plate and see that it is a comic shot done in slow motion. My early assumptions about the candy being a free-standing element proved correct, so I go with the plan of shooting gently rotating elements full frame. There is overall even ambient light with no particular direction, so the lighting scheme will be fairly easy. To light the candy bar I opt to give an overall soft front fill that lights the top and side of the object.

**Figure 9.23:** *The background plate is lit with very soft, nondirectional light. With lighting like this there will be a great deal of flexibility in manipulating the candy bar.*

In situations like this, I usually won't meet the cinematographer and don't get to see any notes of how the plate was shot, so have to deduce what was done from the image itself. I first look at the shadows. I see whether they are soft or hard and what direction they come from. I next look into the shadows to see how much contrast there is in the shot. I raise and lower the fill light to match the contrast ratio that I see in the plate. I also look for any kicks or colored bounce light that affect the image. This aspect is the most important. A well-exposed green screen is useless if the foreground subject is lit incorrectly, such as the key light coming from the wrong direction. It is very important to remember that the green screen is not a light source. As far as the film is concerned, it is a black screen. The sides of the object must be lit as they would be in the real environment. Failure to do this results in a composite image with dark edges that will not fit with the background. There is no way for the compositor to correct this problem that will look natural. The lighting of the foreground element is critical. It is helpful to have some type of playback on the set so that the plate can be seen and then the lighting can be viewed. It may also be helpful to turn off the lights hitting the green screen or place a black card temporarily behind the subject so that the light hitting the foreground can be evaluated. In the best of all possible worlds, a crude video compositor can be set up on the stage to view a rough comp to nail the lighting from the get-go. In practice, however, this is seldom possible due to budgetary constraints and the added issue of the video tap on a film camera showing the entire aperture along with the ground glass with the customary 1.85 markings, etc. The background plate typically is a transfer that extracts the actual composition. As a result, yet another special device is needed that extracts the composition area from the video tap and blows it up to match the background plate even before the composite device is thrown in. Typically, the effects cameraperson looks at the background reference then looks through the camera eyepiece and determines (doing the composite in his or her head) when the lighting is correct. With digital cameras, the viewing compatibility issue is absent and an on-set pre-comp is easier to do even by just switching back and forth between the background and foreground to check the lighting.

## The Exposure Test

Since the shoot isn't until the next day, I opt to do a photographic test rather than rely on the eye match method mentioned earlier. An actual photographic test is always preferable. When I ask various cinematographers how they expose the green screen, I usually get vague answers like, "Same as the gray card or a stop under the card." These explanations have always been a bit confusing; no one seems to commit to anything. The politically correct answer is that they shoot to whatever the compositing house wants. In this example I will get down to the nitty-gritty of how the compositing house determines what is best. Since a Composite Components screen is designed to work with the same key light as the subject, I will start there. Set the gray card in the subject area and read it to get the f-stop; let's say it's f/5.6. Place the card at the green screen and light it to f/5.6 as well. Return the gray card to the subject area and leave it in the composition. Now you shoot a running test in this manner. Prepare a slate that says green screen test from f/2.8 to f/16 in one-third stop increments. You will note on some professional camera lenses that there are two line markings between each f-stop that amount to one-third stops, just like 0.10 ND on the optical printer. Shoot the slate, gray card, and focus chart at the normal exposure of f/5.6. At this point you will do a running wedge. Cover the lens with your hand, and set the f-stop to f/2.8. Turn on the camera. When the camera comes up to speed, remove your hand from in front of the lens to expose the scene (foreground plus gray card and green screen beyond). After a second, cover the lens again and move the f-stop to the first line marking past f/2.8, then remove your hand again to expose the shot for a second. Cover the lens, move to the next mark, expose, and repeat until you've gone through the entire lens run indicated on the slate. Turn off the camera, can up the film, and send it in to the lab for developing and best light print.

## The Shoot Day

### Test Analysis

When the film gets back the first thing I do is roll down the print and take a look at the slate and the focus chart. I view this through a magnifying loupe on a light box and check to see that the gray card appears gray and that the focus chart is sharp. I then check the lights that the lab gave for best light. I see that the lights the lab used were r30, g28, b25; this places the film in a healthy exposure range. If the lights were 48, 40, 40 that would indicate that the lab had to shove a lot of light through the negative to make the print and that I had drastically overexposed the film (the Bell and Howell printing system has a maximum light value of 50 printer points per color). If the lights were low, for example, 9, 8, 10, that would mean that the lab put just a whisper of light through the negative to make the print and that I had somehow drastically underexposed the film. The exposure can also be judged by physically inspecting the negative: a dense, dark image indicates overexposure and a light negative indicates underexposure.

> You might ask why the lights aren't even numbers across. The technical literature on the LAD process indicates that a properly exposed camera negative should print at 25, 25, 25, right in the middle of the Bell and Howell 0–50 printer point scale. Labs seldom print to these lights, however, and the midpoint light also varies between different film laboratories. The slight differences between the red, green, and blue numbers adjust for the variability of the film stock and the emulsion batch. When Kodak makes film, they mix a large quantity of a particular batch of emulsion that is specified by three numbers following the main emulsion number. For example, 5248–456 indicates a particular batch (number 456) of the 5248 film stock. When that batch is sold out and a new batch is made, 5248–457, it will be slightly different than the preceding batch. Sometimes film labs use a combination of "trim lights" and printer points to hit the LAD numbers on the print. Different printer lights are used for intermediate stocks because their base is inherently different from camera negative. A camera negative (5248) might print the gray card to true LAD at 24, 22, 19, while an intermediate stock (5242) would print the LAD aims at 35, 33, 21.

## Densitometer Evaluation

At this point, the negative is rolled down to the exposure that corresponds to the normal f-stop by counting down the exposure flashes when the hand uncovered the lens. So I visually count down from 2.8 to no image to 2.8 and 1/3 to no image to 2.8 and 2/3 to no image to f/4, etc., until I arrive at f/5.6. Then I position the negative under the densitometer and read the gray card. The technical aim is 0.80, 1.20, 1.60 for RGB densities. I read the film and find that the gray card reads 0.72, 1.20, 1.56, which is well within range. The numbers will never be exact, so the thing to do is to try to get the green number as close as possible to 1.20 and see if the other colors fall within range. A range of ±0.10 is quite acceptable. The good thing about this reading is that it indicates that the light meter is giving the correct information on exposure. I now move the sensor over to the green screen and take a reading. It reads 0.78, 1.72, 1.52 for RGB. I note these numbers and move the film over to an unexposed area of the negative (such as the area outside the perforations) and read the base density of the film, which is 0.16, 0.52, 0.95. I now subtract the base density or unexposed areas of the film from the green screen exposure to get the actual dye densities produced at f/5.6 and obtain 0.62, 1.20, 0.57. These are the magic numbers. The rule of thumb from the Ultimatte corporation is that if the value of red or blue subtracted from green is above 0.30, you will get good color separation for the matte. In this case, if I take the higher value for red and subtract it from the green value I get 1.20 − 0.62 = 0.58. The difference is well above 0.30, so we are good to go. If the screen was overexposed, the green density would soon reach maximum and the other values would increase as well; the difference between them would decrease to the point of the green screen exposure being unusable.

It is extremely valuable to test unknown film stocks, as the results for green screen can be alarming. Many stocks were developed for far different reasons than getting good green screen separation. Many have response curves that create pleasing aesthetic looks for the typical subject but create horrific crosstalk and poor separation when used for matte photography. The last set of tests I did for a series of stocks rejected seven different emulsions. It is meaningless to mention them by name, as they have all been discontinued. The main point is to illustrate the objective for any stock that is used for blue or green screen and go from there. This exposure test enabled me to nail down the best exposure and double-check the camera and light meter before committing to the shoot. In this case, I found that the green screen was ideal at f/5.6 and the subject was ideal at f/5.6. If the densitometer had indicated a better result with a darker screen, then I would have used that information to light the screen to whatever f-stop gave the best result. Once I know this information, I can then light the screen perfectly and make note of how my eye responds to the white card balance method and also calibrate the meter to yield direct results off the screen. I could then shoot the candy bar with confidence.

> To calibrate a meter, place a 99 green filter in front of the spot meter and adjust the ISO to a point where the direct reading off the properly lit screen yields f/5.6. This means that next time, using the same meter, the same screen, the same lighting instruments, and the same stock, you should be able to take a direct reading off the screen and have it correlate with a good result on the film.

## Shooting the Candy Bar for Post Animation

The advantage of shooting real objects in front of a green screen is that no one can question their realism—because they are real. Computer graphics, while being infinitely flexible, always suffers from the challenge of being compared to the real thing under a microscope. A common occurrence is that I will receive a shot like this candy bar shot after it has come from a CGI house. A full digital candy bar is certainly no problem to create, but a digital company will commonly show the client a rough model of the candy bar animated over the scene in order to obtain approval of the movement as the model is being refined. Many times a short-sighted client will panic, thinking that the first crude digital model of the candy bar looks fake and won't get any better. When this happens, someone like me winds up shooting a real candy bar. Conversely, a real shoot is sometimes used as a template or animatic for the final effect, which does use CGI. When it is a product shot, like our candy bar example, the approval process can be excruciating. Shooting a real prop takes the reality discussion out of the equation and limits the variables to the lighting only. The tradeoff to shooting the product itself is the fact that a photographed element can only have so much flexibility. The lighting and motion, for example, are fixed. If the digital compositor is clever, however, post animation can be added to the existing motion to create a surprising amount of variations. In this example, the candy bar is rotated in place on a stick. The lighting has no direction, so the digital compositor has the ability to add rotation, up/down, left/right, and zoom motions to the image as well. Since the candy bar is shot full frame, it has quite a bit of resolution and will fit quite nicely within the film frame. If the speed or direction of the built-in rotation needed to be changed, the compositor could use speed alteration and frame blending to achieve that objective. The method can be forced to fail if the light is coming from a definite direction and the post rotation places the key light of the object away from the light source direction in the plate. With proper planning and commitment, however, a very realistic effect can be achieved in a timely and cost-effective manner. The advantage of CGI is that anything can be done, and the movement, lighting, and look can be modified ad infinitum. If you do not have the advantage of a highly skilled CGI artist to build, light, and animate a realistic prop, the photography of a real prop can prove to be a workable alternative. The fast turnaround time when using a real prop is also handy for quickly evaluating ideas in test screenings. In a similar case, several live action props for the film *Dumb and Dumberer* were shot and composited like the candy bar example to quickly try out a gag idea for this comedy. The test shot (involving floating props in a flying bus) was eventually cut out of the picture but was retained for the special edition DVD release.

## Outdoor Green Screen

We now go from the controlled environment of the stage to the whimsy of nature. In this next example, I was asked to shoot a girl falling off a cliff, moving from shade to bright sun. In more elaborate productions, to accomplish this shot a camera would be placed up high, shooting down, with the subject actually falling into a green screen. This approach, which slavishly mimics a real drop, becomes a very expensive proposition because it involves location procurement, many safety issues, specialized stunts, etc. In this case, it was decided to rotate the actress in place on a flying rig and add the *z* axis movement in post (just like with the candy bar).

When planning for work outside, weather is the main consideration. As the old saying goes, "It never rains in California until you want to shoot." This shoot occurred in April during California's rainy season. I checked weather reports every day and made


**Figure 9.24:** *A simple rotating photographic element can have a variety of motions added to it. In the top image the rod is eliminated with a hand drawn matte and the candy bar is skewed in perspective, blurred, and placed in the appropriate part of the frame before matting. The second image shrinks the candy and mattes it into the scene (the sharpness has been brought back). The third image uses a hand drawn matte of Amanda to obscure the candy bar and make it appear as if it has gone behind her.*

plans to shoot on a clear day, with the possibility of cancellation always in mind. With outdoor shoots the main problem is light consistency. The sun moves across the sky, and if used as a key light source will be constantly chased to keep the lighting direction constant. As an alternative, the subject can be shot in the shade and the key light controlled with either powerful daylight lamps (such as HMI lights) or reflectors. In this case, I opted to set up the green screen and flying rig in the shade of a building and use a reflector board to kiss in the key light when needed. Since the subject would be falling into the sunlight, I rigged up an interactive light gag by focusing the reflected sunlight on the subject then blocked that light with a large piece of foam core held by a grip. At the appropriate time, the grip was cued to walk away, revealing the key light, which created the illusion that the girl was falling into the sunlight. I tracked the shadow of the building (where our rig would be placed) over several days to get an idea of when the subject would be completely in shade and we could begin to shoot. I worked out a shoot time of 4 p.m. then worked backward to find the call time. The fly rig crew told me that their device could be set up in 2 hours. Since I had never worked with that crew before, I changed that to 3 hours and included lunch. That brought the timeline to 4 hours before 4 p.m., or noon. Since I did not know whether the director was going to be able to join us, I wanted ample time to be set up for discussion and dress rehearsing with the rig, so I added another couple of hours, bringing the call time to 10 a.m. This gave us a full 5 hours to get everything ready. With all that planning, we didn't shoot until 4:30 p.m. due to unexpected changes in hair and makeup—but we were pretty darn close to the scheduled shoot time. Always allow for time and contingencies.

Wind is also a major consideration in outdoor shooting. Large green screens or flats are essentially sails that can be taken away by the wind very easily. I made sure that we had plenty of ropes and heavy sandbags to weigh down the instruments to avoid this problem. I again made use of the Composite Components screen that was made for outdoor photography, so balancing was not an issue. In order to have the subject appear in the middle of the aperture, we elevated the camera by building a platform so that the lens angle would capture the bottom of the green screen and place the girl in the dead center of the frame. In order to build a fast and simple riser, I rented 10 apple boxes (they're called cherry boxes in New York) and nailed a 4 × 8 sheet of plywood atop them using double-headed nails. The apple boxes come in several heights and sizes, and grips use them to quickly raise subjects or cameras to exact heights. They can also be nailed together and dismantled quickly using double-headed nails whose secondary heads stick up a bit to allow for quick removal.

It is important to use C-stands to hold up flags to shade the camera lenses from sun flare. Covering the camera with reflective cloth is also helpful to avoid overheating, especially in the summer. The video tap monitor should also have a shade constructed over it so that the image on the screen can be seen in the daylight. For this shoot, I shot with 5217 200 ISO tungsten film. In order to shoot outdoors I needed to use an 85 filter to correct the daylight to tungsten color temperature. The 85 filters also come with neutral density to cut down on the bright light outside, enabling the camera operator to choose the f-stop. In this case I used a straight 85, which cut the ISO down to 125. It still enabled me to get a healthy stop of f/11, ensuring that the subject would always remain in focus. In straight production what usually happens is that the Director of Photography will start shooting with an 85 N9 that cuts out an additional three stops of light so that he or she can shoot with a wide stop of f/4 for a narrower depth of field to create an attractive image. As the sun goes down and unexpected holdups occur, the 85 N9 becomes an 85 N6, then an 85 N3, then a straight 85, and unfortunately after the sun has set, the 85 is pulled altogether, leaving tungsten film shot outdoors, which gives a dark blue image. This is usually what the digital post house gets to fix. So, as you can see, with outdoor shoots it is best to be prepared and be ready at least an hour before shoot time because there is no stopping

**Figure 9.25:** *An outdoor green screen setup. Note that the subject is in shade to stabilize the lighting environment. A flag is above the lens to prevent direct sunlight from hitting it. To the left is the video tap monitor that has been shaded with foam core so that the client can view the image in daylight conditions. The platform is composed of a sturdy 4 × 8 foot sheet of plywood nailed atop 10 apple boxes. Photo courtesy of Jamie Baxter and Mark Dornfeld.*

the sun. In this case, all the takes were shot well before sundown. In the composite, the background plate was a view looking down into a chasm lit below by the sun. The green screen plate was animated, reducing in size as the girl rotated, going from fill light to the reflector board "key light," to give the impression that she "fell" off the cliff into the sunlight.

## Green Screen with a Digital Camera

There are many occasions when a small portion of a motion picture image that takes up perhaps one-eighth of the frame needs a green screen element. While shooting a small element like this on film works (as in the case of our candy bar), it is often a good choice to shoot the element with a digital video camera. The process of planning for the screen, the lights, and the lighting remain the same; the camera selection and setup procedure are what varies. In the earlier example, I shot full-frame candy bar elements that would be animated in post for a film composite. Let's examine the background plate more closely. The candy bar will take up about one-quarter of the frame. The horizontal resolution of a typical film frame is 2048 pixels. One-quarter of that is 512 pixels. A typical video frame's resolution is 720 × 486. If the candy bar is shot full frame on video so that its edges are just shy of the frame, when that image is shrunk down it will fit very nicely into the 512 pixel area allotted for it in the composite without losing one bit of resolution. To avoid dealing with interlacing, a


**Figure 9.26:** *Since the subject "falls" into the sunlight I had a grip shield the key light provided by a large reflector using a sheet of black foam core. You can see the grip in the reflection of the glass door. At the appropriate cue, the foam core was walked away and the key light lit the actress. Photo courtesy of Jamie Baxter and Mark Dornfeld.*

progressive scan standard definition (720 × 480) video camera that has at least a 4:2:2 color space that will handle green screen can be used. If there is time, as with the candy bar example, the best policy is to shoot a test and take it through the whole process before making a final decision on a camera or procedure.

## The Digital Camera Settings

One major difference between a film camera and a digital camera is that with a digital camera you have the ability to choose how the medium perceives light. In film, all the emulsion characteristics involving spectral sensitivity, grain, ISO, etc., are built in. All you have to do is load up a roll, use the right filters and exposure, and you're in business. With a digital camera you become your own emulsion designer (in a way) and can set the way the camera reacts to light. You can adjust the color matrix, go from cine look to video, raise the pedestal, lower the pedestal, etc. I once heard a lecture about a popular digital camera at an NAB convention. The lecturer, an

**Figure 9.27:** *The exposed reflector board operated by grip Ryan Beadle. Note the red sand bag used to weigh down the instrument so the wind doesn't blow it over. Photo by Jamie Baxter.*

engineer, claimed that his company's camera had 100 individual adjustments. The first thought that came to my head was that that meant the possibility of 99 incorrect adjustments. This is a rather extreme statement, but it has a great deal of truth to it. The problem with tinkering with the image at the outset is the high likelihood that you could paint yourself into a corner. In my career, I have on many occasions seen film sequences in which the cinematographer shot a sequence with much of the information on the toe, or in other words, purposely underexposed. At times this kind of minimal exposure can yield a pretty good-looking first-generation print, but it doesn't take into account the duplication stages further on in the process. Much later down the line when the Director of Photography (DP) is gone, suppose the Director and Editor view a blocked-up answer print and want to change the look of the sequence to see more detail in the shadows. They find that there is no shadow information in the negative, and they're stuck. This happens with color as well. If a DP shoots with a heavy color filter in order to purposely print it back with extreme color timing, the palette will be irreparably altered. There won't be the information in the negative to start again from a center point. This can be good for a DP who doesn't want his "vision" changed after the fact, but the reality is that anything can


**Figure 9.28:** *The reflector is exposed, introducing interactive lighting on the actress. Photo courtesy of Jamie Baxter and Mark Dornfeld.*

**Figure 9.29:** *Effects supervisor Mark Dornfeld (on the right) and I are pondering the setup. Between us is a view of the taking camera with a side video camera. The video camera was used to obtain a clearer view of each take for the client, as the image off the video tap was poor. Be prepared as much as possible during an effects shoot. Should the supervisor make a last-minute request like "Let's have a side video camera," be ready to say "In a heartbeat." Photo courtesy of Jamie Baxter and Mark Dornfeld.*

**Figure 9.30:** *Two frames of a rough composite of the falling girl. The static green screen element was animated, reducing in size to simulate the fall. Her rotation and the addition of interactive lighting completed the effect. Note that the direction of the interactive light on the girl matches the light falling on the parking lot stop blocks in the background. Will she be saved before she hits the ground? Only the compositor knows for sure.*

and will be changed in the digital world, and if you limit the data, you merely guarantee that it will be changed badly. I have found that the best policy is to stick with the factory presets whenever possible unless there is a very good reason to change them. The craft of element making comes from matching the lighting and camera position of the cinematographer while leaving the colorimetry adjustments for the post process.

## Shooting with the Digital Camera

Fortunately, digital cameras have no registration or film-scratching issues. There may still be the need for focus testing cameras that accept different hard lenses, but many digital and high-definition cameras have built-in zoom lenses, so the main testing for a digital camera is for image quality. To start, I use a standard factory setting on the camera that is being used for the rest of the production. If the DP is shooting using something called Cine Look, then the effects camera should do the same. On the other hand, if the DP is skewing the image by making special settings in the camera that crush the blacks or alter the image in an unusual way, then the effects camera should be set to a standard factory setting. You want to capture as much of an unadulterated image as possible in order to have a full range of data to manipulate later in post. Let the compositor crush the blacks.

When shooting green screen it is best to locate and turn off any detail generators on the camera. This sharpening algorithm tends to build in false matte lines that are hard to get rid of. A detail generator puts "spikes" in the data at transition areas. If it goes from an eyelash to a skin tone it spikes this transition to build contrast and artificially enhance detail. If it goes from the edge of the subject to the green screen and adds a spike, you get a matte line. Set the color sensitivity to the light source you are using (such as 3200 K). If you do not know the light source you are using, you can use a white card to fill the frame and set the camera to perform a white balance. The camera will look at the card and adjust internally to derive the color temperature emanating from the card. After the color temperature is set, it is usually handy in effects photography to turn off all automatic functions. Effects photography is about control, and you don't want the camera to decide to refocus or adjust exposure during a shot because it wants to "help" you. Leave everything on the camera in a manual setting to give yourself total control.

## Screen Evenness and Exposure

Sophisticated digital systems will sometimes include devices called waveform monitors, which are a type of oscilloscope used for checking the quality of the luminance or brightness aspects of the video signal, and/or a vectorscope, which details the hue, saturation, and chrominance of a video signal. I have rarely had the advantage of using these terrific tools on the digital shoots I have been on, and so I have devised the following methods for obtaining screen flatness and exposure using nothing more than the camera and a gray card. The nice thing about a digital camera is that it has the ability to double as a spot meter. The standard digital camera has a function known as exposure zebras. This function was designed as an indicator to tell you when objects within the shot are blowing out through overexposure and going into clip. The word clip means that the whites clip off to their highest setting and will no longer have gradations. This is typically seen when activated over a shot of a subject in extreme contrast, like an interior shot in front of a bright window during the day. The window will be covered by graphic zebra lines (they look like the fur markings of a zebra) because the difference in exposure between interior and exterior is too extreme. In these cases, the DP may opt to let the window go to peak white and let the window "blow out" or to draw the curtains or put ND gel over the windows to dim the outside light to bring all the values within range. This is less of an issue in film due to its wide latitude. The window will blow out, but a lot of the highlight information will still be contained in the negative. Unfortunately, with many digital video cameras, once you hit peak white the whole window will top out at clip, and timing it down will only result in an even gray blob of a window with no detail.

For effects work I find the zebra bar setting useful to check the evenness of the green screen. Once the screen is lit fairly flat to the eye, you can temporarily increase the gain control to high and raise the exposure slowly with the f-stop control until the screen goes into zebra. If the screen is uneven, a portion of the screen will hit zebra first, and you will know that that part is a little hotter than the rest. Using this method you can adjust the lights until you get an even zebra pattern when you raise the exposure slowly to the point where the zebra just appears. If you do this too quickly, the exposure adjustment will go far beyond the beginning zebra point and the whole screen will have the pattern. Don't fool yourself by raising the exposure too quickly. I find that this method can get the screen even to within one-third of a stop or better. On some cameras there may be two zebra settings. Either one will work in this example, as the purpose here is to use the tool as an indicator of evenness and not the point at which things go into clip.

Once the screen is lit evenly, return the gain control to the original setting. You can then place the gray card against the screen and place the viewfinder center marking

**Figure 9.31:** *Using the zebra method we see that the screen is too hot on the left and the light is too high on the right.*

**Figure 9.32:** *In this case, the lights are at the same level but the screen is underexposed in the middle.*

**Figure 9.33** *A good, even screen. Remember to set the gain back to normal and keep that detail generator off.*

in the middle of the card. You may have to zoom in to cover the area of exposure that is being evaluated. Once the gray card fills the center portion of the viewfinder, adjust the exposure until you obtain 50 percent on the viewfinder. This will generally be the proper setting for the green screen exposure for a digital camera, and you can now light the foreground elements to this level as well. A Composite Components digital green screen placed next to a gray card will usually read the same when lit with tungsten light. In other words, if you get 50 percent on the gray card and pan over to the green, the reading should still be close to 50 percent. This is a generalization and should be taken as such. Not all light meters or cameras respond to colored light in the same way. A different green backing lit with colored light might give completely different readings. The best policy is to test, take notes, and evaluate the final result so that you can create a reliable system with the tools at hand.

In the candy bar example, I showed how to use a densitometer to evaluate the exposure. In the digital realm, you can do the same thing by using a super densitometer otherwise known as Photoshop. Shoot some sample footage of a moving object with your digital camera against the screen lit to a gray card exposure of 50 percent. Bring several frames into Photoshop. You can view the image to see whether there are any interlace artifacts to make sure you are truly shooting in a 24P or 30P noninterlaced progressive capture. You can call up the image size to see whether it will fit into your effects resolution strategy. You can also view the image through the separate red, green, and blue channels to see whether the screen has enough purity to create good separation between the layers. An even better procedure is to put through a test composite of a subject with fine blonde hair waving one hand violently to obtain a blur and perhaps holding a transparent object in the other hand. Compositing this type of subject is quite demanding and is often used to check the quality of a compositing system. Conversely, you can use the information picker and read the pixel RGB values at various parts of the screen. If you have average pixel readings of red

110, green 240, blue 90 on the screen, that would indicate a very pure green screen that should pull well if you are in a 4:2:2 color space or better. To evaluate the gray card exposure you can view it up against a synthetic gray card you create in Photoshop by painting a gray patch at the perfect setting of 128:128:128. You can then visually compare your gray card with this perfect card to see if you are within range. The beauty of this comparison system is that it will work even if you have an unbalanced monitor. If your monitor is slightly red, then both the perfect gray and your gray will be displayed together with the same amount of monitor error. As long as the perfect gray and your gray are close, you know that you have pretty good exposure.

During a shoot using a prosumer digital camera you will often end up waiting for a prop to be adjusted or for an actor to prepare, and the camera will decide to "help" you by turning off to conserve power and wear and tear on the system. When you reactivate the camera, remember to double-check the exposure, color temperature, and frame rate settings, as the camera (unless you have a way to save your settings in memory) may revert to a default that is different from your setup. Be vigilant and don't assume. Working with others in the confusion of production can be particularly treacherous. Perhaps the assistant has been religiously loading in the D settings from the memory chip and shooting all morning. In the afternoon, you might say, "By the way, you have been loading in those B settings right?" Well, D sounds a lot like B, and the "I got it covered digitally" approach can fail in a big way due to human error. It is never wrong to manually double-check the settings on a regular basis. Once you adopt the traditional method of always testing the unknown and gathering as much image data as possible to give yourself room to play later, you will be able to quickly adapt to each new thing that comes along.

The biggest change that has come to pass with the digital method is the ability to have a platoon of people look at a variety of monitors and have a plethora of different opinions. On a set you must slave to one calibrated monitor if you want to make any imaging decisions. If in doubt, always slave to the gray card at 50 percent and use it as a constant to judge where all the tones in your shot are sitting in relation to this standard. It is very easy for a shot to look great on a monitor but for the actual data to be completely blown out, especially when shooting high-contrast subjects such as falling snow and the like.

## Conclusion

Both film and digital have a place in the movie industry. For larger budgets, film will remain as an extremely high-resolution archival capture medium that will be converted to digital files for manipulation in the Digital Intermediate houses. After the movie is completed, it may once again be committed to film to be stored away and still viewable 300 years from now. Digital cinema cameras have at long last become a close electronic equivalent of film that do away with the drawbacks of the physical film world, such as weave, jitter, scratches, and dirt. The high-definition cameras are lighter and smaller, and the freedom of the individual to make his or her own movie is more accessible than at any other time in history. As far as shooting blue and green screen, always pretend you are at the original plate location and set up the camera as if you were shooting the background. Once your camera is set, all you are really doing (in essence) is obscuring the background with a green screen and shooting the performer. Some of the most successful green screen shoots are those where the screen is placed in the set on location. The camera placement and lighting remain identical for foreground and background. For example, you would use this method to composite high-speed performers behind a normal speed foreground. It is easy to lose sight of this simple idea when you are overwhelmed by a big green stage. Remember that the green will become invisible, leaving the background beyond. Once the camera and lighting are set, keep the screen pure, flatly lit, and far enough away to avoid spill, and you will be able to shoot excellent color screen elements using any medium.

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# Chapter 10

## Composition and Lighting

### Composition

Most of us are inherently good at composition. It is only when we think about it too much that we stumble over the rules. If you give a child a camera and ask him or her to take a picture of the ocean, you will usually get a well-composed shot that tells a story of the ocean or the sky (there are only two elements), depending upon what strikes the child at the moment. If the horizon is placed in the center, it is a rather uninteresting shot that doesn't have a point of view (ocean or sky). If the horizon is placed too high, so that the sky is almost out of the frame, the composition becomes uncomfortable because people have a sense of psychological closure and will want the sky out of the frame altogether. Seeing just a sliver of something creates tension. Steven Spielberg used this compositional tension in the first scene of the movie *Jaws*, where the shark kills the first victim. In the shots of the ocean, the compositions are purposely off-balance to create an unsettling premonition of what was to come. If the horizon is brought down to a point that is comfortable, it will usually land around what is known as the "golden section."

### The Golden Section

The golden section or golden mean is a mathematical formula for proportion that was worked out by the Greek mathematician Pythagoras as early as 530 BC and promoted by Leonardo da Vinci, the great Renaissance painter and inventor (1452–1519). This golden section or ratio is 1.61803, and when it is used to divide a line, the resulting proportion will continue itself forever. Figure 10.5 shows a line from A

**Figure 10.1:** *This composition slices the frame in two and doesn't favor one subject over the other. It becomes neutral in terms of point of view.*

**Figure 10.2:** *This composition is unsettling because there is only a tiny sliver of sky. The outside of the frame seems to pull on it to try to close it up and get rid of it. This kind of composition can be used to create tension; you can see the technique used in the opening scene of* Jaws.

to C that has been divided at the golden section at B. If the line is folded over at B to move C toward A, another golden section will be created where the paper meets. You can keep folding the paper at this division and it will always repeat. This is what makes the ratio so special—it mimics the natural repeating proportions in nature. Artists have used it for years for the composition of paintings and the proportions in sculpture.

**Figure 10.3:** *A pleasing, balanced composition that tells a story about the sky.*

**Figure 10.4:** *A pleasing composition that tells a story about the ocean. The horizon line bisects the frame at the "golden section."*

In 1927 a famous Swiss-French architect, Le Corbusier (Charles E. Jeanneret, 1887–1965), created a system called the Modulor. The Modulor used the golden section to determine the proportions in a human figure. For example, in the human figure the navel marks the golden section of the human body from the top of the head to the feet. It again repeats itself from the naval to the knees to the feet. The golden section is also found from shoulder to elbow to forearm. The section is roughly three units to five units.

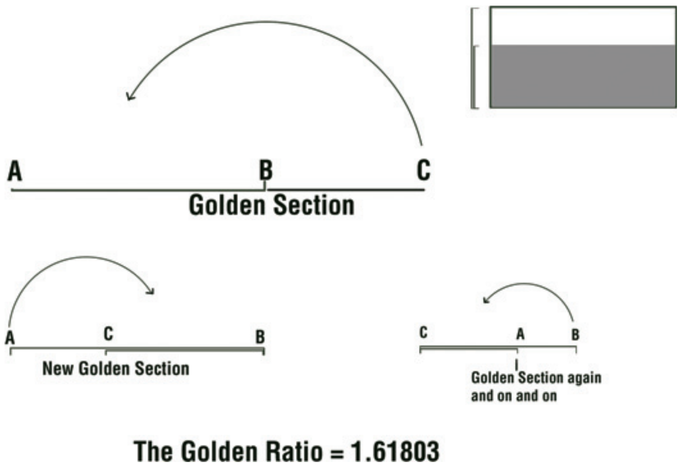


**Figure 10.5:** *The golden section is a magical ratio that not only creates pleasing compositions but also repeats itself endlessly when folded upon itself. The box in the upper right corner is a 1.85 frame divided by a golden section.*

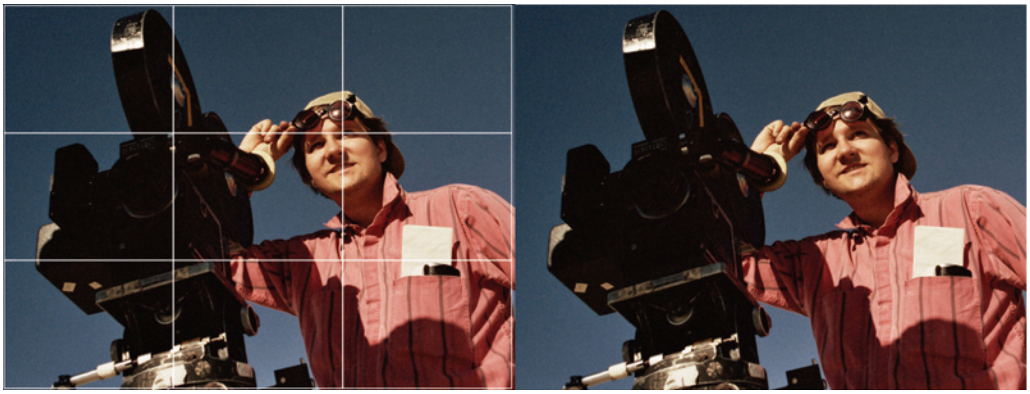

**Figure 10.6:** *The use of the rule of thirds in a 1.33 composition.*

## The Rule of Thirds

Some camerapeople use the idea of the golden ratio by dividing up the frame into nine quadrants. The picture is divided by three lines both horizontally and vertically. The idea behind this "rule of thirds" is that if you place the point of interest at an intersection of these lines, you will generally wind up with a good composition. The picture in Figure 10.6 uses this technique. The cameraman's eye is placed on the upper right hand intersection, and the picture becomes a story about the cameraman. Also note the use of the low camera angle (the camera looking up). This technique emphasizes the subject and makes him appear larger than life. This works because in our early years we were always looking up to our parents, who held great importance to us. The opposite effect occurs in high-angle shots, in which the subject is diminished in importance.

## Choice of Focal Length

Our eyes only have one focal length. In 35 mm motion pictures, this is roughly the equivalent of a 50 mm lens. Our eyes never "zoom in"; only our mind does as we concentrate on a particular subject in our field of view. The camera gives us the ability to have many different lens focal lengths that can simulate what goes on in our mind. The most important phenomenon to remember about using different lenses is that wide lenses not only give you a wider field of view but also tend to keep everything in focus. A longer focal length lens (which would be what you look through when you zoom in) sees less of the scene and tends to have shallower focus or depth of field. This means that the subject will be in focus but the background will go soft. Many cinematographers use this phenomenon to help separate the subject from the background.

The other attribute of lenses with longer focal lengths is that they compress the pictorial elements in depth and make elements of the scene look like they are right next to each other when in fact they are quite far apart. Once again, Spielberg used these ideas to great effect in *Jaws* in the scene where the sheriff is on the beach and sees the shark in the water. The effect he used is called a dolly zoom: the camera starts out close on the sheriff with a wide lens, and then pulls back while zooming in to keep the sheriff's face the same size in the frame. The image that results is the sheriff's static face with a background that seems to compress and pile up behind him. It is a clever use of lens technique to achieve a startlingly dramatic result.

## Traditional Lighting Instruction

In my early days we had few avenues for learning how to light. The usual training exercise was to light a person's face using a hard key light angling down to create a slight offset shadow to the nose for pleasant modeling. Next, a large soft light was used from the camera position to "fill in" the shadows so that they would not be crushingly dark. To obtain a lighting ratio for pleasing contrast, a light meter reading was taken of both key and fill light combined, and then the key light was blocked off and a reading was taken of the fill light alone. If key and fill read f/8 and the fill alone read f/5.6, then the key plus fill would be twice as bright as the fill alone and result in a fairly flat 2 : 1 ratio. Some authors at that time who were more concerned with tone reproduction than art would habitually recommend no more than a 3 : 1 lighting ratio. The last light to kiss in on the subject was a "kicker" or back light that was used for isolating the figure from the background. Finally, a background light was used to illuminate the back wall, usually through a card with a random pattern of cutouts called a cookaloris. This "broke up" the light on the background, creating a bit of interest, and if rendered soft would draw more focused attention to the subject.

If the lighting instruction covered color, the general rule given was that a cooler tone lighting the background would make it recede and bring up the prominence of the subject. Using colored gels or a different color temperature on the foreground was frowned upon, as flesh tones would not be reproduced accurately. These light placements were a great way to light a newscaster and put forth basic ideas. To tell stories with pictures, however, we need to build upon these basic principles and break the rules once in a while when we start to paint with light. The rules I speak of involve the direction, quality, and ratio of the light.

## Key Light

The key light is the primary source of light that provides the definition in the form of the figure. The hard key light I spoke of previously is based on conventional stage lighting that is designed to emulate the kind of lighting on a face that we see during a pleasing time of day, such as 10 a.m. There is nice modeling to the face in that the shadow direction doesn't overpower other features of the face, such as with high noon lighting directly overhead. Top lighting from directly above is generally avoided because the eyes disappear, falling into deep shadow from the overhanging brow, and the nose casts a long shadow over the mouth. Is it wrong to have the key light overhead? Not at all if the scene demands it. In the opening scene of *The Godfather*, for example, all the characters in the Don's office are lit this way. The gangster characters look like skulls skulking within dark confines. The quality of the key light does not have to be hard light, either. In our standard example in Figure 10.7, the key light was hard because it was "mimicking" sunlight, but it is not wrong to have a soft key, soft fill structure. In fact, many cinematographers follow this method to achieve a pleasing look.

The main purpose of the key light is to not only define and reveal the main subject but also to tell a story about the character. Key lighting is a difficult subject to teach because of the tremendous variety of situations and stories. The important thing to remember is that you can place the key light anywhere as long as it does its job of contributing to the story.

## Fill Light

As I mentioned before, the general recommendation used to be for photographers to avoid going beyond a 3 : 1 lighting ratio. Gosh! What if you didn't use a fill light? Would the video police come after you? Once again, the fill light is needed when it's needed; any ratio from no fill at all on up to 1 : 1 can be perfectly valid. Different colors of light can be used as well. Many cinematographers will add yellow or blue gels to warm up or cool down different areas of the frame to add depth and meaning to shots. It is rare, however, that this coloration exceeds the correct color temperature to the point at which the scene can't be corrected for a recognizable skin tone. The fill light also does not have to cover the whole area of the scene. The scene may have pools


**Figure 10.7:** *Traditional portrait lighting and the general placement of lights. The basic concepts of key, fill, and kicker are a great starting point for creative lighting; they are not rules set in stone. The top picture with key light alone is just as valid a choice as the bottom picture that uses all the bells and whistles.*

of key and fill lights dotted about. In many situations when a character runs up to the camera for a closeup, a bounce card will be brought up to kiss in the tiniest bit of light on the face at the last minute when the actor hits the mark for the beauty shot.

## Kicker

The main trick of the back light is to separate the subject so that it does not blend in to the background. It can be blazing hot or the merest whimper. It can be white

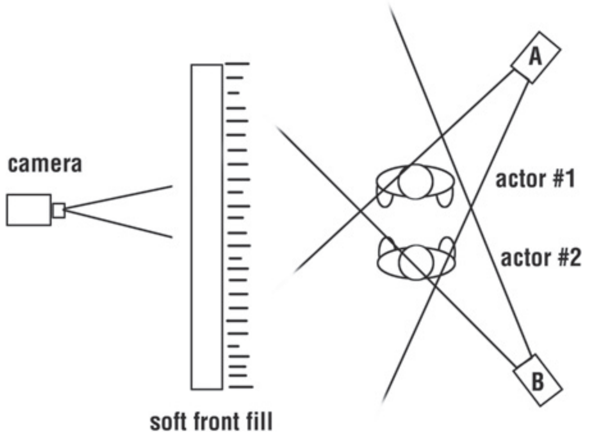


**Figure 10.8:** *Aerial view of a simple cross-key lighting arrangement. The lights are suspended from the ceiling above the performers and the audience.*

or a color and can come and go as the performer walks into and out of it. It can be gone altogether and the isolation will occur due to the difference between foreground and background. A common TV lighting technique is the cross-key method. The set of TV sitcoms that have multiple cameras is lit very flat from just above the audience with broad soft fill lights. Above the set are a number of lights that cross over one another that will meet up with the actors at certain positions. As shown in Figure 10.8, when the actors hit their mark light A will be the kicker for actor #1 and the key for actor #2. Conversely, light B will be the key for actor #1 and the kicker, or back light, for actor #2.

## Matching Lighting

One of the duties of the visual effects cameraperson is to light an element to match what the Director of Photography has done. In most cases there will not be any reference other than the background plate. The most straightforward lighting to match is outdoor sunlight. There is only one key light (the sun) filled in by sky light. To match lighting I find the shadows in the plate.

I look for a person or object on a clear ground plane and I see how far the shadow moves away from the figure. I will be able to match the key light height by raising and angling the light until I achieve the same shadow distance and angle. The next thing I look for is the contrast in the figure. I look into the fill side of the subject and see how much detail is resolved. This is accomplished by visually comparing the plate and the element. If you don't have the benefit of an on-set compositing system, you can get very close by switching back and forth between the element and the plate. If the contrast is slightly off, it can always be raised or lowered in the post process. What you can't do is change the direction of the key light.


**Figure 10.9:** *A background plate with a reference shadow. Note the angle, direction, and length of the shadow as an aid to placing the key light. If you are fortunate enough to shoot the background plate, it is always a good idea to have a stand-in as a reference for the blue screen element, who just needs to stand in for a few frames at the head of the shot and then walk out.*

The most difficult thing about matching sunlight is getting the intensity and the ultra sharp shadows that are cast by the sun. Whenever possible, you should shoot outside in the sun to obtain the true look of sunlight. Movie lights, even when focused, create a slightly soft shadow. Depending on the subject matter, this is usually not too noticeable, especially with overcast or smoggy day plates. In the previous example of the girl being lit by the reflector board, the shadow it casts is not as sharp as direct sun. On the other hand, the amount of control gained by using a reflector can overcome the drawback of a slightly soft shadow.

For indoor plates, matching lighting is quite a bit more difficult. The key and fill are usually soft, and a room may be filled with areas of light that the subject will move into and out of. I look for practical light sources in the shot and mimic them when I can. A shaded lamp casting soft light on the subject can be replaced with a movie light with diffusion placed in front of the beam. If light sporadically streams through a curtained window as if generated by the reflections of passing cars, then a light is rigged that can pivot to create this interactive light, and fabric might be hung to mimic the curtains the light passed through on the set. Take notice if the coloration of a light is different. Warm light through a window can be roughly simulated with straw gels over the window light. You might not get the color gel exactly correct, but the difference in the color of the key and fill can be exaggerated or modified in post. The other thing to watch for is the color of bounce lighting. If you are shooting a blue screen element of a person matted into a forest setting, you might want to take into account the green bounce light coming from the grass and leaves.

It is extremely useful to obtain experience on live action sets so that you can see the variety of tools used by cinematographers to light. For example, Chinese lantern balls are very popular for supplying soft overall fill. To obtain directional soft light, many use a chimera, which is a large soft light with a front that looks like an egg crate, with many tiny square portals that cause the soft light to go in one direction. Many cinematographers bounce light off foam core sheets to get a large overall soft source; others use banks of fluorescent lights. What you use to light will probably be different from what the cinematographer used. The important thing is that you see what the light is doing and match it with whatever tools you have at your disposal. I have found that a good learning exercise for students is to have one student shoot a plate and take notes as to how he or she did it. Another student then examines the plate without the benefit of notes and tries to match the camera angle and lighting by shooting a foreground element. The shoot uses digital still cameras with high resolution and color space. The composite is done in Photoshop. At a later time the composites are examined in class and the students compare notes to see how close they came to guessing and executing the camera and lighting setup of the plate. In the end, if it looks right, it is right.

## Matching Perspective

Matching perspective is a more difficult proposition. The traditional method of lining up the film camera was to put a film clip of the background plate into the viewing system directly in front of the ground glass.

When the operator looked through the eyepiece, he or she would see an image of the plate on top of what the camera was shooting. The system was a bit difficult when using a print instead of a negative in that the image was dark and it was hard

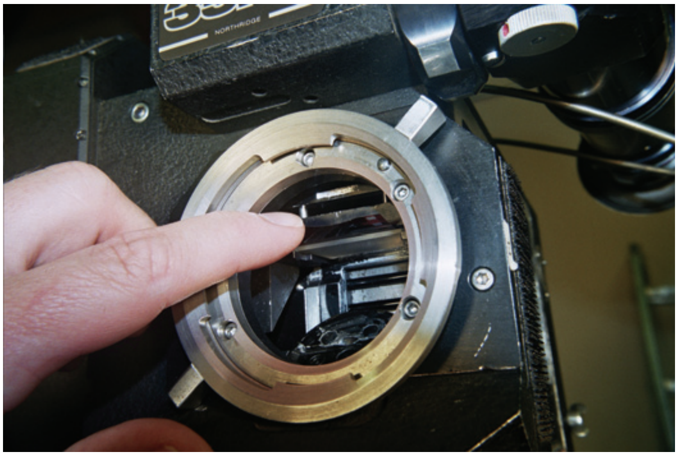

**Figure 10.10:** *Placing a negative clip of the background (from an unused section) on top of the ground glass of the camera. After the clip is in place, the lens will be put on the camera so that critical element alignment can take place.*

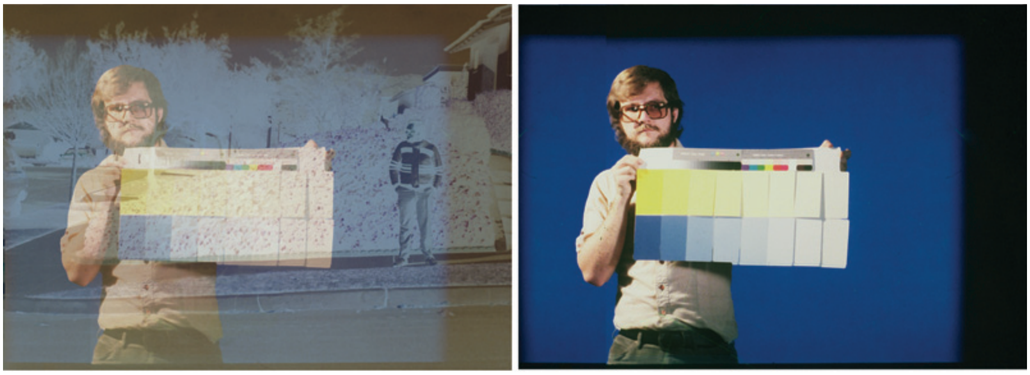


**Figure 10.11:** *Through the camera eyepiece the operator sees both the blue screen element and the negative plate image simultaneously. The raw stock in the camera exposes only the blue screen element.*

to view both elements simultaneously. If using a print clip, the brightly lit figure would come through fairly well, but the print itself would be dark by comparison.

The process was to occasionally hold a white card in front of the lens so that you could briefly see only the plate brightly lit. You would reference this image in your mind and quickly remove the card to see the subject. By doing this quickly, you could create a "mind's eye" composite that allowed you to judge the perspective. If the plate was static with an object that has squared edges, like an end table or a bed, you could put a similar object in that position and raise and lower the camera as well as move the camera toward and away from the subject until the edges of the boxes match as you move the white card in and out. Once a geometric object is aligned in this way, you have empirically arrived at the original lens and camera position.

The process is much easier with a digital camera, as both background and foreground can be signals sent to a monitor for switching back and forth, or a split-screen wipe or rough green screen composite in real time can be done. Another method is to view the plate on the monitor and trace geometric objects using grease pencil on the face of the monitor itself. The monitor is then switched to the camera view and the camera is moved about until the table or other square-edged object aligns with the grease pencil marks. This exercise is critical for shots that need to closely integrate objects into a scene, such as set pieces like a table.

## Lighting a Miniature: Practical Example

I was once asked to create a spooky tower for a film with very little time and money. Since the tower was to be hundreds of feet tall, I decided to build a forced perspective miniature to shorten the length of the tower model while creating the illusion

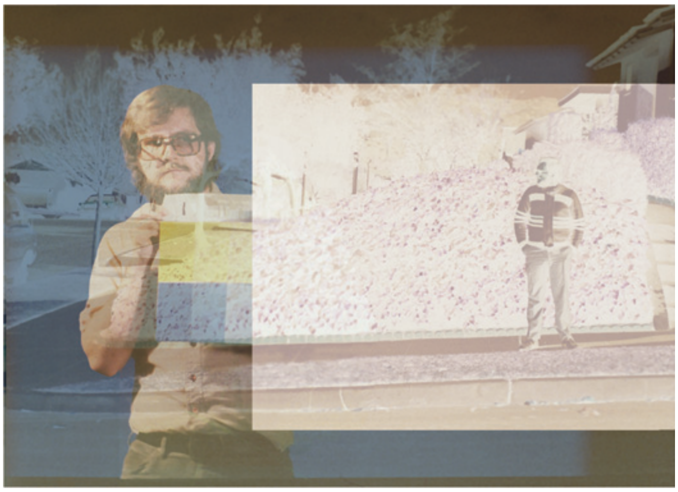

**Figure 10.12:** *Moving a white card between the subject and the lens will momentarily reveal only the background plate as an aid in camera alignment. Most film cameras do not come with a facility for placing a clip on the ground glass. In that case, you must make do by viewing the background as playback on a monitor and looking in the eyepiece to create a rough approximation that will most likely have to be adjusted further in post.*

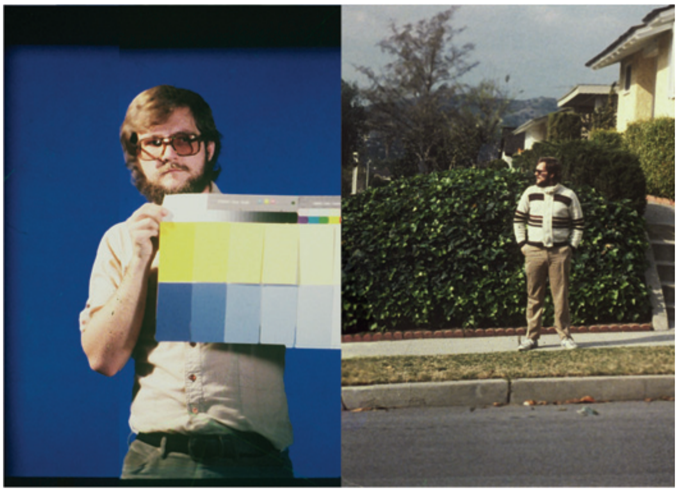

**Figure 10.13:** *A digital camera and a switcher allow either a crude composite on the set or a simple split-screen that can wipe back and forth or simply switch between the two images to assist in aligning the element.*

of great height. In addition to it being more convenient to work with, I was able to more easily obtain a deep depth of field to keep all parts of the miniature in focus, which is essential for maintaining the illusion that the tower is full size. The model was a very simple affair built by using four 4 × 8 foot sheets of foam core built into a pyramiding form. The staircases were made of easily shaped balsa wood. The only drawback to a forced perspective miniature is that it has a limited number of shooting positions before the illusion gives itself away. In this case, the appropriate shooting position was straight down the center.

## Building a Forced Perspective Model

In this example, the tower was engineered backward from the materials at hand, namely, 4 × 8 foot foam core sheets. The objective was to make the tower look dynamic and interesting and then compress the dimensions so that it was easier to build and photograph. If one of the sheets represented the first level of the miniature tower (for convenience sake) and I assumed that a miniature person within that first level is 18 inches tall (because that looks about right), assuming that the average person is 6 feet tall, or 72 inches, that told me that I was building a one-quarter scale miniature (18 inches divided by 72 inches, equals 0.25, or a one-quarter scale). I kept the height of the first level the same height as the foam core, 96 inches, and to see how tall a full-size first level would be, I multiplied 96 × 4 = 384 inches, then divided by 12 inches to obtain feet, getting a 32 foot tall first level for a full-size tower. I wanted this tower to be quite high and to have four levels. Since each level was 32 feet, multiplying by four told me it would be a 128 foot tower. In one-quarter scale, the miniature would be 32 feet, or four foam core sheets laid atop one another. Needless to say, building to this scale would be rather difficult and would require quite a bit of light to obtain sufficient depth of field to keep the whole thing in focus.

In order to keep things practical, I decided that the height of the tower should be 8 feet, and the extreme height would be suggested by bringing the walls of the tower closer together as they ascend. To do this, I drew a center line along the length of the foam core and decided to compress the 4 feet at the base to 1 foot at the top. At the top of the sheet I made two marks 6 inches on either side of the center mark and then drew two lines to the bottom corners of the base, thereby forming a triangle with a flat top for the shape of all four walls. To obtain the scaled heights of the floors, I decided to make the first level 4 feet, half of the original scale height of 8 feet. I bisected the triangle at this point for the first level. Next, I scaled the second level by 50 percent, or 4 × 50 percent = 2 feet, and drew a line there. The third level became 2 feet × 50 percent, or 1 foot; the last level was then 0.5 foot. As Figure 10.14 shows, the scale diminished dramatically.

For the staircases, I measured the widths of the floors of the different levels to see how I should scale the bottom stair to the top stair. The first-level floor was 4 feet across, and the second-level floor was 2.5 feet across. To make the calculation easy, I decided to simply convert these figures to inches, so the first step was 4 inches and the last step was 2.5 inches. I also based the other sets of stairs on the subsequent floor widths and found that the next stair would go from a 2.5 inch step size to $1\frac{3}{4}$

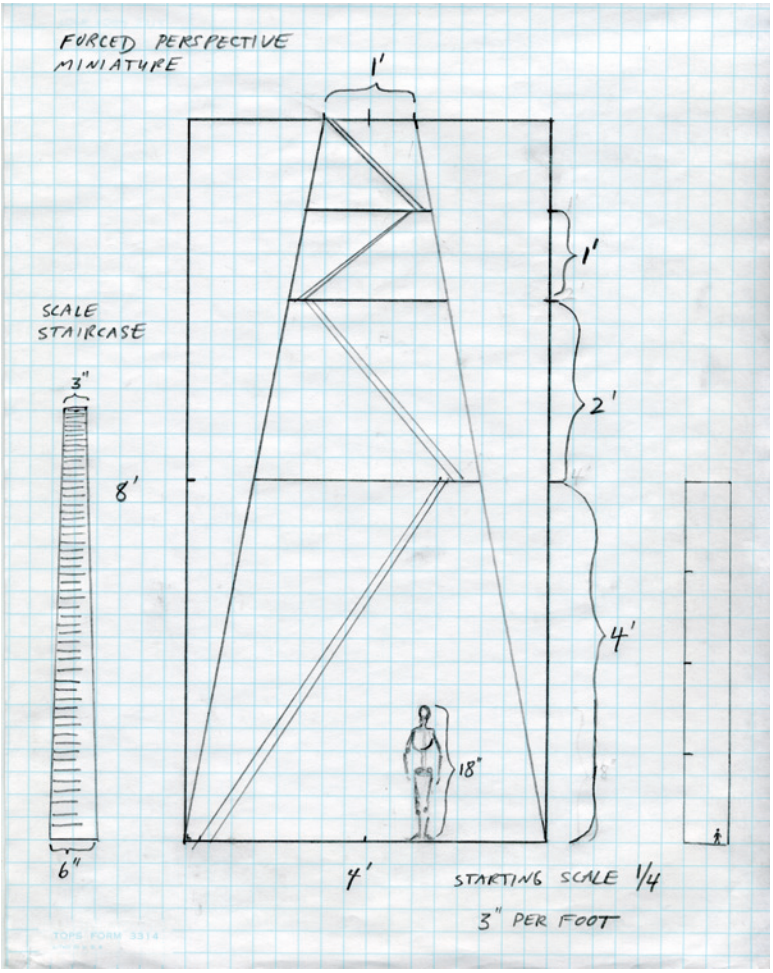


**Figure 10.14:** *A diagram showing the scaling approach for a forced perspective miniature. Each 4 × 8 foot sheet of foam core is cut into a pyramid shape and put together to form a cone to "force" the perspective of the tower. This is a more economical solution than building the entire tower to scale, as shown by the drawing at the right depicting four sheets of foam board stacked atop each other to create a 32 foot tall model. To save time I allowed the top level to extend farther than 0.5 foot and scaled the steps by 50%.*

inches. The third level was 1¾ inches to 1¼ inches, and the last level was 1¼ inches to 1 inch. I found it difficult to mathematically work out the geometry of the ascending stair pattern, so I resorted to an old art trick of cutting a strip of paper and folding it upon itself to create an accordion-like stair pattern. I placed this against the uppermost level along the wall and then traced out the angle of ascent. Once I had this pattern, I placed it in a copy machine and scaled up the side stair pattern to obtain multiple scale templates that I used to cut the balsa wood to make the stairs.

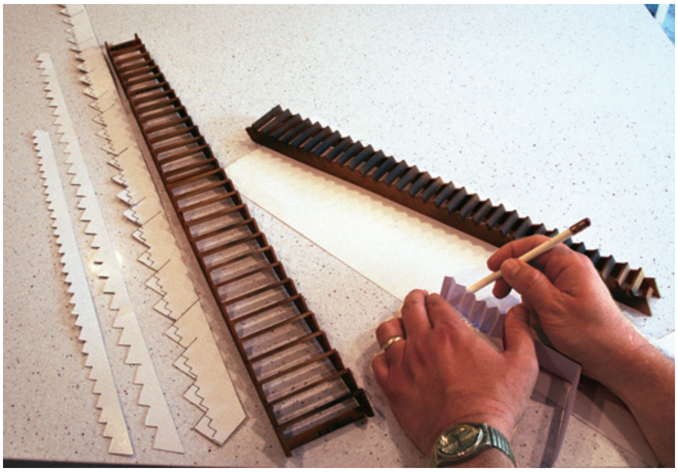

**Figure 10.15:** *Tracing out the side step pattern using folded paper as a guide. The different templates on the left were resized with the aid of a copy machine. Note the difference in size between the first and last steps; these are attached first, and then progressively sized steps are glued on using the skewed side portions as a guide.*

For the bottom-most stairs I cut two side boards based on the templates and then hot glued a bottom step that was 4 inches across and a top, shorter step that was 2.5 inches across, giving me a form that gradually got narrower. All I needed to do then was glue progressively shorter and shorter steps along the length of the staircase. If this was a computer graphic model, you could achieve absolute accuracy by creating a normal-size stair in the computer and then scale one end so that the height and depth of the steps would scale as well. In the case of this model, that level of accuracy was not needed since I was creating an impression of height for mood. The slight inaccuracies in the construction of the staircases could actually add to their believability since nothing in real life is absolutely perfect. After creating the wooden scaled stairs, I used spray stain to color the stairs and painted the surface of the walls a flat gray tone. To texture the walls, I peeled off the cardboard from the foam layer underneath and carved a brick pattern into the foam. By using the paint methods outlined in Chapter 1, I aged and shaded the card and foam so that it became a decaying wall of loose plaster revealing old bricks underneath. For a final touch, I cut out window patterns and added vines and a broken patchwork of boards for the upper level.

## Worst Lighting Ever

Figure 10.16 shows how crude this simple model looks. The soft front fill lighting shows every bit of the shoddy thing and it looks awful. This illustrates a common error in CGI lighting: when the artist forgets to turn off the ambient light in the CG environment. The CGI looks plastic because it looks just like this model lit with

**Figure 10.16:** *Front lighting reveals the crudeness of the tower model. In computer graphics this would be like leaving the overall ambient light on. When doing CGI models the ambient light should be turned off; the lighting should be accomplished with artistically placed illumination.*

**Figure 10.17:** *Finding a good key light placement for a stand-alone shot (one that isn't linked to other shots before and after it) is a process of trial and error. This first placement is rather heavy-handed and unbalanced.*

room lights. The fill light is kept on for ease of illustration in the next few figures, but in practice it is rarely used at this level.

## The Key Light

This shot is about a dark, spooky tower, and so an obvious place to put the key light is up above, shining through the grate. I had an assistant move the key about and found this first position, shown in Figure 10.17, which is only a marginal placement. The light comes through the hole and casts a big spot on one wall. It's dramatic but makes for an unbalanced frame.

The picture isn't about that wall, however; it's about the top of the tower. So I try a different position for the light that rakes the light and breaks it up using not only the grate but also the precious staircases, which have great potential for casting

**Figure 10.18:** *This second light placement is more compelling. A white card was placed beyond the hole and was hotly lit to fill out the source that was missing from this particular key light angle.*

shadows. This second key light position, shown in Figure 10.18, is much better. The rays of light lead the eye to the focal point of the picture (the trap door) and gently glance off the staircases, giving them interesting modeling.

## Faking the Source

Even though I had arrived at an interesting key position for the raking light, I noticed that it never hit the area beyond the portal even though it looked like it should. In order to fill light into that area I lit up a white card just behind that hole and lit it very hot so that it appeared to be the source of the raking light. As far as the camera was concerned, it was.

## Balancing the Frame

Though the raking light looked great, it was still heavy on one side of the frame, so I thought it would be good to balance off the other side and also reveal some detail in the model. I shined a hard spot through the window on the opposite wall past a twig (that acts like a cookaloris) and lit an area of the wall just above a thrusting parapet. This silhouetted a bit of the ruined architecture and helped to balance out the light effect. Since now a bit of the window could be seen, I placed a white piece of paper just beyond the window hole to show something back there like I did with the hole at the ceiling.

## Faking the Source, Part Two

An examination of this lighting in a literal sense shows that by lighting from the top and the side, I had created the land of two suns. It looks good, but might ring false to some critic out there. To remedy that situation, I opened up a tiny crack in the black wrap foil resting on top of the ceiling of the tower to let a little shiner of light

**Figure 10.19:** *Sneaking light in from the window on the left to balance the pools of light.*

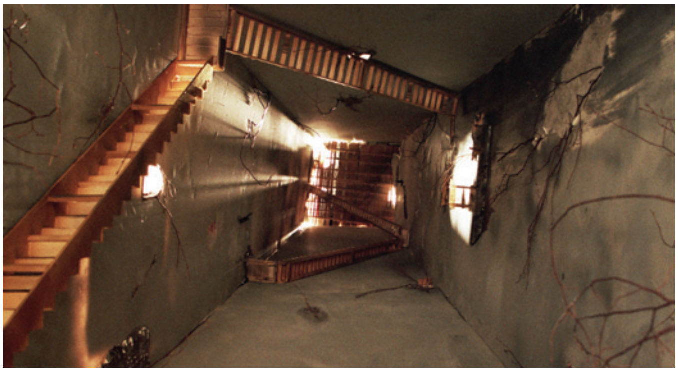

**Figure 10.20:** *Tearing open a hole in the black foil above the ceiling created a dot of light that looks like the motivation for the spot above the parapet.*

peer through from the first key. It only lights itself, but by being positioned just on top of the light striking the far wall it looks as if that is the light source instead of the window. This truly is painting with light. The shape and angles of these light splotches create "vectors" that help direct the eye to the story point, which is the spooky room at the top of the tower.

## Atmosphere

Since this tower is supposed to be over 100 feet tall, there should be quite a bit of dusty air between the viewer and the top of the tower. This subtle diffusion goes a long way in imparting a sense of realism to a model. On professional miniature shoots, entire rooms are filled with movie fog kept at a uniform density to create this "miniaturized atmosphere." For this shoot, I used an inexpensive Halloween fogger to generate smoke to fill the tower model. This atmosphere not only is good for diffusion but also enhances the light by creating "rays" and bouncing the light about to create a low-level fill. Because the smoke will vary over time it is best to spray it in,

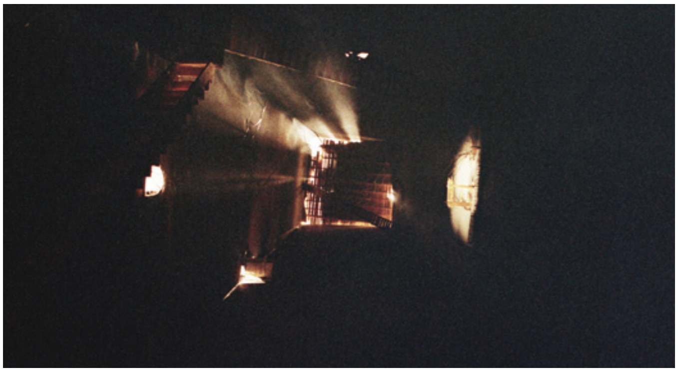

**Figure 10.21:** *The shot without fill shows the relationship of the various modeling keys. All that is needed is to find an exposure that gently lifts the fill until it is just right.*

**Figure 10.22:** *The final shot with just a hint of fill provided by the light reflected within the "atmosphere."*

let it settle a bit, and then bracket exposures at different fog densities. There will come a point where it will look absolutely great!

## Using the Zone System

In a dark scene such as in the preceding example, I sometimes use a system devised by Ansel Adams, the famous Yosemite National Park photographer, to derive exposure. He developed a system of zones representing particular areas of the image that fell along the D–log E curve. Middle gray is set at zone 5 and Caucasian skin tone at zone 6, one stop above. Using a spot meter I read the top area of the key light just as it strikes the wall and set this exposure to be a little under zone 8. This will place it at 90 percent white, which will descend to a nice range of grays into black as the light rakes down the wall. I do this by using my spot meter and reading the EV, or exposure value, in this area. Suppose the reading in this area is EV 6. I then adjust the exposure until that number is placed three stops above middle gray, to zone


**Figure 10.23:** *The lighting setup as seen from the outside.*

8. I then expose for EV 3 (which is now at mid-gray) to obtain the correct exposure. Of course, I will need a deep stop such as f/16 to obtain a good depth of field, so the intensity of the lights should be adjusted to obtain this stop at the required frame rate. I can also read other parts of the tower to see where they fall along the curve and adjust my key or fill light accordingly. The white card that fakes the source can be over the scale at zone 10 if I want that to really bloom out and burn, which in this case would be fine. For focus, I consult the depth of field table for the lens I'm using and pick an f-stop and focus setting that will allow me to hold the entire length of the tower in focus. For example, if I use a 30 mm lens at a setting of f/16 with a focus of 3 feet, I discover that I will be in focus from 1 foot 9 inches to 22 feet 3 inches. This is more than enough to keep the entire tower in focus. I now place a C-stand holding a focus chart 3 feet away from the camera and focus on it with the lens wide open. Once focused I close the lens down to f/16 and am ready to shoot.

## The Zone System in Video

If I was shooting this shot with a digital video camera, I would zoom in to the area on the top wall and place it just below the clip level using the zebras. The white card beyond could go into clip, which is fine because there is no information there anyway. I would then view the scene on a calibrated monitor to see how the tones were resolving. A director of photography once told me a very important thing about night scenes. A night scene is not underexposed; it just has more areas of darkness. As can be seen by our light rays, they are just like a long continuous gray scale with middle gray hitting right where you want it to somewhere down the line. The natural fill light off the walls is usually all that is needed to keep the detail in the dark shadowy recesses.

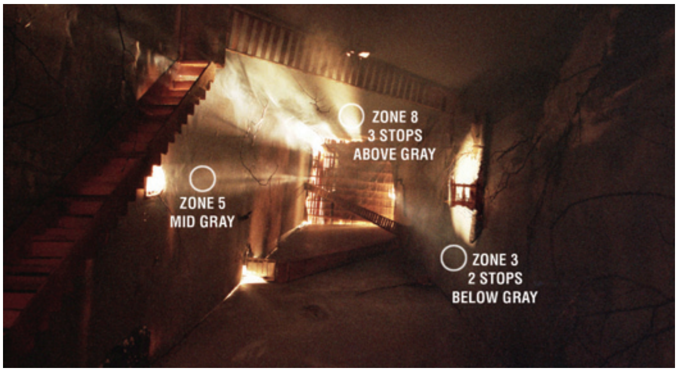


**Figure 10.24:** *Using the photographic zone system created by Ansel Adams. The circles represent spot meter readings in relationship to the gray card.*

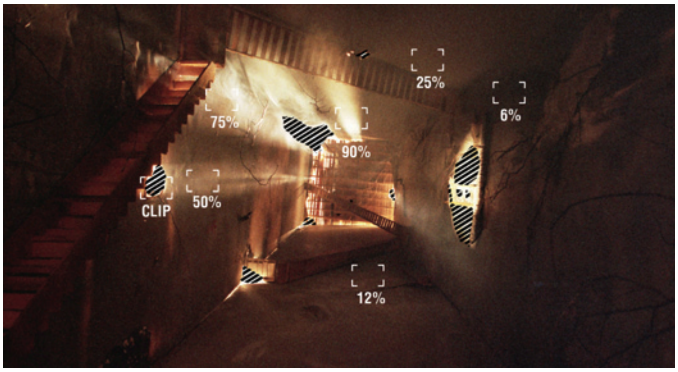


**Figure 10.25:** *With a digital video camera, areas above 90 percent are clipped and show no more gradations. These areas are represented by the zebra pattern over "blown out" portions of the image. The other readings are percentages of brightness as seen through the viewfinder of the camera. Note that the 50 percent reading coincides with the zone 5 middle gray of the photographic process.*

## Balancing in Post

Ansel Adams not only would use the zone system to place his exposure correctly on the negative but also would selectively modify the exposure of his prints through dodging and burning on an enlarger. Dodging entails waving a dark dot over an area of the print causing a shadow, allowing less light to hit that area of the print while it was being exposed. Burning involves the opposite, adding more light on a separate exposure to the print. In the Digital Intermediate environment, filmmakers use a similar digital process to enhance or correct images. In the case of the tower miniature, I noticed that a light had been bumped, taking away the silhouette of the parapet. In post I was able to take that area of the film and selectively print it way down to bring back the shadow I had lost. In this particular case I cut and pasted from a previous take to blend in with the almost perfect one. This is a good example of using the DI process. A bad example would be to try to make the image in Figure

**Figure 10.26:** *An example of post digital enhancement. The blown out parapet in Figure 10.22 was isolated and brought down in density to "break up" the big pool of light on the wall.*

10.16 look like the final shot. Ain't gonna happen. You really want to try to get as much in the can as possible so that a later "fix" is more of an embellishment than an emergency room procedure.

Hopefully these few tips regarding lighting will entice the reader to pursue further study of the art. I cannot overemphasize the importance of proper lighting when shooting elements for visual effects. Compositing becomes a much simpler task when the lighting is executed correctly.

# Chapter 11

## Miniatures vs. Computer Graphics

### *Daylight*

The last big project I worked on at Illusion Arts was the Holland Tunnel destruction sequence for the film *Daylight*. It is an excellent example of classic miniature effects that are designed to integrate seamlessly with real-world photography. Visual effects masters Bill Taylor, Syd Dutton, and Academy award winner Grant McCune, of *Star Wars* fame, helmed the visual effects.

I was very privileged to do setup documentation and standby camera operation throughout this project, assisting Bill Taylor and the crew in executing the cinematography. In the film, an explosion goes off within the Holland Tunnel in New York, creating a chain reaction resulting in the destruction of the structure. This project was meticulously planned through the use of storyboards and computer previz simulations to work out the camera placement and special rigging to manipulate the miniatures. In some cases, foam core mockups were created as a planning aid as well.

### Scale and Speed

The scale of the miniatures was one-quarter scale, meaning that each car inside the tunnel was one-fourth the size of a real car. A frame rate of 48 frames per second (fps) was used to make the miniatures appear real size as they went through their ballet of destruction. In order for a dynamically moving miniature to look right, the camera has to be overcranked, that is, run at a higher speed to slow down the movement of the model when the footage is projected at 24 fps. For example, this

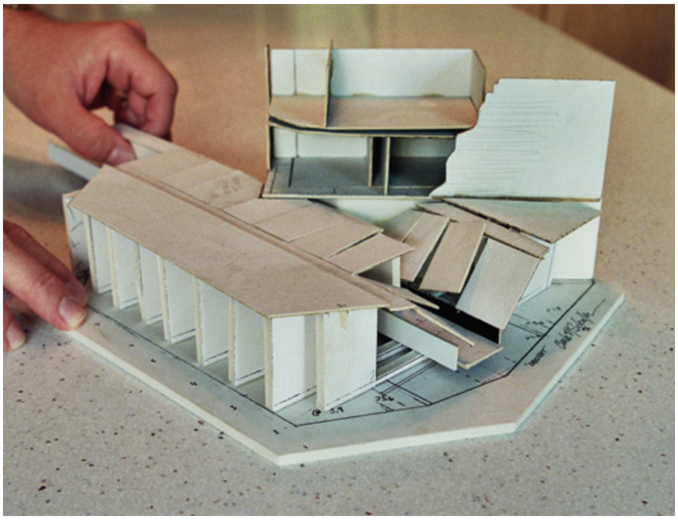

**Figure 11.1:** *A gag mockup built by Clark Schaffer. As the support is pulled, the roadway gives way and a miniature brick wall collapses, revealing the apartment within. Models were constructed with special breakaway sections so that a pre-choreographed destruction could take place and the model could then be reassembled quickly for subsequent takes.*

overcranking would be used for a shot of a car falling off a cliff. If in real life a car drops off a 100 foot cliff and hits the ground in, say, 3 seconds, in a one-quarter scale, the event takes place in a mere 1.5 seconds. If the miniature car was shot at 24 fps it would look like a toy. By using a miniature formula, however, the camera speed needed for a one-quarter scale miniature can be computed. This formula expresses that the linear dimension appears to be magnified as the square of the magnification of time:

$$\sqrt{\frac{D}{d}} = f \quad \text{so if } D = 100 \text{ and } d = 25, f = 2$$

$$\sqrt{\frac{100}{25}} = \sqrt{4} = 2$$

where $D$ is the distance in feet for the real object, $d$ is the distance in feet for the miniature, and $f$ is the factor by which the camera speed is increased. From this equation, the square root of a full-scale car dropped off a 100 foot cliff ($D$) over a one-quarter scale cliff 25 feet high ($d$) equals a factor of 2. The normal frame rate is multiplied by this factor to obtain the speed that the one-quarter scale miniature should be shot with: 2 × 24 fps = 48 fps. At that speed, the miniature car will hit the ground in 3 seconds from a 25 foot platform, mimicking the speed of the full scale event. Table 11.1 is a convenient table of various scales and speeds.

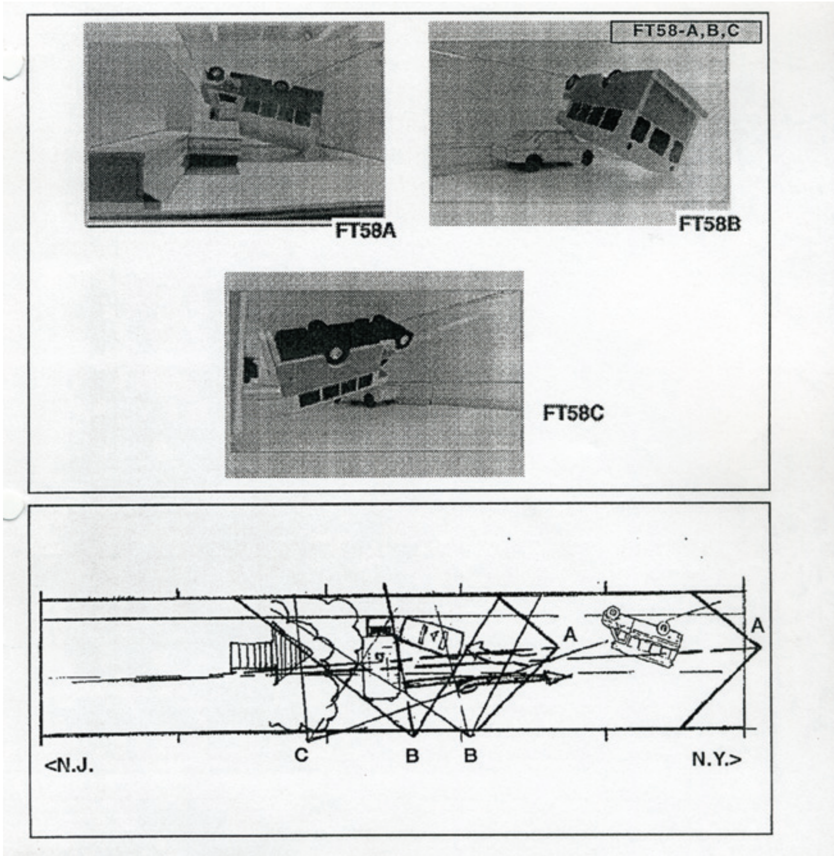


**Figure 11.2:** *Many shots in* Daylight *had storyboards with computer graphic previsualization along with diagrams for camera placement. Courtesy of Grant McCune Design.*

**Figure 11.3:** *Here, I am posing in the miniature Holland Tunnel at one-quarter scale. Courtesy of Grant McCune Design and Illusion Arts.*

**Table 11.1:** *Camera Speed Adjustment for Miniature Photography*

| Miniature Scale | Adjusted Camera Speed |
|---|---|
| 1/2 | 33 frames per second |
| 1/4 | 48 frames per second |
| 1/8 | 67 frames per second |
| 1/10 | 77 frames per second |
| 1/12 | 84 frames per second |
| 1/16 | 96 frames per second |

As shown by the table, the smaller the model, the faster the film must move. The advantage of film is that it has the ability to go to very high speeds, usually topping out at 96 or 120 fps for most production cameras. Digital cameras usually top out at 60P; that can be extended by using time stretch software, which adds synthetic frames to the footage. So digital can get to higher speed, but the quality may suffer a bit as those extra frames are "faked" using software interpolation. Other digital high-speed capture systems involve dropping the linear or color resolution to allow for higher frame rates. A slow-motion shot is obtained, but it will be a softer image than one shot at a normal frame rate. Exceptions to digital cameras losing resolution at high speed are specialty cameras such as the Vision Research Phantom camera, which can generate very fast digital frame rates. These are highly specialized instruments and tend to be used only on larger budget pictures. In my career I've never shot faster than 120 fps. I have mostly shot at a rate between 48 and 96 fps for the high-speed effects I've been involved with.

## Lighting and Depth of Field

The miniature tunnel was lit with bright miniature fluorescent lights fashioned after the actual tunnel lighting. We shot with 5298 that had an ASA of 500 tungsten so that we could obtain a fairly decent stop on the cameras to carry a good depth of field. It is very important to reproduce the focus of full-size photography. If miniatures go soft they give themselves away immediately. The typical setting was 48 fps with a 28 mm lens at f/4 for a VistaVision camera.

## Explosions and the Timing of Events

Safety considerations were foremost, and special plywood "bunkers" for the cameras and personnel were built for protection. The explosive charges were designed for maximum show and minimum force. To plan a typical high-speed shot, miniature supervisor Grant McCune would analyze the action by plotting the events on several time scales: real time, video time, high-speed time, and projection speed time. Using this method, Grant could calculate when to cue triggers for events and see how they would affect the action on the various time scales. Nothing was left to chance, but at the same time the miniature benefited from chaotic yet happy accidents, such as the random distribution of debris that gave these shots great realism.

The triggers had to be timed to within fractions of seconds to translate into events happening many frames apart. To achieve this, the pyrotechnician used a modernized version of what used to be called a nail board. In early cinema, a nail board was just that, a series of nails separated at various distances in a row, perhaps 0.5 inch to 1 inch to 0.25 inch, that acted as a controlled series of switches activated in time. The nails were attached to separate bombs or other triggers. Another wild nail was attached to the power supply and was raked across the nails to close the circuits and fire the bombs in sequence. Since the moving nail was raked across at a constant speed, the bombs were fired at times determined by the distance between the nails. For *Daylight* we used a safer and less crude device to control these temporal events.

At this point I would like to add that there is no substitute for a fully licensed pyrotechnician to do this type of work effectively and safely. With production becoming more decentralized, it might be tempting for a producer to use a local hire who sorta kinda (occasionally) assists on once-per-year firework displays. Aside from the obvious legal and safety issues, what typically happens with such a local hire is that the charge used will be too strong and too fast. A story comes to mind in which an inexperienced technician was hired to explode an elaborate plane miniature as it flew past the camera. The bomb was very fast, and it went off while the shutter was closed. The result on the film was a view of the airplane for a few frames and then nothing but a wire swinging in the wind. Needless to say, this was an expensive surprise.

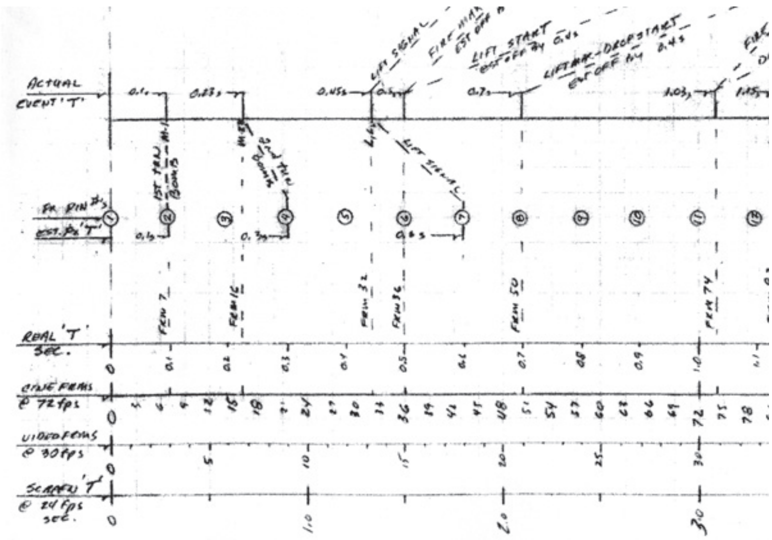


**Figure 11.4:** *An example of a traditional timing breakdown sheet. Each event is planned along several time scales. From the bottom, there is screen time, video time, high-speed camera time (72 fps), and real time plotted against circled numbers that represent the trip switches. Today all planning is done via computer software for extreme accuracy. Courtesy of Grant McCune Design.*

## Determining Explosion Exposure

A common mistake is to overexpose explosion shots. It is not uncommon to watch a motion picture and see an explosion at night become one overexposed blob lacking any detail or texture. The most common reason for this is that the crew had a limited budget for lighting instruments and wound up shooting the scene at around f/2.8 or less. An explosion is an extremely bright light source, and at f/2.8 (depending on the speed of the film or sensitivity of the camera) the fireball will most certainly bloom into clip or be high on the shoulder of the film. So how bright is bright, and how can the brightness of an explosion be predicted? A method that I've devised is based on the logic that a candle flame is at least two stops above peak white. My goal is to bring the value of that flame to peak white or just above on the exposure curve so that I can preserve the detail of the fireball. In order to do that I have my licensed pyrotechnician light a tiki torch in the middle of my shot and I take a spot reading of the flame and place it at peak white, or three stops above mid-gray. I then light the set and bring it to an intensity that balances with the fire. When using a digital camera I place the flame right at the zebra point. After setting this point, I increase the intensity of lighting on the set for the desired look. When the bomb goes off I obtain a beautiful explosion with lots of detail. This scheme will only work with controlled gas explosions that are roughly the equivalent of the tiki flame in intensity. For situations involving extremely bright explosions (that involve burning metals like magnesium) it would be wise to make a photographic test.

## The Shoot

The typical shot on *Daylight* began with effects supervisor Bill Taylor shouting "Roll camera!" and then the operators yelling "Speed!" (the cameras are very noisy). At this point Grant would cue the action by yelling, perhaps, "Run the cars," and the cars would start moving either by pulleys or by radio control motors. When the cars

**Figure 11.5:** *The pre-explosion photo on the left used only ambient light with the gain control of the camera set to the highest setting. This allowed the set to be seen, but it placed the flame so far above peak white that when the explosion went off in the photo at the right there is absolutely no detail and the fireball goes into clip instantly.*

**Figure 11.6:** *With my system I set the fire exposure to just above peak white using the zebra display on the camera. In other words, if the exposure was decreased slightly, the zebra would disappear off the flame. I then increase the lighting on the set to bring up the ambient exposure. The gain setting was not needed since I had ample illumination (the set light can be seen as a reflection in the window). When the explosion goes off it is rich in detail and makes for a more photogenic event. The jagged appearance of the flame is due to video interlace.*

**Figure 11.7:** *Another angle of the miniature Holland Tunnel showing the high-speed camera protected by wooden braces from the carnage it is about to photograph. There is a gap in the center divider of the road that allows some cars to be pulled from underneath. Courtesy of Grant McCune Design and Illusion Arts.*

got into position, "Action!" was called, and the pyro effects were activated. After the shot, "Cut!" was yelled, and the fire brigade moved in with fire extinguishers. The take was analyzed off the video tap recording, and adjustments to the charges, choreography, or triggers were made during the re-dress of the set.

The camera operators always kept close check on the camera mechanisms and made sure that they were oiled on a consistent basis. The film was running through the cameras at a blazing speed, which puts quite a bit of wear and tear on the camera movement. Too little oil can damage the movement, and too much oil will tend to

**Figure 11.8:** *The entrance to the tunnel was shot outdoors at night. Master grip Larry Schuler can be seen bracing the camera in the foreground. Courtesy of Grant McCune Design and Illusion Arts.*

**Figure 11.9:** *Another view of the entrance setup. Note that the light in the foreground is casting a "helper" light underneath the practical miniature lamp to light the wall. The other miniature lamp to the right does not have the power to cast a real beam of its own. This traditional trick can also be used in computer graphics programs to enhance the lighting of computer models. Courtesy of Grant McCune Design and Illusion Arts.*

spray onto the antihalation backing of the film, preventing its removal during processing. When this happens the film comes back with a snowstorm of white specks over the image, which are the result of blobs of the black backing remaining on the negative, which create white specks on the print. Fortunately, they can be removed by putting the negative through the processor a second time (known as a rewash), which will remove the remaining backing. It is best to avoid this procedure, however, as it puts the negative through more handling.

**Figure 11.10:** *An example of an outdoor miniature shoot in daylight. In this case a collapsing bridge model is shot in front of a painted backdrop. This setup was used in the film* Funny Farm. *I am the cameraman. Courtesy of Grant McCune Design and Illusion Arts.*

In the typical shoot, three high-speed cameras were shooting simultaneously. The schedule was, on average, one day of setup and pre-light, one day of shooting, one day called hot wrap, which was used for set dressing and review of the previous day's dailies, one day for reshoots if necessary, and the final day, for wrap to prepare for the next series of shots. After the miniature photography, some shots were scanned and brought into compositing for the elimination of wire pulls or other "gags" that helped manipulate the miniatures. When the shots were finished, they intercut with footage of full-scale destruction shots perfectly. Tremendous experience, craftsmanship, and proper time allotted for execution were required to obtain these spectacular results. For this shoot, the planning and construction phase took six months, and the shoot itself was a four-month endeavor resulting in an amazing sequence that lasts about 2 minutes on the screen.

## *From the Earth to the Moon*

I joined Area 51 as a co-supervisor with Tim McHugh for the Tom Hanks miniseries, *From the Earth to the Moon*, about the United States space program. Ernest Farino was the head supervisor for the series and made the decision to use both motion control

**Figure 11.11:** *An example of a water dump shoot. The oil drum is filled with water and will be tipped, allowing a crash of water to slam through the miniature mounted at a slant below. Sean Phillips supervised this effect. Production by Bob Benderson, CMI.*

**Figure 11.12:** *Master pyrotechnician Tassilo Baur preparing to tip his dump tank rig. The shot itself (before the water crash) can be seen in Figure 13.11.*

models and CGI (computer graphics imaging). This was a fascinating opportunity for me to experience a side-by-side comparison of both methods. The model shoot methodology was very well worked out using traditional motion control of models photographed in front of black. On a separate exposure the ultraviolet red screen process was used for the mattes. In this process a special screen is used that emanates red light when lit by ultraviolet sources. During this matte pass the model was not lit and became a silhouette. This is an excellent system for nonhuman subjects under motion control. The red light results in a high-contrast cyan matte image against the orange base of the negative film. There is no problem pulling mattes. The motion-controlled models made excellent elements that were completely convincing.

## CGI Spaceships

The important thing to realize with computer graphics is that there is no "magic spaceship" button. It takes just as many months to create realistic spaceships using the computer as it did to manufacture traditional models. The advantage with CGI is that crude models can be used to start roughly laying in composites for movement and composition while the model is being perfected. It would be expensive and impractical to do this with physical models, as you would have to wait for the finished model to be built before committing to photography.

One of the first uses of a CGI model was the depiction of a Gemini spacecraft wildly spinning out of control. Even though a physical Gemini model was available, it was too problematic to create a rig that could spin the model on each different axis required without the rods and manipulators getting in each other's way. With CGI there are no holders or rods supporting the model so it is free to move in an infinite number of ways. This freedom has a further advantage of allowing the movement and lighting to be tweaked ad infinitum. In model photography, the motion control move is "fixed" and can't easily be changed without reshooting. That being said, the CGI model isn't always a shoo-in because (as with models) a talented crew of artists is needed to get the thing to look real. One of the main reasons for this is the struggle to mimic the effects of real light hitting a real object.

## Real Light and Software Simulation

The interaction of light upon surfaces is an extremely complex phenomenon. So much is taken for granted when a subject is lit for photography. When rays of light hit the surface of the subject, the quality of the light is changed through absorption and reflection. The rays bounce off and hit other objects that may color the light again as it bounces back and once again hits the subject, and so on and so on. Light is complicated, and the simple quality of illumination seen from a single light striking a subject is almost too overwhelming for the computer to simulate. Simple software programs can compute the light needed to go from the source to the surface, then

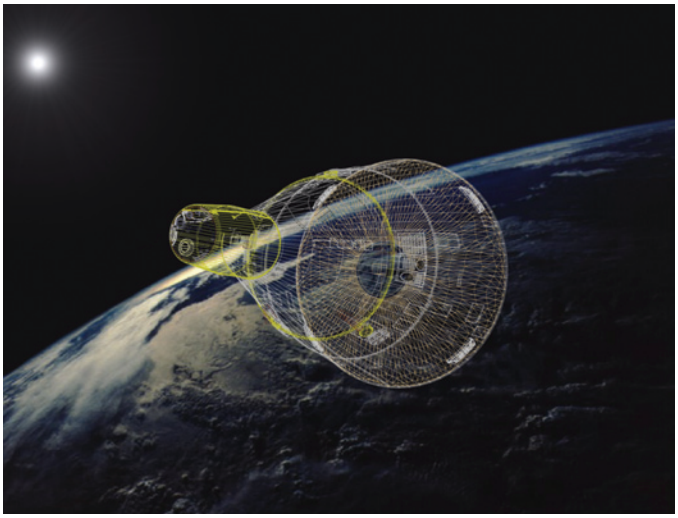

**Figure 11.13:** *A wire frame model composed of a multitude of polygons that create the framework of a CGI spacecraft. Courtesy of Glenn Campbell of Area 51.*

**Figure 11.14:** *A simple shaded model that can be used for move tests while the final texture is worked on. Courtesy of Glenn Campbell of Area 51.*

to the virtual camera, and then stop. This light brightens the surface but does not bounce off, reflect, or even cast a shadow unless more computation time is used. In the process of ray tracing, the computer produces a realistic representation of a shadow by calculating the path of the light ray from the source, to the subject, to the surface the shadow rests upon, to the virtual camera. The calculation of the travels of this enormous bundle of rays is computationally intensive. A normal render without ray

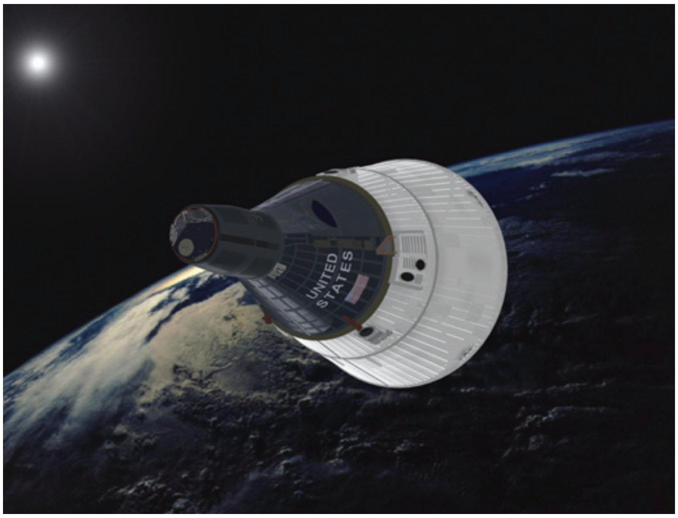


**Figure 11.15:** *The model with the final texture applied. Note that the ambient fill light is made purposely high to show the texture for this illustration. For the actual shot, the fill will be brought way down to fit with the backlit background image. Courtesy of Glenn Campbell of Area 51.*

**Figure 11.16:** *The final shot with the proper lighting balance. Regardless of how a model is created, it still has to be lit properly to key in to the background. Courtesy of Glenn Campbell of Area 51.*

tracing might take 1 minute to “draw” the CGI image. When ray tracing is turned on, it could take 10 minutes to render the same picture.

For even greater accuracy, a technique called radiosity can be employed that calculates every bounce of every light ray off every nook and cranny that it encounters. This gives the most realistic render, but each frame might take 1 hour or more to render.

Obviously, this amount of render time puts a real crimp on production time. The current approach is to render one frame of the environment utilizing radiosity calculations that might take 6–8 hours to render but, once done, can be "baked" onto the model almost like a holographic representation of the set. As long as the lighting and the set do not move, the camera is free to shoot this highly rendered baked set from many angles. A CGI character that animates within this set would have to be rendered with radiosity, but since it is only the character requiring heavy computation, the render time for the shot becomes much quicker.

If radiosity rendering and baking are not available, different workarounds for mimicking the light affect can be used. These techniques are similar to traditional art department approaches for sets. For example, for a set in which practical light sconces are supposed to light the wall but their intensity is too weak to overpower the ambient light of the set, a solution might be to paint the part of the wall above the sconces a brighter color to simulate a wash of light. Similar methods are used within CGI software. A faster way to compute shadows other than ray tracing, for example, is to use depth map shadow computations. This is much faster because it amounts to the same thing as painting black paint on the floor to create a shadow. Thinking of light in this way can be mind boggling. The operator has the tremendous advantage of being able to light without casting a shadow or casting a shadow without lighting the object. These concepts are impossible in the real world.

The problem is that the simplest lighting setup on a real set can be quite difficult to simulate in software. To illustrate this issue for my students at UCLA I created a lab in which I light a simple Styrofoam ball resting atop a table with a single light and a bounce card. The challenge for the student is to create a CGI ball and light it so that it looks identical to the real sphere when composited next to it. This is amazingly difficult. After much consternation, the student finds that lighting the computer graphic ball convincingly while conserving computational resources requires five lights to simulate the one real light and the bounce card. If the ball is animated, the lights will have to be animated to follow its movement to maintain the illusion. Creating convincing CGI lighting requires a thought process far different than that of a photographer. The sculpting of computer light in order to create a photo-real image is a talent that takes many years of experience to develop. On top of this is the added issue of creating convincing models through the use of texture maps, specular maps, bump maps, etc., to simulate the surface effects of real materials.

## High Dynamic Range Imaging

High dynamic range imaging (HDRI) is a lighting method that has recently come into the mix that has been a great boon to lighting CGI performers. While on a live action set, a special camera shoots into a mirrored dome and collects a 360 degree

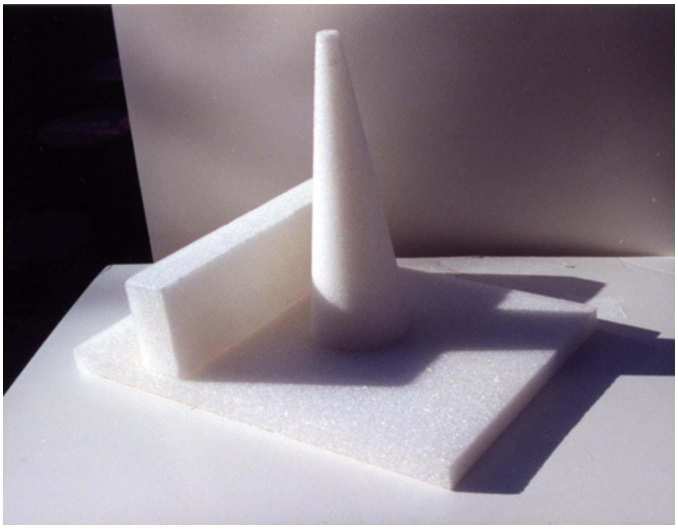

**Figure 11.17:** *A good exercise for those learning to light using software is to photograph simple shapes like these using a single light source as a background. The artist then creates a mimic of one of the shapes and tries to place it within the scene. The challenge is to light the CGI object so that it is indistinguishable from the real object. The complexity of the real light can be seen by observing the shadows and the effect the bounce light has on them.*

view of the environment. Several exposures and different brightness ranges are shot with the camera, and a software program unwraps the image and essentially places this 360 degree image around the CGI figure. A similar method was used to great effect for the molten metal man in *Terminator II* to reflect the environment off his chrome surface. Today this same idea can be used to create a dynamic lighting fixture that uses the image itself as a light source. This can be thought of as surrounding the figure with an invisible transparency of the scene and allowing light shining through this transparency to illuminate the figure. If the figure is standing next to a green wall that is photographed with the 360 degree camera, then green bounce light off the wall will hit the figure, creating a soft green fill as it would in real life. This process can be remarkably effective but does require that someone have the forethought to shoot the HDRI image and utilize it. Considering the chaotic nature of production I believe that the digital lighting compositor will be a viable occupation for some time.

## Real or CGI?

If I were given the assignment of creating a title background that looks like a crumpled burlap bag, I would not be inclined to create it using a computer. A photo-real image can be produced instantly by using real burlap and real lights. Doing the same thing via the computer and getting it to look natural would be a relatively involved endeavor whose extreme control would actually get in the way of the aesthetic. It is better to find and shoot the perfect fabric crumple by rapid trial and error than to painstakingly manufacture the perfect crumple. The extreme orchestration of a CGI fabric element can take away the naturalness and accidental nature of real fabric. It is not a simple matter of pushing a button. So while CGI can give us infinite flexibility, it is this very attribute that is its downside. If something can continue to be changed forever, there is no pressure to commit.

That is not to say that CGI can't look completely convincing. In the case of *From the Earth to the Moon*, the talented artists of Area 51 created footage that was so realistic that the producers of the show would occasionally get confused and complain about the motion control models looking "too CGI." This is not to say that the real models were not up to snuff. A common problem with models created for the space race story is that the real spacecraft were right off the assembly line and therefore didn't have any aging effects that model makers traditionally use for scale cues. There are many photographs of the real Saturn rocket that look a bit odd because the surface of the rocket is so pristine. So how does one choose between real and CGI? The ability to get to real so quickly with a photographed element can outweigh the advantage of flexibility, but this is seldom the case today. If the shot is simple with easily tracked movement, I'll shoot a real element every chance I get. If the shot has an elaborately animating subject, such as a giant robot, I would be foolish not to take advantage of the extreme control that CGI affords. It often boils down to a sign posted on the wall of many effects facilities. The sign has three simple words on it: fast, cheap, and good. You can only pick two.

## The Future

Making something truly organic like a photo-real character digitally is a monumental task that can involve hundreds of people. I have no doubt that we will see a full CGI human actor in the future, just as I am sure we will clone a human being—because people just have to do it. This does beg the question as to why we would want to do such a thing. From a studio's point of view, creating a CGI actor would be great because it would mean creating a star that would never age, get residuals, or share in the profits. I hope the reality is that the audience will still want to connect with real actors to vicariously live out the hopes, dreams, laughter, and fears of us all. Besides, whom would the scandal magazines write about?

# Chapter 12

## So You Don't Have a Million Dollars

On many projects I have used video cameras to create elements to be incorporated into film composites. Shooting elements on video is a very fast, money-saving option compared to renting an expensive film camera. In some cases (depending on the digital camera) there may be issues with low color space that create difficulty for the digital compositors later on, but there are ways to shoot that can alleviate this potential problem. What follows are some methods of shooting digital video elements for motion pictures that I have used. These methods can be used for lower-end video projects as well.

### Interlace

I always avoid shooting video with interlace because film does not have interlace. An interlaced image combined with a noninterlaced image will stand out and not blend well unless the interlaced element is an insert for a TV screen, where one expects an interlaced image. Depending on the camera I have available, I will always shoot 24P if possible to get whole progressive images that can be easily composited with film. If I can only shoot 30P, then I will adjust the performance of the subject on the set or rely on the digital department to time-compress the footage to fit into the 24 frames per second (fps) rate. A rate of 30 fps is 1.25 times faster than 24 fps, so the action could be performed slightly faster so that it will play back at the right speed. If the action takes 10 seconds shooting at 24 fps, then a similar action should be performed in 8 seconds when shooting at 30 fps.

$$10 \text{ seconds} \times 24 \text{ fps} = 240 \text{ frames}$$

$$10 \text{ seconds} \div 1.25 = 8 \text{ seconds}$$

$$8 \text{ seconds} \times 30 \text{ fps} = 240 \text{ frames}$$

That is, there will be the same number of frames per action regardless of the frame rate. If you were to shoot an image of a background actor walking in the distance to enhance a matte painting and you want him to go from one end of a walkway to another in 10 seconds of film time, or 240 frames, then you would have the actor walk the same distance in 8 seconds if you shoot him at 30P. You will then wind up with 240 frames of progressive image of the actor walking the same distance.

## Green Screen Workaround

If you are using a camera with 4 : 1 : 1 color space recording to a medium that further compresses the signal, you may have a difficult time obtaining acceptable blue or green screen composites. There are some software fixes that attempt to deal with these issues, but in my experience they are marginally satisfactory. There is very little color information in 4 : 1 : 1 and that becomes problematic for blue and green screen software. One philosophy for dealing with this issue is to avoid working with images that have been recorded on tape. As the saying goes, "If all you have are rotten apples, go to the tree." The Ultimatte Corporation's solution to this issue is to take the S video out directly from the camera and put it into a hardware device called the Ultimatte DV to create an "on-set" composite using the best analog signal coming directly out of the camera. This now becomes a performance type effect that is done on the spot and can be output as a final digital composite for editing, just like a regular shot. The background input can be anything, even compressed footage, since no color matte extraction is done with the background. The signal directly from the camera is used in order to create better matte extraction. The best workaround of all is to avoid green screen altogether.

## Look, Ma: No Green Screen!

I once worked on a shot in which two hands were operating an animation flipbook in front of a bush. As the shot continued we panned up and went into a high-speed drive down a street. In the rush of production it was decided to shoot the flipbook in front of green using a video camera that had 4 : 1 : 1 color space recorded onto mini DV tape. When the digital department received the shot, they had great difficulty pulling a satisfactory matte with the software tools they had at their disposal. The edges of the hand and book would "ripple" like heat waves, which was unacceptable. The flipbook needed to be shot again using the same camera in a way that could work around this problem, yet still be able to be composited in post instead of on set as described above.

**Figure 12.1:** *A photo is taken of a portion of the background plate and blown up to an 8 × 10 still.*


**Figure 12.2:** *The flipbook element is photographed in front of the still.*

The solution was to use a different technique. People usually associate green screens with anything and everything that has to do with effects. In the old days, however, because of the expense we avoided blue screen at all costs. For the flipbook I reverted to an old standby: I shot the flipbook in front of a still photograph. The original reason for shooting the flipbook against green was to be able to composite a background element of a far distant view that was also in focus to obtain an impression of infinite depth of field. Since the background was a far distant bush that didn't move, all I needed to do was shoot the bush on a digital still camera and make an 8 × 10 inch print of the image. I shot the flipbook in front of this print and completely avoided any matte lines or jaggies because nothing was matted! A simple soft

**Figure 12.3:** *A soft split is made through the foliage area.*

**Figure 12.4:** *The final composite with flawless edges on the hand and flipbook.*

split was put through the foliage of the bush on the print and blended with the live action bush in the background. The audience never thought to look there.

## Front Light/Back Light

In the early days of-stop motion, blue screen was often out of the question due to its expense. A clever, inexpensive workaround that worked well for stop motion was the front light/back light technique. In this method, the animator set up a puppet on the stage and photographed it in front of a black velvet screen. This frame was called a "beauty pass," as it contained the subject with appropriate "beauty" lighting in front of black. After this frame was shot and before the animator made the animation adjustments, the front lights on the model were masked off, the black velvet screen was raised, and a white card behind the puppet was lit. There was now a black silhouette of the puppet in front of the white screen or its matte. This matte pass frame was then photographed. At this point the black velvet was dropped, masking out the white card. The front lights were again allowed to light the subject, the animation puppet was repositioned, and the next frame was shot. This process was repeated for the entire animation sequence, yielding film that had a beauty pass frame followed by a matte frame followed by the next beauty pass frame, and so on. The beauty pass and the matte pass were extracted off the interpositive using an optical printer to create the composite. Are you ready to call suicide prevention yet? As time-consuming as this was, it did result in very accurate and cost-effective matte extraction.

I still use this idea today when I have a video camera that has a color sampling that is insufficient for easy green screen pulls. On the film *Stay Alive* I shot a number of video elements of skulls and props that were composited into the background plates. The typical procedure was to lock the camera off on a sturdy tripod, then shoot a burst of the skull in front of black as I animated a key light swinging underneath

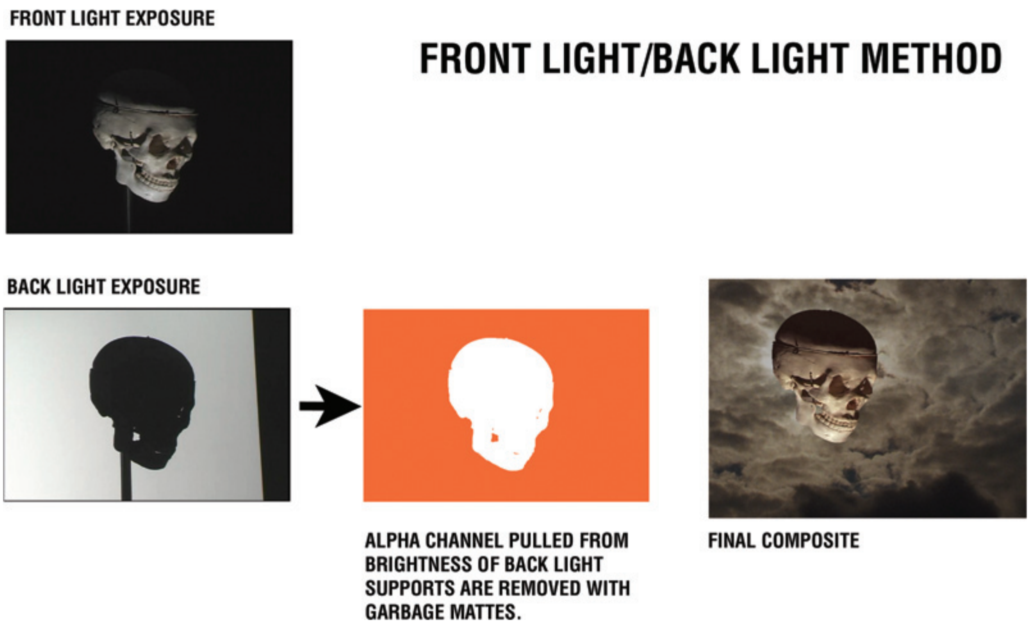


**Figure 12.5:** *A front light/back light scheme. The backlit exposure is used to pull a luminance or brightness matte of the image. This makes use of the full 4 of the 4 : 1 : 1 sampling scheme and obtains much better matte edges.*

and shining upward to create a ghostly appearance. When the light was off, the skull the frame went black. As I swung the light toward, underneath, and away from the skull, it appeared as if the skull was moving into the light when in fact the light was moving past the skull. After this "beauty pass," I turned off the front light and shot a burst of black silhouette of the skull in front of a white card. The position of the skull was the same; only the light moved, so the matte pass and the beauty pass were in register. When the footage was brought into compositing, the digital crew could use the full signal for both the beauty pass and the matte pass. This allowed the digital compositors to pull excellent keys. The static skulls were then animated, tracked, and composited over the live action plates. If perspective changes had been required, such as having the skull rotate, then the process would have had to be animated as described earlier. In the case of *Stay Alive*, perspective shifts were not needed for the skulls, so a great deal of time and money were saved using this traditional technique.

## A Word on Black Backgrounds

For many elements the best background to use is black. This is appropriate for smoke, fire, snow, bubbles, etc. If a matte is pulled based only on the brightness of the object, there will not be any issues with color spill or colored matte lines that can occur with color screen composites. The best way to keep the background black is to use a good grade of black material, like velvet, and simply don't light it. In a situation where lighting the object and the velvet simultaneously is unavoidable, it is best to use a transparent velvet rather than opaque material. What I mean by that is that if you have a dense, black fabric like duvateen and hold it in front of a light, it will totally obscure the light. Unfortunately, when front lit, the tight knap of the fabric tends to diffuse the light and will show up as a dark tone on the film or digital image rather than a true black. The blacks can always be "crushed" in post, but it is better to get it right in the first place. A better fabric would be what I call "transparent" velvet, fabric that has a deep plush that absorbs a great deal of light. When held up to a light, the light can be seen through it. This material tends to photograph as dead black. Most of the light hitting it passes through to the other side, and the little that is reflected is absorbed by the thick knap.

## Try Not to Blend Color Space

These days, everybody wants to try everything all at once. For example, some directors will want to add an element shot on video to an element shot on film. Because shots on film and shots on video are so different, this is only successful when there is no close interaction between the two elements. It is fine for backgrounds out windows, images in monitors, or elements like the flying skull mentioned earlier but is difficult for a smooth blend between two images that closely interact, such as a live action plate and model with delicate lighting that take up one-quarter to one-half of the frame. A model shot in an 8-bit linear still format such as JPEG will not blend easily with a live action set shot on film and scanned in 10-bit log. These color spaces are so far away from each other that it is extremely difficult to obtain a good result. When blending 8-bit linear with 10-bit log color it quickly becomes apparent that there is very little room to move and color-correct the 8-bit file; the data really have to be wrestled with to be acceptable.

I once was required to shoot a model enhancement to a live action shot that consisted of an ice cave in the fog. In this case the "ice" was built from shaved Styrofoam and photographed through the mist of a fogger, much like the tower example. The subtle tones of light would have been difficult to maintain and blend and would have had a high possibility of clipping if I had shot this static element in 8-bit color space. My solution was to shoot the model using a still film camera loaded with the same movie film that the plate was shot with and click away. After the photography, the roll of still film was put in a regular movie film can and sent to the movie laboratory for conventional processing. After developing, the stills were put on a film scanner to create 10-bit log Cineon files just like those made for the plate. This put both the element and the plate in the same color space, and indeed they married together perfectly. Whenever possible, create both the plates and elements with the same medium. If you are shooting film and an exacting blend is needed, keep everything on film. If you are shooting in a digital format, keep everything in that color space. This will ensure that you will have an easier time blending the elements later on.

## Difference Matte

When you have a poor color space signal, another option instead of using green screen is to lock off the camera and shoot the element both with and without the actor. This can be done in front of any background, including a full set. When these two plates are brought into the compositing software, the computer can create a difference matte by analyzing both images pixel by pixel, comparing each against the other. If in plate A, shot without the actor, the computer shows a value of 50, 35, 61 for a pixel located at coordinates *x* 500 and *y* 400, and the same pixel on plate B, shot with the actor, shows the same numbers, then there will be no difference and no matte. If a pixel at *x* 700 and *y* 540 on plate A that is showing the background reads 20, 34, 40, but the pixel on plate B reads 40, 50, 55 because that pixel is now over the actor's hand, then the software will detect a difference and generate a matte. This system works amazingly well but is not perfect, as there will be tones at the same place on the actor and the background that match. In other words, the matte will have many holes and imperfections that will have to be cleaned up through rotoscoping, but at least the bulk of the matte and the edges can be generated automatically. The method does require the use of a locked-off camera or motion-controlled plates, but the results can be quite acceptable, particularly for dark scenes where there is not a lot of fine detail in the matted element, such as blowing hair.

## Front Projection

Another method for compositing images that can be quite successful is to project the background behind the subject and shoot on set. The subject can wear any color and react to the image on the screen as though it is really happening. I outlined the front projection process briefly in Chapter 3 by illustrating the properties of Scotchlite (Figure 3.26). Unlike rear projection, this process uses a two-way mirror that reflects the background over the performer and onto the Scotchlite screen. The screen retroreflects the image back through the mirror to the camera, which films a composite of both the performer and the background (see Figure 12.7). When the optics are aligned properly, the actor hides his or her own shadow. In the film process, specially prepared low-contrast prints made on large-format films are used for

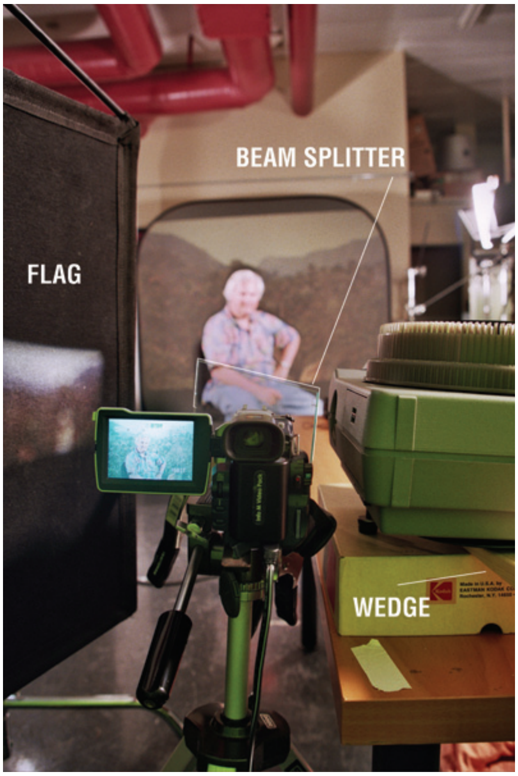


**Figure 12.6:** *A front projection setup using a slide projector. The two-way mirror is spring-clamped to a board held in place by a C-stand. The black flag on the left prevents light from bouncing back into the mirror again. Wooden wedges like the one on the right of the frame underneath the projector are very handy when trimming up and aligning the various optical components.*

the backgrounds and the composite is created in-camera on the movie format of choice. The projection method can be extremely effective for car shots, looking out windows, etc.

Front projection can also be used with a slide projector, should the background be static. A low-contrast film transparency on a slide will have more than enough resolution for a digital video camera or a standard format film camera and can be a viable alternative to an expensive translite (this is a large translucent backdrop that, when backlit, is used for providing backgrounds for movie sets). To accomplish the trick, a high-gain Scotchlite screen made from the 3M materials is needed; it can be made to order from www.virtualbackgrounds.net. This company also has projector housings that contain the two-way mirror needed to do axial projection so that the projection

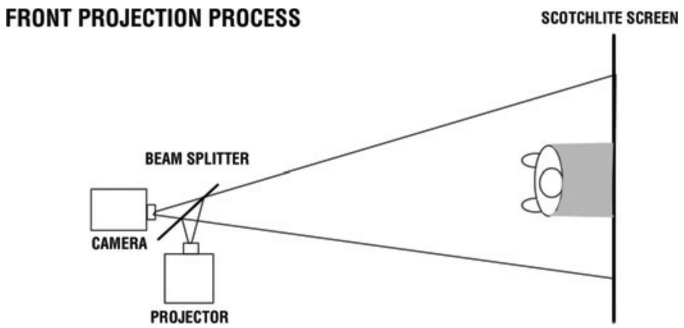


**Figure 12.7:** *Front projection diagram. When the optics are aligned properly, the subject hides his or her own shadow.*

**Figure 12.8:** *If you have to align your own optics, one trick is to place a small strip of Scotchlite in front of the screen to see whether it hides its own shadow. If the optics are misaligned, then a shadow edge will be clearly apparent, as in the picture at the left. To align the optics, gently move the camera over to the side or up and down as necessary until the shadow disappears, as in the picture on the right. The brighter foreground screen is the virtual background product and the dimmer screen behind is the Reflecmedia screen. Though both can be used for front projection, the virtual background material is a better choice for this application.*

**Figure 12.9:** *A front projection composite using a 35 mm slide projector. The high resolution of a slide can yield spectacular results on video.*

**Figure 12.10:** *Any color clothing can be used for front projection. The process also has the advantage of the performer being able to see the background image. It will appear very dim, but it is visible enough for the actor to react accordingly and be able to gauge his or her position by seeing his or her shadow in relation to the background.*

and camera are on the same axis. You can take a digital still and send virtual backgrounds the file, and they will create a transparency that can be projected onto the screen. All that remains is to position the digital video camera at the mirror to see the composite. If the camera is placed on the nodal point, as was shown in Chapter 1, then you can also do small moves on the image. This method can be used with any camera and medium, film or digital.

### Teaching Visual Effects Using Front Projection

I have noted that schools have a difficult time teaching subjects such as visual effects, because many school programs are "software-centric." It is a challenge for schools to stay on budget when faced with constant software and computer changes, let alone upgrades. The front projection system can be a viable, inexpensive adjunct for teaching the principles of compositing that can have a long shelf life. Any consumer video camera can be used, and the projector can be one from in the audiovisual department as long as it is a traditional slide projector or an LCD video projector. The screen, while exotic and relatively expensive, can be used to demonstrate both projection and blue screen methods, thereby doing double duty. The activity of setting up and shooting a front projection composite can be a fun group activity that is fairly instant and tangible. It can be a great introduction to planning, camera placement, lighting, and compositing before getting into more sophisticated software compositing.

## The Video Projector

For moving images we have the advantage of the modern video projector. A video projector has real-time contrast and color adjustment and is extremely quiet, unlike the older film projectors. Its one problematic issue is that of synchronization between projector and camera in order to avoid "roll bars" or flicker in the projected image. If you use an LCD (liquid crystal display) projector that has a long image lag time and you shoot with a digital camera with a wide shutter angle, the flicker can be eliminated. In practice, you would shoot the background plate as regular video and then take it through a compositing program to flop the plate so that when it is reflected off the beam splitter it will show up with the correct orientation. Those who don't have a compositing program could shoot the plate reflected off a front surface mirror to flop the image from the start.

## The Mad Doctor and the Miniature Woman

The film *Dr. Cyclops* (1940) is an excellent example of early rear projection effects executed by Farciot Edouart, who was considered a master of the technique in his generation. The film deals with a scientist who shrinks people to the size of dolls. The movie has a fun shot of a doctor reaching for a miniaturized woman. As an homage to Mr. Edouart, I will describe how to execute a similar shot using front projection with digital tools. To recreate this classic shot, the first step is to shoot a background plate. I used a Panasonic DVX 100 shooting at 30P in order to obtain clean, un-interlaced frames. I placed the camera dead on the floor, which put the lens right at the eyeline of the tiny girl. To make the lighting fairly simple I placed a soft key and soft fill opposite each other with a low lighting ratio. I used two identical

**Figure 12.11:** *Shooting the background plate at level camera down on the floor.*

soft lights and lit one bulb in one fixture and two bulbs in the other fixture, giving me an easy 2 : 1 ratio.

After the background was shot, I loaded the file into Fusion software and flopped the image. This file was then recorded onto another mini DV tape. I then rented an EIKI Diamond LCD projector LC-SDIO from a local disco supply house. The image is created by liquid crystals changing their orientation all at once in front of a projector lamp. The liquid crystal imager has a long image lag time, which allows rephotography of the image without flicker. The inexpensive digital light processing (DLP) projectors are problematic because the mirror chip that produces the image refreshes rapidly and is colorless. In order to introduce color, a spinning color wheel moves in front of the chip that will display the red, green, and blue colors in succession. While this works for the eye, it introduces flickering when rephotographed with a camera, so an LCD projector that has a lingering image should always be used. To check whether the projector will introduce flicker, rephotograph a projected image. If a flicker is detected, it can sometimes be eliminated by shooting with a wider or (slower) shutter setting.

The LCD projector was positioned to point at a semitransparent mirror that had approximately 60 percent transmission and 40 percent reflectance. These mirrors can be obtained from www.edmundoptics.com (they are referred to by this company as plate beam splitters) or www.two-waymirrors.com, or a true front projection mirror device, available from www.virtualbackgrounds.net, can be used. On the other side of the mirror (after the projection has passed through) I placed a black flag for absorbing the excess light so that it would not bounce back and once again reflect off the mirror and into the lens. For the camera I used a relatively inexpensive Sony TRV consumer camera. I positioned it to shoot through the mirror and aligned it to

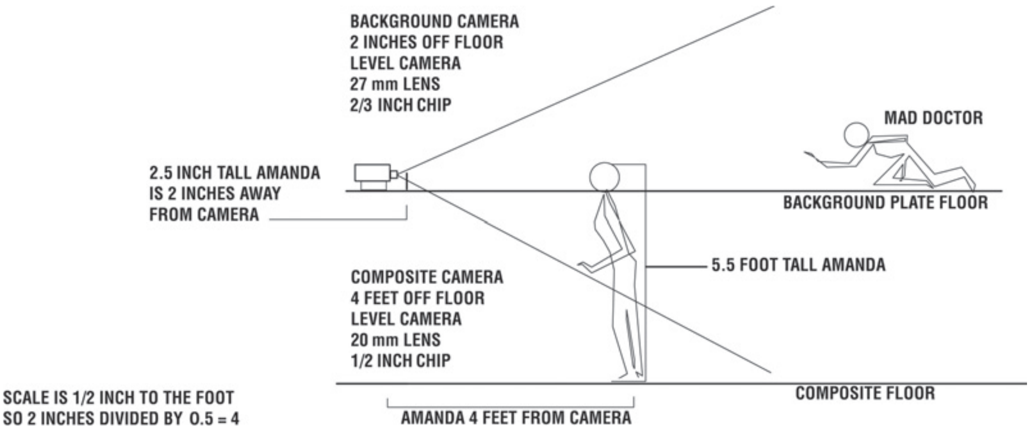


**Figure 12.12:** *Finding camera position by using scale calculations. If you block off the bottom half of the diagram below the background plate floor, you will see where the camera was placed to shoot the background. For the projection composite camera position use the composite floor as a reference, and you can see how everything is scaled up along the vertical lens angle.*

coincide with the lens of the projector. Beyond this arrangement was a Scotchlite screen. Since the background was shot using a level camera, the composite camera was set level as well. As far as matching lenses, I took some liberties and positioned the actress and focal length until the image looked correct to my eye. To do the shot by the book, I would have measured from the floor to the center of the lens in the background camera, arriving at 2 inches. If I had assumed that the actress, Amanda, was 2 inches tall and I made the scale 1/3 inch to the foot, then I would have placed the composite camera 6 feet above the floor when I shot the projection. The screen would be positioned so as to fill the camera with the background image.

As far as the lens goes, I may find that the background camera has a different size chip than the composite camera, so to match the lenses I need to consult a lens lookup table. If the background camera has a 2/3 inch capture chip and I shot with a 27 mm focal length lens, I would have a 35 degree horizontal angle of view for a 1.33 presentation. If the composite camera I use has a 0.5 inch chip, I go to the lookup table and find that for a 0.5 inch chip to give a 35 degree horizontal angle of view I will need to use a 20 mm lens. (Refer to the lens angle table found in Chapter 9.) Since the composite camera in this demonstration did not have convenient focal length markings, I positioned the lens by eye. I mention the different size capture chip for those who might face a situation in which the background camera and the composite camera have different-size chips and yet have the ability to adjust to an exact focal length.

One method of aligning the projector and camera lenses is to place a scrap piece of Scotchlite on a flat surface positioned in front of the Scotchlite screen in the subject

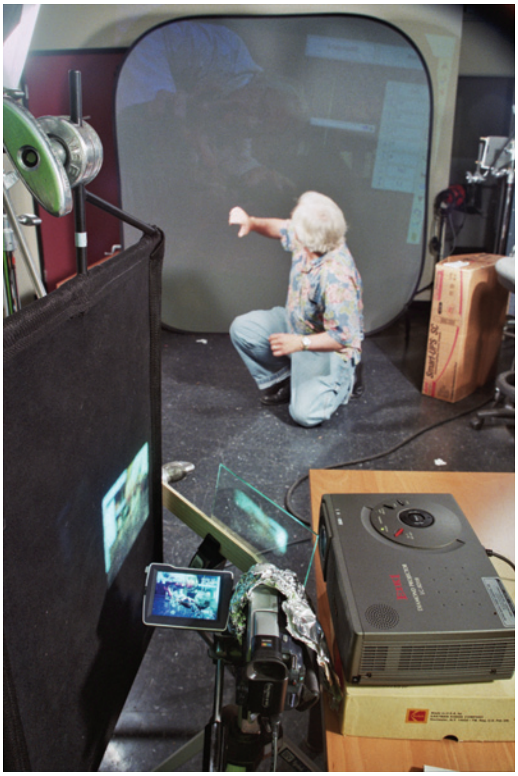

**Figure 12.13:** *Front projection using an LCD video projector. The aluminum foil over the top of the Sony TRV camera was used to deflect heat blowing out of the LCD projector from the front. This is a good example of dealing with unexpected situations on set at the last minute.*

area. If a shadow line is seen around this foreground screen, the camera will have to be moved in order to align it to the projector lens and eliminate the shadow. If there is a dark line on one side of the small screen, then the camera will have to be moved ever so slightly until the shadow shrinks and disappears. The same is done for the top and bottom of the small screen (see Figure 12.8).

Once the alignment is accomplished, next is the challenge of matching the color of the projected image to that of the foreground. In this case, the foreground was lit with tungsten light and the Sony camera was set to "indoors" or tungsten color temperature so that the subject will be shot with the correct color. The background tape was put in a player and a good quality video signal, such as S video, was sent out. The image that comes out of the projector will probably be very blue, because the projector is balanced to the bluer daylight color temperature. My procedure for dealing with this problem was to have an actor stand in front of the screen for a skin tone reference. I then paused a frame of the background that had a matching skin tone and called up the menu of the projector. It is helpful to remove the black flag

**Figure 12.14:** *Front projection composite shot with the Sony camera. The advantage to projecting moving video is that the actors can react directly to the image. The drawback is that the background will be second-generation quality. The quality can be improved if a high-definition background is projected and the front projection composite is executed using a standard definition camera.*

so that the menu can project through the mirror on a white surface so that the display can be read. I went to the color temperature settings and adjusted the red, green, and blue settings until the skin tone seemed to match the foreground. I did this by increasing the red and decreasing the blue, until the settings were red 51, green 32, and blue 7. These numbers, of course, are a rough guide; you would come up with unique numbers for your particular equipment and situation. At this point, the lights on the foreground were adjusted to match the lighting on the background plate. I looked for the highlights and the shadows and adjusted the key first and then added fill to match the contrast of the background.

The next step was to fine-tune the brightness and contrast of the projection until the tones in the foreground and the background matched. For this shot I increased the contrast to its maximum of 63 and set the brightness to 31. The trick is to first match the blacks using contrast and then raise the brightness for a pleasing overall reproduction. The idea of increasing contrast seems contrary to what I've said before about film prints, but in the case of video projection the image often starts out being low contrast so the challenge is a little less daunting. Once the background is dialed in I merely put the heroine in front of the screen and shoot the composite with her reacting to the mad doctor. The performer will be able to see a very dim image of the background behind her, but it will be enough for her to give good reactions. This shot can be cut into your movie with no further image processing.

For further reading on front projection composites, I highly recommend *Visual Effects for Film and Television* by Mitch Mitchell and *Visual Effects Cinematography* by Zoran Perisic, both published by Focal Press.

## Front Projected Color

Obtaining a pure, even screen for color matting can be a challenge. Colored light can be projected onto a front projection screen using a pure blue or green filter, resulting in a perfectly even color without danger of spill due to the retroreflective nature of the screen. Since colored light is being projected, the projector and camera can be mounted together and the camera can be moved at will at a variety of angles in front of the screen for a pure color surround. If the subject comes in wearing the same color as the blue screen (such as a blue tie) and time is of the essence, the projection color filter can be changed from blue to green in seconds. If it is decided to move the camera, there will be a slight increase in brightness nearer the screen, but it is usually within the tolerance of the compositing system. Unlike a raw light source, the retroreflected light does not follow the rule of the inverse square law. The inverse square law states that if a light source distance is doubled, the observed intensity decreases to one-quarter of its original value. So if an incident reading of 400 footcandles is obtained from a light 10 feet away and then the light is moved 20 feet away, the incident reading will drop to 100 footcandles. Front projected light, being retroreflective, does not vary its intensity to this extreme. There are systems, such as Reflecmedia, located at www.bogenimaging.com, that use a ring of color LEDs (light-emitting diodes) that circle the lens that are used for front projected color. The light ring can be dialed up and down in intensity and creates a very bright, even screen.

One drawback to this system is that because the light comes from the perimeter of the lens instead of right down the center as with beam splitter systems, there is

**Figure 12.15:** *The LED light ring manufactured by Reflecmedia.*

**Figure 12.16:** *A blue screen using the Reflecmedia product.*

**Figure 12.17:** *Closeup of the blue backing using the ring of LEDs. Note the shadow fringe around the subject. In the majority of cases this is a marginal issue.*

**Figure 12.18:** *Mad doctor composite using front projected blue process in conjunction with the Ultimatte DV. There is no issue with degradation of the background, as both the background and the foreground are the same generation.*

**Figure 12.19:** *The Scene Machine, manufactured by www.virtualbackgrounds.net.*

shadowing around the subject that must be taken out in the subsequent compositing. The Reflecmedia product is often sold in conjunction with the Ultimatte DV hardware compositor mentioned earlier. If shadowing is present, it can be "crushed out" using the Ultimatte but at the expense of edge detail. Another solution is to use a product made for color screen front projection, such as the Spectravue Model 100, manufactured by Virtual Backgrounds. This unit can be attached to the camera and comes with a semitransparent mirror and projector for colored light or slides. Because the lenses are optically aligned through the use of a mirror there is no shadow fall off. The other benefit of the projector unit is that it can also project slides to execute conventional front projection shots with still images. The Reflecmedia product is less expensive on the front end but will require the matte pull to be amped up to eliminate the shadow fall off and possibly some fine detail with it. The Spectravue system is more expensive at the outset but will have no shadow issue and slides can be used as well. I find that the front projection technique can be a viable production solution in some circumstances and is a fun and accessible teaching tool for visual effect fundamentals.

# Chapter 13

## You Can't Always Get What You Want

While it is great to be able to shoot things properly, there are many occasions when you can't get what you want so have to make do. The key words here are adapt, improvise, and overcome.

### Old School Crowd Replication

It is rare to create armies of CGI people unless you have the enormous resources of a large digital effects studio. Normally, you find ways of making many actors out of a few. The traditional way to put crowds in a scene when you can only have your brother's family show up is to ask them to bring many changes of clothes and be ready to walk. The camera is locked down and five people are positioned on the right for a take. After this take, the same five people move to the left, put on different jackets or sweaters, and a second take is made. Next, the same five people change clothes again and move further to the left. This process is repeated several times until you have the correct number of people for a crowd. If you need 30 people, you shoot six takes of your five people in different positions and then composite them all together. This technique is great in that the perspective always matches, as does the lighting. If you are shooting outdoors, you will want to be speedy with this process, as a moving sun can create lighting mismatch if you wait too long between takes. If movement is needed, a motion control camera can be used or the move can be made in post over the locked-down shot.

Another method of creating a crowd of people uses temporal displacement. In this method, a locked-down shot is made of a moving figure. By using traveling mattes over the same subject at different frames, you can create a parade like with


**Figure 13.1:** *A handful of friends can be turned into an army.*

the bicyclist in Figure 13.1. This method is particularly effective for large groupings of vehicles, such as an army moving down the road.

## Ghoul Replication When I Couldn't Shoot Properly

I did a shot for a horror film that required many ghouls to come crawling through a previously photographed tunnel toward the camera. The tunnel was very long,

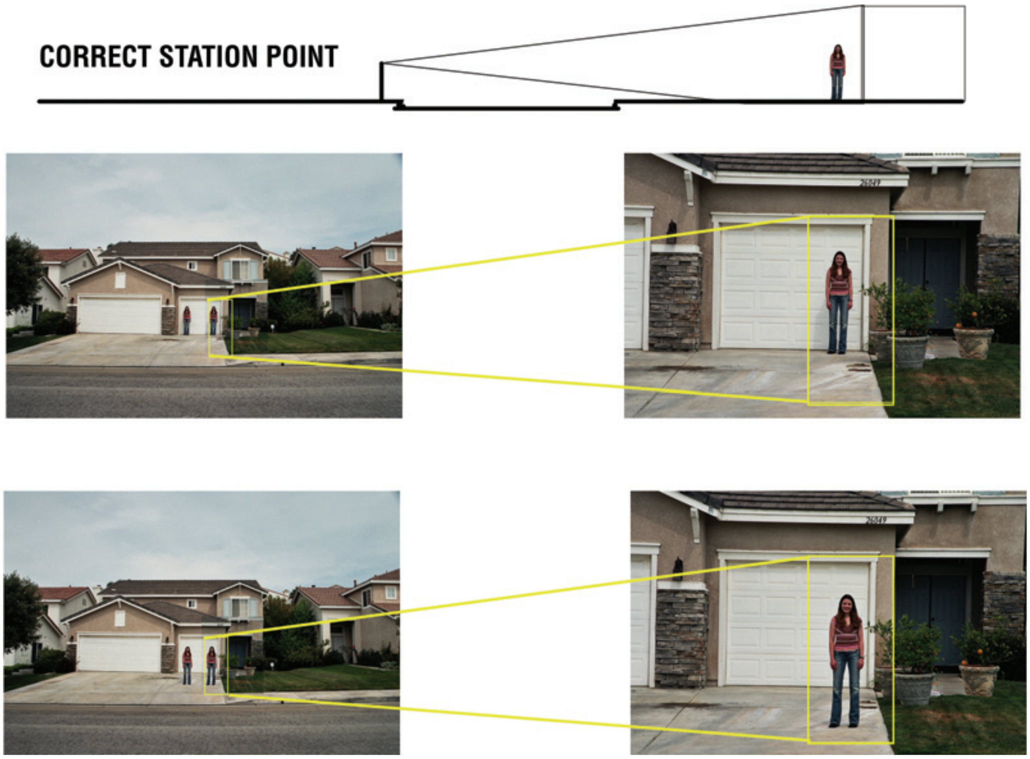


**Figure 13.2:** *If the station point is kept the same for all elements then all lens focal lengths will be able to nest inside each other.*

extending perhaps 40 feet. My original idea was to place the camera at the proper station point and shoot the ghouls crawling along a dressed parking lot that would replace the floor of the plate. As it turned out, the floor in the plate had to be used, which meant that the figures had to be placed on a green screen set and composited. Not only was green screen to be used, but also the stage space available was only 25 feet, which meant that the camera station point was a great deal closer than it should have been.

The reason station point is so important is shown by the following examples. Figure 13.2 shows a picture of a house with a figure in front of the garage door walking forward on the left. These two shots on the left were shot with a wide-angle lens from across the street, as illustrated in the diagram at the top. The pictures on the right were shot using the same station point (camera position) but using a longer focal length lens (to get a closer shot). When the full-frame figure was reduced and matted into the master shot on the left, the figure increased in size by the same amount as the figure photographed with the wide lens. When the station point is the same, the elements will fit together regardless of focal length.

This technique of maintaining the station point and shooting the live action element so it fills the frame was used for rear projection composites (such as the matte painting example in Chapter 8) to preserve quality. In this case, the house might be a matte painting and the figure and the garage door would be rear-projected onto a screen behind the painting. This would allow you to move in on this composite and not lose quality in the rear projection because you would have to fill the frame with it before you rephotographed it in a one-to-one relationship. The important thing is that by preserving the station point you matched the perspective.

Let's see what happens to the shot in Figure 13.2 when station point is ignored. In Figure 13.3 I moved the station point to the other side of the street at the foot of the driveway and shot with a wider lens for the pictures at the right, as shown in the diagram at the top. As the actress walked forward, she increased in size tremendously over the same distance and appeared to grow enormously when composited with the shot at the left. Compared to the actress shot at the original station point, the composited actress looked like a giant even though she walked forward the same

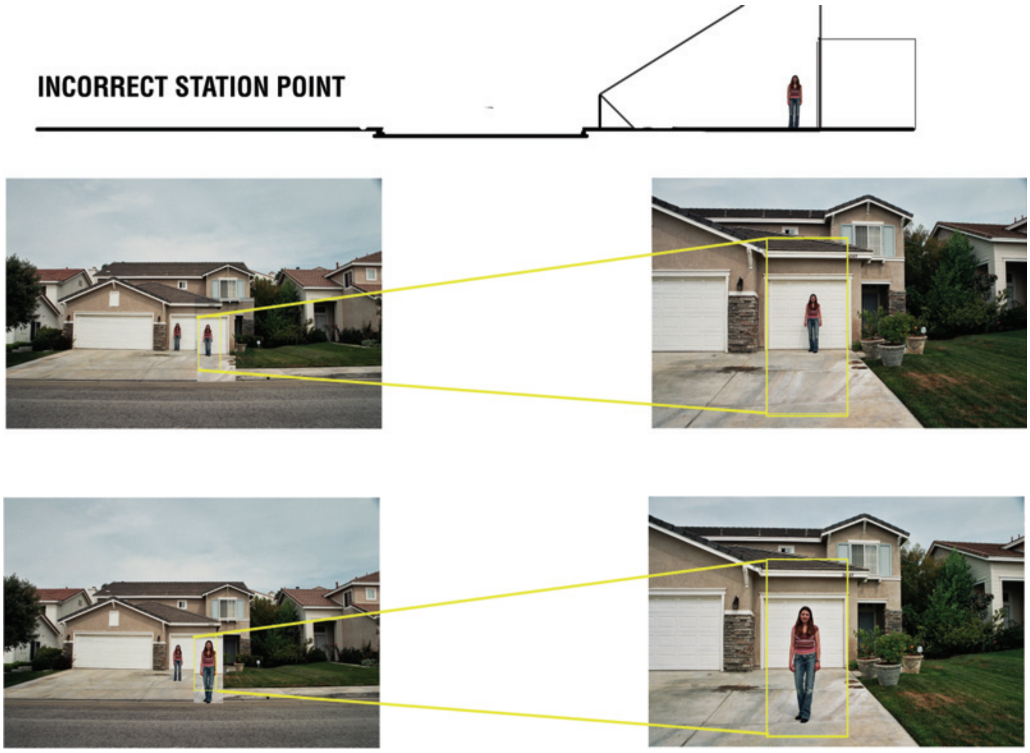


**Figure 13.3:** *If elements are shot using different station points and lenses, the growth rate of a figure coming toward or away from the camera will not match. In the bottom picture we can composite the garage door on the right over the shot on the left by reducing the image, but we cannot keep Amanda from growing abnormally large as she walks forward.*

# OVERIDING PERSPECTIVE SIZE CHANGE BY REDUCING ELEMENT

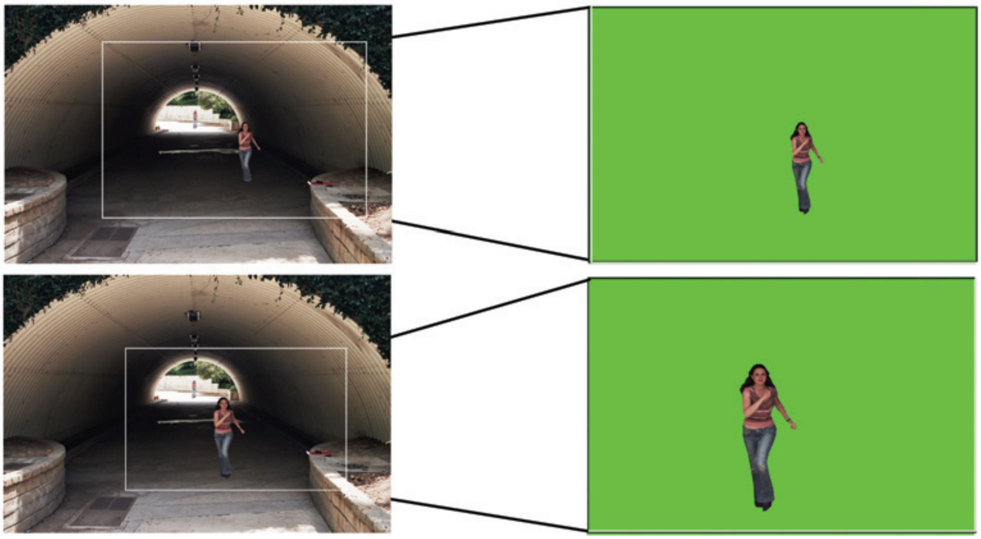

**Figure 13.4:** *When you are stuck with a green screen element shot from a station point that is too close, you can retard the growth of the figure by reducing the plate frame by frame as the action progresses. Note the size of the white box (the green screen frame) on the image of the tunnel at the top compared to the size of the box on the lower image.*

distance in both shots. You can "nest" a longer focal length within a wider focal length only when the station point is identical. When the camera was moved to the end of the driveway, the perspective change on the subject became much more pronounced than the point of view using the station point across the street. In the past, the only fix for this mistake in a matte painting composite would have been to reshoot or to paint the painting as if it were shot from the closer station point with an extremely wide or fish-eye lens. Not the greatest solution. If the figure stays fairly stationary and doesn't move forward or back you can get away with it, but it is not recommended.

In the case of the ghouls and the small green screen stage, I knew that the station point would be correct for figures in the foreground near the camera. They would grow at the correct rate from 15 feet forward, but I had to shrink them down to look like they were 30 feet back. If the figures were reduced and placed in the composite to look like they were 30 feet back, as they came forward they would enlarge in size too fast and appear false. Fortunately, since the figures were green screen elements I could override the size change by reducing their size frame by frame to retard their enlargement and make them appear to grow at the slower rate of figures 30 feet back. For the final shoot I photographed several takes of ghouls crawling, limping,

**Figure 13.5:** *By changing the brightness and contrast of each green screen Amanda element, you can make it appear like she is coming out of the shadow into the light. The settings of brightness and contrast are animated as the character moves closer to us. The fourth figure back is in silhouette because the brightness and contrast were both reduced to yield a shadow. Since the green elements were shot with overall shadowless fill light, synthetic shadows were added with animated artwork underneath the figures.*

and walking toward the camera. These separate elements were then positioned and animated to have them nest within the background in a natural manner.

## Shoot It Now, Light It Later

This request always has me rolling my eyes. There is NO WAY to light something later and have it match real lighting. The best you can do is a cheap approximation that you can sort of get away with for short shots. The best-case scenario is to get the light direction correct on the shoot but not the light ratio. In that case, the shadows all fall accurately and the contrast of the element can be adjusted to match the look of the background plate. A less desirable scenario is to light the figure absolutely flat and use mattes to simulate a key light. This can be a solution for far distant figures, but closeups are out of the question.

Figure 13.6 shows the matte logic behind creating a false key light. The hanging girl is flatly lit and a hold-out and burn-in matte is pulled off the element. If these mattes are offset from each other they can create a partial organic "window" to selectively color a portion of the figure. In the case of the hanging girl, a key light can be falsified by brightening up one side of the actress. In the closeup in Figure 13.7 a similar scheme was used to take a flat-lit shot and tone down a portion of the figure using a hand drawn matte to create a shadow. This method can work marginally well for a still, but a figure in motion would require an enormous amount of complex matte animation that would need to track with the figure.

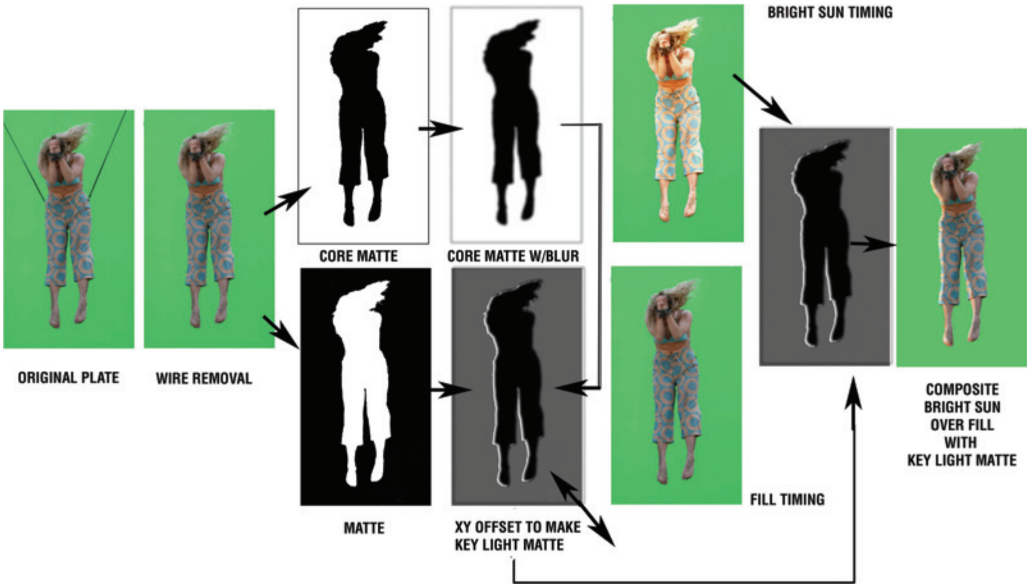


**Figure 13.6:** *A crude way to simulate a key light using mattes. The idea is to offset two mattes to create an organic window in the figure and then blend a high-contrast bright correction over a normal one. It can be marginally successful on rare occasions for distant figures.*

The worst-case scenario is to light something incorrectly (the key light coming from the wrong direction) and expect to be able to change it later. If you are lucky and the key light is roughly on the opposite side, the easy fix would be to flop the shot. If the key is from the top and you need it on the side, the fix will involve a very labor-intensive operation of subduing the key to make the shot flat and generating the synthetic methods mentioned to move the key. No matter how much money and time you throw at this fix, it will ultimately be unsatisfactory.

Last, if you do shoot an element, be sure that you at least shoot something. If you anticipate that a green screen subject will only be needed for a silhouette, the one thing you absolutely don't want to do is shoot an unlit figure. I was once on a shoot where the director wanted the subject to be just a black shadow in front of the green screen. Being accommodating, I shot the actor without any light on him at all. Well, when I got back to the effects studio I caught holy hell because I had boxed everyone into a corner. There was absolutely no information containing detail of the actor on the negative, so we were stuck with the silhouette idea. If I had shot with an overall flat fill then the effects studio would have had options. You can always obtain a silhouette by just using the matte, but you can't create detail where there is none.


**Figure 13.7:** *The middle picture shows a false hand drawn shadow laid on top of the flatlit picture on the left. This might work for a few frames, but the result is a far cry from the beautifully complex shadows that you get with real lighting, as seen in the picture on the right. Note that the middle picture does not have a nose shadow. You could create one, but this becomes yet another element to deal with.*

## Walking on Green Screens

In a common "Damn the torpedoes; we'll sort it out later" situation, an actor is placed in full green screen rooms with the floor and walls painted green. The big problem with this setup is that all the rules for good green screen, namely, an even screen and the reduction of spill, are broken. Well, there will be spill all over since the screen is right on top of the actor, and it will be darn near impossible to get a perfectly even screen since lighting the actor artistically will result in shadows and uneven lighting on the screen. For example, for a backlit figure on a green screen floor, the floor will be brighter than the wall due to the white glare bouncing off the floor.

This phenomenon also happens with the traditional coved stage, in which the floor slopes up gently to combine with the wall. The cove idea has been used for years, but the ugly fact is that this always results in a light change. A better solution is to have the subject on a flat stage that the camera shoots past to blend in with a flat wall. There is usually a better chance of getting this to be successful, since bounce only comes from the floor and you have a fighting chance of getting the wall screen further back to avoid spill. In the case of backlight glancing off the floor, I would use a polarizing gel over the lamp illuminating the stage that filters the light rays so that they vibrate in one direction. When this polarized light hits the floor, some of it will be diffused, illuminating the green, and the portion that reflects (causing the white glare) will continue to be polarized, enabling a counterpolarizer on the camera lens to cancel out the white reflected glare while allowing

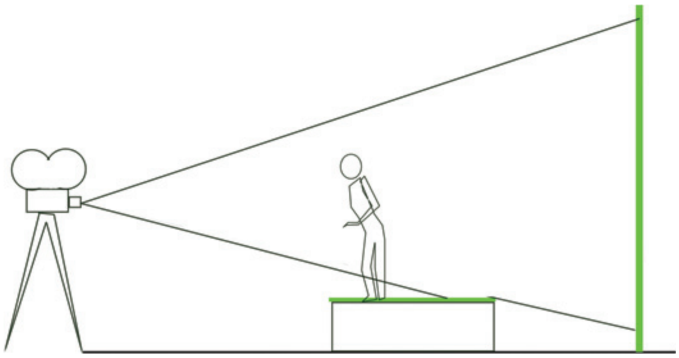

**Figure 13.8:** *A more successful method of blending a green floor with a green backdrop is to use an elevated stage.*

the green to show through. This solution is a good one, but it does eat up a great deal of light, somewhere in the order of one and a half stops for both light and lens.

Even with all this there can still be an uneven green screen situation. The best way to handle this is to shoot a clean plate, that is, the screen by itself with no actors. When the clean plate is used in conjunction with the live action element and put into Ultimatte software using the screen correction function, the computer can calculate what is green screen and what isn't. It can then raise or lower the value of the green screen pixels to be completely uniform. If a clean plate was not shot, there are methods for the compositors to manufacture one by picking frames that reveal different portions of the screen uncovered by an actor's movements. This method only works for static shots or those shot with motion control. Another labor intensive way to create a clean plate is to do roto screen correction, in which a fast and loose roto matte is used around the actors to tell the computer where the subject is in order to "clean up" the green screen. In the rush of production, the easiest way of obtaining a clean plate is to merely have the actor clear the frame before you cut. If you shoot a clean plate, a compositor might take you to lunch. Unfortunately, what happens more often than not is that there is no clean plate, and spill and glare issues are so bad that the compositor just cranks up the matte pull contrast and blasts everything away, including any fine detail in hair and edges. After this butchery, the matte is used to create a synthetic shadow and the edges of the main matte are made uniformly soft so it is less of a poke in the eye. As Kermit the Frog says, "It ain't easy being green."

## The Mirror Method

In cases where the reflection of a figure is needed, a great way to capture this and avoid spill is to have the actor walk on a stage floor made of reflective Mylar. The

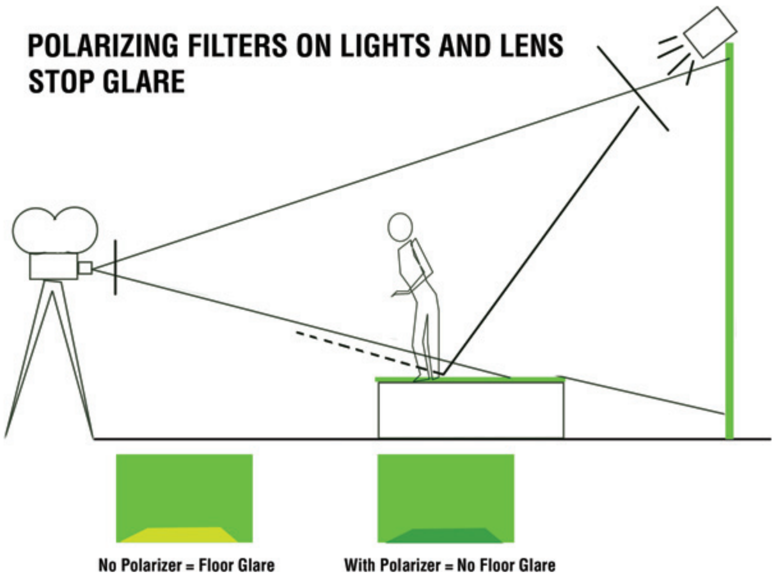


**Figure 13.9:** *A polarizing filter used on both the light and the lens can eliminate glare and make the green floor blend better with the backing. A great deal of light is lost, however. The best method is to shoot a clean plate.*

**Figure 13.10:** *An example of using Mylar to obtain a reflection of the subject while still surrounding the figure with blue or green. This is also an illustration of purifying the background color by lighting with colored gels. As you have probably guessed, this is a rock video set up in the kitchen of my tiny apartment. This is from the 1980s video "Stop: Wake Up."*

Mylar will reflect the background screen along the angle of incidence and won't add much spill light to the figure. A synthetic shadow will still need to be pulled, but you will have a much cleaner green screen. If a reflection is needed off a painted or fabric floor, all the compositor needs to do is flip the green screen element upside down and have it meet at the shoe line. This flipped element is made transparent by

**Figure 13.11:** *An example of flipping the element to serve as a reflection through double exposure. This was the shot produced from the setup seen in Figure 11.11. The blue screen element of the girl was used to place her in the scene and was flipped upside down to superimpose her image onto the floor. The water crashed through the window, making our "rock doll" ecstatic. Courtesy of Bob Benderson, CMI Productions. Effects supervisor was Sean Phillips.*

double exposure over the background plate. In digital, this would be accomplished using a screen function.

## Shooting Chrome on Green Screen

This is usually a horrible situation if you don't have the proper tools. A chrome ball placed up against the screen will reflect all the green to the point where the ball will disappear. To solve this problem, John Erland and effects supervisor John Sullivan of Apogee invented the reverse front projection method, which works exceptionally well for miniature subjects. Needed for this method are a Scotchlite screen, a projector emanating blue or green light, and a large pane of glass. As shown in the example in Figure 13.12, I set up the Scotchlite screen so that it is on the left hand side of the camera. I placed the projector to the right of the camera so that its light projects through a sheet of glass positioned to reflect the retroreflected light from the screen toward the camera. I used a slide projector and a Kodak Wratten 47B blue filter to obtain a perfect wavelength. Note that the 47B is a gel filter and will overheat and melt very quickly, so try to obtain a heat-resistant equivalent; otherwise, use the projector light sparingly. The shiny subject was placed between the glass and the camera. The lens of the projector and camera were aligned so that the light coming from the projector lens passed through the glass to the screen, where it was

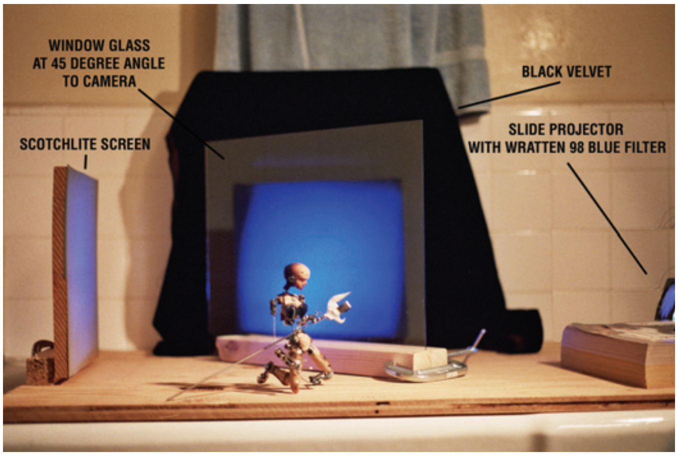


**Figure 13.12:** *The reverse front projection process. The blue light shines through the glass, bounces off the Scotchlite screen, and reflects off the glass, which is at a 45 degree angle, directly into the lens of the camera. The light rays zip past the chrome instead of reflecting off it.*

**Figure 13.13:** *A top view showing the reverse front projection setup. Note the use of black velvet behind the glass to prevent the camera from seeing anything but the reflected blue light.*

retroreflected back to the glass, where it was then reflected to go around the subject and into the lens of the camera. Because these light rays are unidirectional, this eliminates the possibility of spill. As shown in Figure 13.14, the chrome can opener "spear" is absolutely devoid of spill, allowing the proper photography of the shiny robot figure.

## Live Figures in CGI Backgrounds, aka Paper Dolls

The best way for green screen actors to match the background when you are limited by space and time considerations and the background will be computer generated is

**Figure 13.14:** *The reverse front projection technique allows mirror-like subjects to be photographed in front of a blue or green screen with no spill or reflection issues. I used this technique to composite shiny BioMechadroid robot puppets into the Judas Priest videos "Locked In" and "Turbo Lover." Both videos were produced by The Company and directed by Wayne Isham.*

to match the background to the green or blue screen elements. The comedy film *Rescue Rocket X-5*, directed by effects supervisor Kevin Kutchaver, utilized this method to great effect. If the blue screen actor is lit in a satisfying manner, there is no need to shoot a live action background to match. The full CGI background can be lit to match the blue screen element lighting with more ease and flexibility than trying to match two live action plates. Perspective correction can also be done, along with the benefit of having the CGI set lighting cast shadows of the green screen element onto the set in a realistic manner.

The best way to think of this is to imagine the green screen person being placed into the three-dimensional CGI set as if the person were a paper doll that faces the camera. A CGI light is created to just cast a shadow and not add light to the doll (the doll is self-illuminating). This shadow light is moved to a position where it strikes the paper doll and casts its shadow onto the set, where it can crawl up dimensional architecture just like a real shadow would. This technique is most effective when the lighting has a dramatic effect. If the actors are lit flat because of lack of vision or planning, then the background CGI set will have to be lit flat as well to match. As in the flatly lit tower example in Chapter 10, this usually results in an awful-looking image. When using this technique it is a good idea to generate some stills of the base set with some lighting "roughed in." You can then get an idea of

**Figure 13.15:** *Two blue screen elements overlapped. In this case the set was so small that the actors were shot separately on different takes and moved further apart to increase the apparent size of the room. Courtesy of sheerforceofwill.com.*

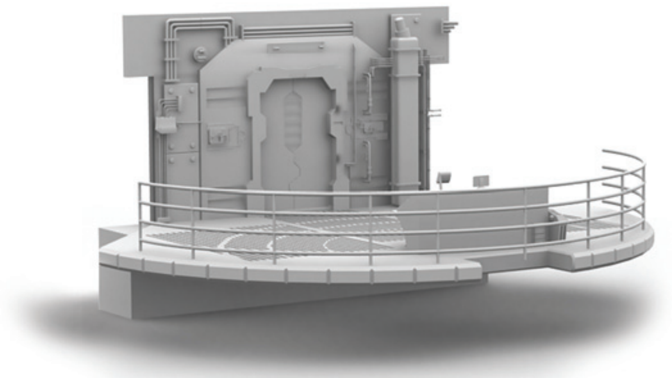

**Figure 13.16:** *The basic computer graphics set without texture maps or lighting. Courtesy of sheerforceofwill.com*

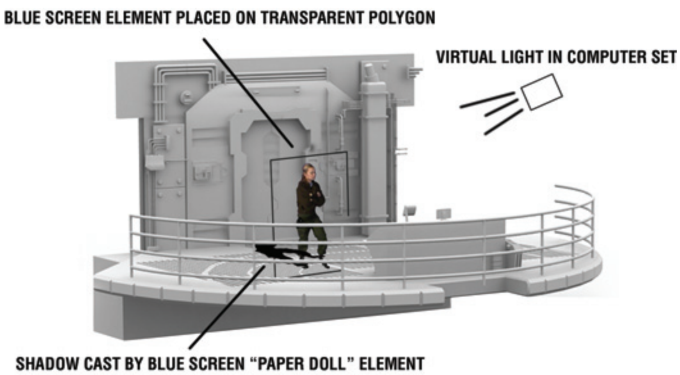


**Figure 13.17:** *The blue screen figures are mapped onto polygons and placed into the CGI set. The computer can cast the shadows of their cutouts onto the virtual set just as if they were paper dolls. This is similar to attaching clay figures to a Plexiglas sheet, as discussed in Chapter 3, without the nuisance of hiding reflections and the other myriad problems of the real world. Courtesy of sheerforceofwill.com*

**Figure 13.18:** *The completed composite, integrating the performers into a fantastic spaceship setting. This method eliminates the need to photograph a real background with identical setup and lighting but still requires a great deal of planning to light the figures artistically for dramatic effect. If you shot all the blue screen setups with flat light, for example, you would lock yourself in to lighting the CGI set with flat light as well if the composite is to blend. Courtesy of sheerforceofwill.com.*

the general lighting direction for the actors and later fine-tune the set lighting to blend perfectly.

The only thing that would make this technique even more controllable is having a full CGI actor, so that the light would hit and react to both set and actor in exactly the same way—just like we used to do with real actors and sets. Hmmmmmm.

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# Chapter 14

## Welcome to the Circus

### Personalities and the Work Environment

During my matte photography days, I had the advantage of observing set etiquette and hierarchy from a safe observation point. When I shot matte painting plates, the members of our effects crew were the "guests" of the production. We brought our own exotic camera, such as VistaVision and were set apart from the main production unit. By the time the director and actor were ready for us we were ready for them, and their main concern was the performance of the actors. There was no discussion of camera placement because it had been worked out ahead of time, and since it was such an exotic setup no one dared offer up alternatives out of fear of making a mistake.

This system worked well for the effects specialist who traditionally worked at a very measured pace back in the controlled environment of the effects studio. It was a comfortable way for cautious and meticulous effects professionals to join a fast-paced production. Today, with regular production cameras being used for creating plates, the comfort of this isolation is gone. When the effects person is invited to the set, he or she has to learn to play ball rather quickly. In movie production, the main driving force is speed. The production needs to get as many setups in the can as possible, and tempers quickly flare if there is a hold up. What follows are a few things I've learned over the years that have helped me when I've suddenly found myself in a fast-moving production with a bunch of strangers.

## Get to Know Your Host

There have been many times when I've been sent out to a set to consult with only a day's notice. In such a situation, the first thing I find out is the nature of the shot (for example, TV screen inserts) and the names of the principals I have to deal with, that is, the director and the cinematographer. Thanks to the Internet, I can look these people up and see their credit list. More often than not, I will have seen some of the films they have worked on and will make note of a particular shot or scene that was memorable to me. This gives me a great icebreaker to start a conversation. On many sets an effects person is thought of as an intruder who is going to tell everybody what to do and spoil the party. The director may look at him or her suspiciously, thinking that he or she is a spy for the producer. An unseasoned cinematographer may fear that his or her capabilities may be questioned by this technologically savvy stranger and embarrass him or her in front of the crew. This sounds a bit far-fetched, but a lot of money is spent on these sets and in many cases there is an underlying current of fear. As an effects person, you have to quickly establish that you are a buddy who is there to make everyone look good. The fastest way I've found to get to that point is to be a fan of the work the director and cinematographer have done. This has to come from a point of genuine admiration for, or at least curiosity about, their prior work. People very quickly sense when you're "faking it" and that can really get them to hate you. Even if I don't like anything the principals have done, I can always find some shot that I have questions about. I learn something, and they feel good that someone was curious about their work.

## Remember Names

Everyone likes you to remember his or her name. On a set, as at a party, it is often difficult to remember many names. However, it is helpful to try to remember the names of the people on the set whom you will be interacting with. Even the lowly PA is deserving of acknowledgment by name. We all started somewhere, and we all hate to be treated as insignificant peons. Memory tricks can be used to help with this task. If I meet someone named Frank, I say hello and immediately start repeating that name in my head as I scan his face, looking for a non sequitur association that will nail that name in my head. If Frank has a crew cut that gives him a squarish top to his hair, it might make me think of Frankenstein and that helps me nail down the name. If I meet Mary and notice that she happens to have arched eyebrows that, when run together, form an M, then I have a reminder for that name. These techniques take practice and a bit of concentration but can be very helpful. Another technique that I've seen a cinematographer use when he dealt with many people and had a lot of other things on his mind was to call everyone by the same nickname, often something very engaging, like "sexy."

## Don't Think Out Loud

I have found thinking out loud to be the hardest habit for me to overcome. On a set people want very fast responses of yes, no, or "go there, do that." They don't want to hear anybody "thinking about it." In the effects studio, away from the fast-paced set, the effects pro can ponder the shot and slowly tinker with it, as in a stop motion setup. There is usually no one else in the room and there is enough time to try this and try that until something comes together. If on the set a production person asks you where to place the camera, he or she absolutely doesn't want to hear "Well, if we place the camera down below, there is a slight chance that the actor will go in front of the sky we want to replace, which will require extensive rotoscoping, which could be expensive but, on the other hand, if you placed the camera too high, we might avoid that problem but need to bring in a blue screen to mask out the area where we're going to put the CGI building." You can easily see why that production person would look at you like you were crazy. When effects people speak like this, they sound indecisive and technical and it seems like the production is about to spiral out of control. To be in control, you have to be prepared to silently take all the technical details into consideration and quickly commit to something. So when asked where to place the camera, one correct response is "In my opinion, I think you'll get the best bang for your buck down here."

Please note that you are being asked for your opinions and not your dictates. The director and cinematographer are running the show, and you are there to help them. You want to throw out a suggestion and have them bandy it about. If they are agreeable, then go with your first inclination and don't change your mind. You might wince as you commit because something might occur to you that you didn't originally consider, but it is better to get part of what you need than have no input at all. If you develop a good relationship with the principals, then you will have more give and take and can blind them with science if they suggest doing something that will be an inordinate amount of work for the budget.

You definitely want to empower the director and not challenge him or her. A surefire way to create problems is to say something like, "You have to lock off the camera for this shot." The response is usually, "Oh yeah? Well, I'm not going to lock off anything and in fact I'm going to get my steadicam and move all over the place. What do you think of that?" The situation becomes more about a power play than getting the best result and thus is to be avoided whenever possible. Avoid phrases like "you must" or "you have to"—people hate that, especially if they've worked all their life to be in charge. I find the trick is to always be positive but realistic, and, as always, keep in mind that money talks. The response to the director's desire to use a steadicam might be more effective if you said, "Wow! That is a really cool idea. I can see where that would make a great shot. . . . Oooooh, it'll be very expensive though, but it could rock!" It is best to say this type of phrase—that is, mention the expense—within earshot of the producer, who is likely to step in and say, "Forget about it."

The important point to remember is that the producer, director, and cinematographer are your clients, and they run the show. Let them do what they do. Don't talk to the actors directly if doing a green screen shot; that's the director's job. Don't talk to the camera operator directly; that's the cinematographer's job. Remember that you want to be a pal and help the filmmakers realize their vision.

## Help the Indecisive

There are certain personality types that have trouble making decisions, or "they'll know it when they see it." They can't quite communicate what they want. Your job is to help them find their vision with a confident statement of opinion. The director might say, "I don't know if it should be red or blue." A good response to get things moving might be, "Blue, definitely blue. In my experience I've run across this situation a hundred times, and blue has always worked." The director usually responds to this in one of two ways. He or she will either be truly nervous about the decision and defer to "what has always worked," or will want to be different, a renegade, and will defiantly pick red. Either way is good, because you've gotten the director to make a decision, which is much better than floundering.

## The Genius by Committee

I once worked at a commercial production house where the owner, at great expense, hired a production designer to look over a television commercial we were struggling with and give suggestions. The fellow was very pleasant and ingratiating and had a marvelous disarming manner about him. A most interesting meeting with him took place after we had all screened the commercial. The owner stated something like, "There's something about this that bugs me, I dunno, maybe it's the color." After hearing this, the expert spoke in a slow, pondering manner, saying, "Yes . . . color. It needs . . . it needs a bit more . . . [searching for the words] a bit more. . . ." At this point, someone at the meeting spoke up and finished the sentence for him: "Green?" The expert then smiled and pointed at him and said, "Yes, that's it, absolutely." The boss interjected with, "Yeah, okay, green, but is it a light green or a dark green? I mean. . . ." The expert spoke again. "Hmmm, yes . . . dark . . . green? Or it could be light, depending on the general [mumble mumble]. I think it would be best if it were . . . it were. . . ." Once again, a voice from the audience shouted, "Dark green!" The genius offered, "That's right! You are the clever one!" The meeting went on this way for over an hour. The expert made everyone feel good yet said absolutely nothing, and made a ton of money for it. It was like watching a politician at the top of his form—it was one of the most amazing things I've ever seen.

This scenario may seem absolutely ludicrous, but in this business it does happen. These experts serve a purpose, because in their own way they dislodge creative roadblocks. Shots that can't be finaled can be saved by this frivolity as well. Once Area 51 was working in tandem with another company, whose work the client was unhappy with even though we at Area 51 thought it was fine. The client pulled a shot from the

**Figure 14.1:** *The committee genius.*

other company and gave it to Area 51 to "fix." All we did was color correct it slightly bluer and send it back. To this the client replied, "There—we knew you could fix it!" It's unfair, it's stupid, but it happens. Sometimes the act of moving something from one place to another is enough to take the curse off.

## I'm Not Impressed

This heading describes a character trait I've noticed in some supervisors that is startlingly effective. The basic trick is to be totally unimpressed with everything, constantly. This drives artists nuts. The compositors will work late into the night to do anything to get a rise out of this type of supervisor. Everyone will be exhausted, the shot will finally be screened, and everyone will wait for some sign of approval. All that they'll get is, "Well, I guess that's promising. Give it more oomph." Then the supervisor leaves, everyone is miserable, and everyone wonders what the hell "oomph" means. I think this is part of the reason that reality TV shows of performers trying to impress bored critics are so successful. People will kill themselves to get any kind of approval or recognition. This methodology works to get quality output with many variations from a company, but it is a nasty, manipulative trick that can backfire when people decide that they don't care anymore and give up.

## The Tweakaholic

This individual is the most dangerous threat to the effects industry. The inability to say "It's done" has caused the demise of many effects companies working on "fixed bid" projects. In the past, movies were meant to be seen as temporal events during which images flashed by at 24 frames per second until the curtain closed. With the advent of DVDs and other digital presentation mediums that allow for freeze frames and back and forth analysis, we find ourselves polishing the effects to death. The

**Figure 14.2:** *Ho hum: is that it?*

movie may be horrible, but there won't be one speck of dust on any frame. It is foolish to shoot poor elements and then flounder around endlessly redoing an effect to try to correct what should have been shot properly to begin with. There is a level of acceptability that should be maintained, but in the digital age the goal of achieving absolute perfection for every pixel on the screen is ridiculous. Albert Whitlock referred to this attitude as "picking the fly excrement out of the pepper." It is not uncommon for a tweakaholic to take issue with elements in the frame he or she thinks were added by the effects facility when in fact they were part of the original photography. When people start picking apart the effects to this degree, you know there is something seriously wrong with their movie because they are expecting the effects to save the picture.

Addressing this issue is a problem for the producers, who need to be fiscally responsible and pull the plug when the shot is done or be willing to pay for cost overruns. In the early optical days, the budget for the shot included three takes. On the first two takes the optical house was still making money; by the third take they were breaking even. Today it is not uncommon to redo shots a dozen times. This endless polishing is part of the reason for the staggering cost of effects today. Studios blame the vendors for these high costs and decide to open their own effects facility, then are shocked when they lose money, so they close up shop and use vendors again, who come and go because they have a hard time staying in business. After a point people have to be practical about such things. If you install a faucet and it works and the plumbing doesn't leak, you don't worry about someone seeing an imperfect solder joint because very few people are going to climb under the sink and examine the pipe with a magnifying glass and flashlight. In my opinion, movies are fleeting emotions revealed by time. Movies are not still pictures. It is a film "business," after all.

**Figure 14.3:** *The tweakaholic.*

## Bend in the Wind of Vicious Aggression

It is an unfortunate fact that the film industry has a large population of dysfunctional personalities who have black tempers. If you choose to enter this field you will run into this type of person time and again, and it can be very hurtful and damaging to your self-esteem. In my career I have been viciously abused verbally on many occasions. When it is a client or a superior hurling the abuse you may not be in the position to tell them you don't want to work with them anymore. In that case it is best to maintain your composure and "suck it up." People who flare back with an equal rage are usually fired and have difficulty working again unless their strong will leads them to form their own company. You will be called every name in the book, you will be humiliated, and you will get your feelings hurt. As the song says, "The first cut is the deepest." As time goes by you will develop a thick skin and find ways of dealing with these personality types. As a wise effects supervisor once told me, "Whatever doesn't kill you will only make you stronger."

So, how do I deal with abusive people? Since I do not subscribe to screaming, I use an old acting trick: if they go high, you go low. If people scream at me at the top of their lungs, I act like a sieve and let their hot air blow through me. It sometimes helps to imagine that the screamer is a character in a movie and you are merely watching the show. Avoid taking things personally, as that will destroy you. In a low, calm voice, I acknowledge that I can understand why the screamer is upset and ask what it would take to resolve the situation. This does two things: first, it makes the screamer stand out like a sore thumb because he or she is the only one losing control, which is embarrassing. Second, it gives the screamer part of the responsibility for solving the problem by making him or her ponder what he or she wants to have happen. It is a nasty, uncomfortable, unpleasant situation, so you want to quickly move on to actions that resolve the conflict so that you are dealing with productivity rather than negativity.

**Figure 14.4:** *The maniac, whose main weapon of choice is the blamethrower.*

It also is helpful to be empathetic and look upon the person as you would a screaming teething baby. Behind many screamers is usually deep-seated anxiety and fear of failure. Other screamers have just been brought up to deal with people that way. I once witnessed a person screaming at someone on the phone nonstop for 10 minutes before slamming the phone down. This person then calmly turned to me and asked where I wanted to go for lunch. The screaming was merely a performance to accelerate whatever process that person wanted to move along. I'm sure the person on the other end of the phone was a wreck for a week, yet the person who caused all this grief was happy as a lark. The lesson in this story is to find your own path to deal with such people and to take care of yourself by whatever means work for you. These people exist, and you will have to deal with them if you are to be a true professional.

## Fired on the Spot: A Real World Example

Once a large production wanted to shoot a plate in VistaVision, but they didn't want to hire me as the cameraman. They decided to rent the camera and hire their own technician to save money. Well, the day of the shoot came and the company became a little nervous about exposing the green screen, so they called me in just to call the exposure. I showed up and found that the technician had already set up the camera and threaded it. My mind was on the green screen and the fact that it was under trees and lit with mottled light. The technician seemed nervous but very anxious to assist me. I asked if he had a gray card, and he tore one out of a technical book that he had. I didn't want him to destroy his book, but he wanted so badly to please. I thanked him and got a reading. The star showed up and we shot the scene. Someone called "Check the gate," which means that the lens is removed to expose the aperture so that you can see whether any hair was trapped in the gate and photographed. Usually people hang around for the okay, but this time, after “Check the gate” was uttered, all the principals were off to the next setup. So I went over and removed the lens and saw black in the aperture. I rotated the shutter, thinking that that was what I was seeing, but it remained black; I racked the internal mechanism of the camera movement inside the camera and still saw black. I opened the camera door and discovered that the technician had threaded the film base to the lens so that the black antihalation backing blocked all light from striking the emulsion. A VistaVision camera has a very windy threading pattern, and the technician in his nervousness had only concentrated on the threading and not the emulsion position.

Needless to say, the shot was ruined. The technician wanted to send the film in anyway, but delaying the disaster was out of the question, as we might get a chance to rethread and shoot again later that day. Well, we had to tell the producer, who subsequently fired the technician on the spot. He did it calmly, but it was still quick and brutal, and I felt bad for the technician. I could have had the opinion of “Glad it wasn’t me,” but I also felt some responsibility because I could have double-checked the technician’s thread to be on the safe side. In this business we do rely on people to do their jobs, but this disaster could have been avoided if I had just taken a friendly glance at this nice fellow’s work. Many people are sensitive about people checking up on them, so this approach must be taken carefully. In this case, however, I could have saved the shot and the technician’s job.

The next day we brought out another camera and I was the operator. The Director of Photography came up with a sour look on his face because he really didn’t want to be doing this shot again. I diffused the situation by saying, “Well, on the bright side, the light seems better.” He agreed, and this immediately changed the focus to the positive and we were able to get on with the shot without discomfort. The lesson to be learned is to be your brother’s and sister’s keeper. Help each other look good, for as sure as the sun will rise tomorrow, someone will help you out of a snag one day.

At the end of all this drama, the shot was cut out of the picture.

## The Ramifications of the Blowhard

I was once in the middle of the desert to shoot a matte shot that needed a steady platform. The seasoned grip and I showed the production effects supervisor a diagram of how we wanted our platform built and offered to assist in constructing it. This generous offer was met with a swagger and wild gesturing with a smoldering cigarette: “Hey, look, I’ve been around, this isn’t my first barbeque. Remember [insert gigantic blockbuster movie here]?” We were told that the platform would be built by the supervisor’s grips, were assured it would be solid, and were dismissed.

**Figure 14.5:** *Little miss blockbuster.*

Well, the shoot was at dawn and the grips finally put it together about 3 in the morning. Sure enough, when we arrived the thing was swinging in the wind like a sailboat and the big blockbuster expert was nowhere to be found. My grip had to scurry about to try to firm up the platform as best he could at the last minute. The emergency workaround for this situation was to get everyone off the platform and just leave the camera there with a glass of water sitting atop it. I observed the water in the glass from afar and when the water had settled down, I knew that the platform was steady. I then plugged in the battery that was positioned away from the platform to actuate the camera and executed the shot. A better solution would have been to show up at the site at 3 in the morning to double-check the construction. This is just one example of how people save face by bullying in order to justify their position. Unfortunately, when things go awry, the blame always seem to fall on the effects company.

## When to Stand Your Ground

A few years ago, a major earthquake struck Los Angeles. The apartment I was living in was literally torn in two. Needless to say, I was quite shaken up by the event. It was a curious earthquake in that my area of town was hit very hard, and yet 5 miles away, a book may have fallen off someone's shelf. To some, the earthquake was an annoyance, but to me, it was traumatic. The next day I had to go on a set to help shoot a shot from the rafters of a tall stage. Under the best of circumstances I am afraid of heights and have to "suck it up" to work high. This fear and the earthquake trauma combined caused me to request to bow out of going high. The Director of

Photography was a tough guy who gave me a dirty look and questioned my refusal. I stood my ground, despite the humiliation, and I'm glad I did. If I had gone up, especially during the aftershocks that were occurring every half hour, I would have been frozen with fear and could have made a fatal mistake.

I spoke to a crew member of the show about the earthquake, and he said he had called one of the principals of the show to ask if he and his family were all right. The response he apparently received was, "Forget about them. What about the film!?" People in this business can have very skewed priorities, and you must protect yourself. These "drivers" have gotten people killed. No movie is worth that.

## Conclusion

I hope that I've given the reader a bit of insight into the effects business as I have known it. It would be impossible to mimic my career, as the industry has changed so drastically. Many of the old film cameras, such as animation stands and optical printers, are gone, and digital cameras are smaller, lighter, and much more effortless to use. This ease of use should not be an excuse for sloppiness, however. Seamless realistic effects don't happen by accident, and wrestling bad elements into submission in post seldom yields terrific results. Nothing beats a well-thought-out effects shot with properly composed and lit elements. Digital technology allows us to have a much more comprehensive safety net than ever before. The contingency factor of being able to erase unwanted artifacts after the fact or enhance in post is a great advantage. Always remember that the new digital marvels should be a ladder, not a crutch. With proper planning and execution, excellent effects can be created with much less cost and effort than with a haphazard approach.

It is my hope that this book and its humble contribution might give an appreciation for what has gone before and allow the new breed of filmmakers to build upon it and give image to their own voice on that silver screen. Today's tools may be different, but the concepts remain the same. To summarize, I close with the words of a wise old grip named Larry Schuler: "Nothin' changes but the date."

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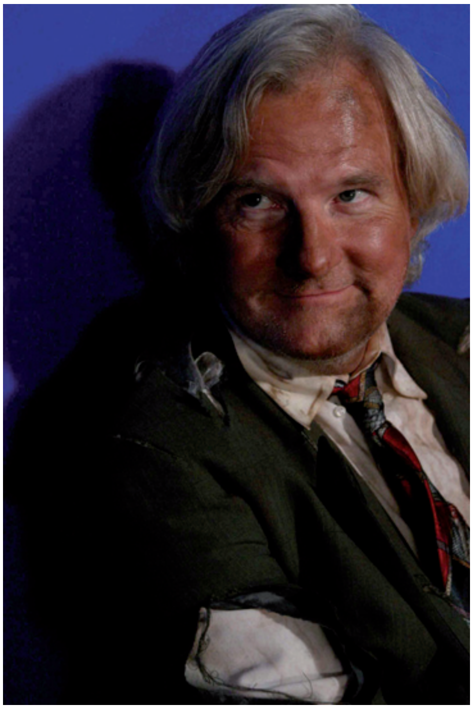
## The Man Behind the Curtain

*Mark Sawicki*

Cameraman, artist, and actor Mark Sawicki began his career as a stop motion hobbyist in Jackson, Michigan. His early work as a teenager led Mark to enroll in the University of Southern California Cinema program in Los Angeles, where he and his friends struggled to find ways of breaking into the film business. An early effort of Mark and his classmates was the independent feature film *The Strangeness*,* for which Mark was co-producer, visual effects artist, and actor. This film was a terrific introduction into the field and opened the door for Mark to work at Roger Corman's New World Pictures. While at Corman's, Mark experienced the rough-and-tumble world of low-budget effects that recreated the spectacles of much larger pictures using very limited resources. After working on several 1980s genre pictures such as *Galaxy of Terror* and *Saturday the 14th*, Mark was invited to set up the optical department at Celestial Mechanics Incorporated and was introduced to the world of commercials, where he won a Clio for his camera work. After a 5-year stint at CMI, Mark went on to become

*Featured in the book *Nightmare USA* by Stephen Thrower, Fab Press (2007).

an independent stop motion animator on several MTV rock videos and educational projects. Throughout this period, Mark performed as an actor in a number of independent features.

In 1986 Mark was invited by Bill Taylor ASC to become the matte cameraman for Illusion Arts. While at Illusion Arts, Mark was exposed to the time-honored tradition of latent image matte painting effects and had the fabulous opportunity of working under Albert Whitlock in the last years before the great matte painter's retirement. While working under effects supervisor Bill Taylor and master matte painter Syd Dutton, Mark composited more than 1000 matte paintings; some of these shots, like those used for Martin Scorsese's *Cape Fear*, became haunting imagery burned into the memories of audiences around the world. Mark was a first-hand witness to a craft that had been handed down from generations of artists dating back to the silent era. His stay at Illusion Arts was highlighted by sharing in the win of an Emmy certificate for his contributions to the Star Trek television series. During this period Mark was invited by Eastman Kodak to become a trainer for the groundbreaking Cineon Digital Film system. Mark was responsible for writing tutorials and personally training a new generation of digital compositing artists in Los Angeles, London, and the National Film Board of Canada.

In 1996 Mark was offered the position at Area 51 of co-supervisor along with Tim McHugh on Tom Hank's *From the Earth to the Moon*. This miniseries was a pivotal event that ushered Mark into the remarkable world of computer graphic effects.

After the miniseries, Mark re-entered the field of optical printing by becoming head cameraman for Custom Film Effects, founded by former Disney effects supervisor Mark Dornfeld. Mark executed high-quality, traditional optical composites for major films well into the twenty-first century, in the midst of the digital revolution. The printers were ultimately retired in 2005, and Mark continues as a digital colorist and effects camera supervisor. Although Mark no longer engages in clay animation, his creations are sold in the fine art market and have been featured in several magazines as well as HGTV's *Carol Duvall Show*. Mark has taught visual effects for more than 15 years at UCLA Extension along with effects supervisor Glen Campbell of Area 51. Mark has also authored several video programs on the art of clay animation that are distributed to schools worldwide. Today, Mark tries to keep abreast of a wide spectrum of techniques by working in high-end postproduction and performing as an actor in low-end independent projects.