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A Shot in the Dark

A Creative DIY Guide to Digital Video Lighting on (*Almost*) No Budget

Jay Holben

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By Jay Holben

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A Shot in the Dark: A Creative DIY Guide to Digital Video Lighting on (Almost) No Budget

Jay Holben

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If you are unfamiliar or uncomfortable with any aspect of the projects, consult a professional. Individuals are advised to incorporate all standard and recommended safety gear, always follow manufacturer's instructions on electrical components.

While all of the projects in this book have been tested for safety and functionality, it is not possible to overstate the importance of safe practices when dealing with electricity and heat generated from electrical components.

Library of Congress Control Number: 2010942051

ISBN-13: 978-1-4354-5863-5

ISBN-10: 1-4354-5863-X

eISBN-10: 1-4354-5864-8

Course Technology, a part of Cengage Learning
20 Channel Center Street
Boston, MA 02210
USA

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Printed in the United States of America
1 2 3 4 5 6 7 13 12 11 10

To Mom,

Your indefatigable support of my pursuit of my dreams
has always allowed me to find the light.
From bridges over the pool to backyard theater,
you've been wiping the proverbial cherry juice
off the cabinets all my life, and I am eternally thankful.

About the Author

Jay Holben has been involved in the lighting community for over 20 years. His entrée into the world was an apprentice electrician for a civil/industrial contractor while working simultaneously in live theatre in various positions, including master electrician and lighting designer. Embarking on his Hollywood career, he started on film sets as an electrician, rising quickly through the ranks to gaffer, where he spent several years honing his craft before advancing to the role of director of photography. As a cinematographer, Holben shot various projects, including commercials, music videos, documentaries, and feature films.

In 1996, Holben started as a contributing writer for *American Cinematographer* magazine, eventually serving as a technical editor for the publication. He is currently the technical editor for *DV* magazine and remains a contributing writer for *American Cinematographer* and *Videography* magazines. He has also contributed to the prestigious *Hollywood Reporter* and several books, including the *American Cinematographer Manual* 9th Edition. Over the past decade, Holben has taught dozens of workshops and lectures on the art and science of lighting for motion pictures.

He is currently an independent producer/director living in Los Angeles.

Acknowledgments

Filmmaking is a collaborative process; it cannot be done in a vacuum. Nor can a project like this book be done without the aid of many people, all of whom I wish to extend my most sincere gratitude.

My thanks to editor Megan Belanger, who came to me out of the blue and asked me to write a technical book. She suckered me into this thing, and then ran off to start a whole new life out of the publishing world. Geez… it's enough to give a guy a major complex… Was my writing that bad, Megan? I wish you the best. Thanks for opening a new door for me (squeee!).

In the void Megan left, I had the privilege of working more closely with Stacy Hiquet, my publisher, who patiently endured my anal-retentiveness and fostered me through this process with a deft hand.

With probably the worst job, my copy editor, Kezia Endsley, had to slog through my ramblings and esoteric figure numbering and smooth out the rough edges. Thanks, Kezia, for making everyone believe I have a much better grasp on the English language than I really do…

A hearty thanks to my friend, co-worker and technical editor, Jayson Crothers. His work not only double-checked my facts, but constantly challenged me to refine my presentation, to consider more, and to be as comprehensive as possible.

The man who first took a chance on a young writer, and became a good friend, was Stephen Pizzello. Steve has endured my quirkiness for over a decade and a half and I am incredibly proud to have been a technical editor and frequent contributing author for *American Cinematographer* under his tutelage for many years.

Alongside with Steve, I met David Williams as an editor at *AC* Magazine and he has expanded my CV over the years with publications such as *The Hollywood Reporter* and *Videography* and offered me the incredibly fun task of being the technical editor for *DV* Magazine. Much of what I've written for *DV* and taught in my lectures at the DV Expo became the basis for this book.

To Alex Preda, Amanda Bolten, April Adamson, Dean West, Douglas Holben, Heather "Sparrow" Carr, Ilaria Giansianti-Borden, Lauren Solomon, Lauren Waisbren, Lisa Jay, Mark R. Gerson, Mason Rae, Michelle Berthelot-West, Sarah Lindsay Hall, Shannon Setty, and Stirling Gardner, for lending their faces to me to show light across a beautiful landscape. And to Chris Probst, Claudiu Gilmeanu, and Shannon Lee, for their images: the few instances in which I allowed another photographer's work to sneak into this volume.

A heartfelt thanks to my good friend, Dr. Jeffrey Crane, who endured my scientific inquiries and engaged in nerd-fest discussions on physics and theoretical color temperatures. Our longtime friendship has a place of honor in my life, and this book is very much in the spirit of his G.I. Joe dolly solution so many years ago.

To my good friend, Chris Probst. Over the years Chris has been my student, teacher, mentor, employee, employer, pain-in-the-ass, savior, and—above all—friend. His work continues to inspire me. Chris taught me to abhor compromise and to always push further. We came up through the trenches together, pushing each other, learning from one another, and surviving the Hollywood game together. A lot of the adventures that Chris and I had starting our careers shaped the experiences that led to the projects in this book. Thanks, Chris. Happy shooting.

To my friends and family, who have been supportive not just of this project, but of my impossibly long trek through this business.

Finally, to my wife, Jennine. She has the hardest job coming home to a house *filled* with equipment as I have—once again—turned our living room into a location to shoot another component for this book (or dozens of other projects over the years). She has endured my impossible vampiric working hours, my endless parade of equipment invading our home, my irritable moods when the project wasn't going as I wanted or—heaven forbid—when a piece of gear didn't perform as I wanted it to and I launch into a tirade that would make an ADHD 6-year-old blush. She tirelessly came to my rescue when I was unable to be the one-man-band creating the step-by-step images for this book. This simply could not have been done without her. Thank you. Love you.

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Introduction

Discovering Light

I lived a large portion of my life working as a lighting professional; manipulating, controlling, coercing, and painting with light. It started in high school, working in the theater and lighting for plays, choir concerts, band concerts, dance recitals, assemblies, and corporate functions. I did many things backstage, but lighting was one of the jobs I became good at. I branched out from there, lighting theatrical performances in Community Theater. A little later, I started working as an electrician in professional theater and moved up to master electrician and, eventually, to lighting designer. All of this was while I was living in Arizona. When I made the move to Los Angeles to work in movies, I started where I thought I could transition most naturally from stage to screen: as an electrician. I worked my way up the ladder, making a brief stop as a *best boy*, and then as a *gaffer* and, eventually, I became a cinematographer. Up until the point where I officially "hung up my meter" in 2005—although I still continue to shoot on the side—lighting had been a key component of my life for nearly 20 years. I studied it; I lived it. My life was creating light, crafting light, and painting with light.

Seeing the Light

I used to drive my wife a little crazy (well, truth be told—a *lot* crazy) because I was always thinking about lighting. We would be sitting in a restaurant and having a conversation and suddenly I would get quiet. After a moment she would cock her head slightly and glare at me, "You're looking at the lighting again, aren't you?"

And I was.

See, at that moment, the way the overhead lamp at the table was creating a combination of *hard light* (directly from the partially exposed bulb) and *soft light* (through the lampshade) was defining the shape of her face quite wonderfully. It wasn't a perfect toplight, more of a sidy-top from where she was sitting. The warmth of that *incandescent* bulb, slightly dimmed down, combined like a perfect meal with the very soft, cool natural twilight that was coming through the restaurant window and edging her face. I have a very beautiful wife, and the light was very beautiful—so I had to stop and *see it.* My mind made me stop, break down what I was seeing, and file it away for later use. I remember what she looked like that day perfectly.

So, she caught me. But it was worth being caught, because that moment of *seeing* that light, of breaking down its components—complete with the tiny sparkle in her eye from the candle on the table and the way the delicately flickering flame put a tiny edge on the lower line of her lip—and locking that image into my memory gave me a tool in my belt to refer to at another time. I would pull that memory out of the dustbin of my subconscious on some occasion when I had to light a romantic, realistic dinner scene. Over the 20 years or so that I was, primarily, a lighting professional, I had thousands of these moments. Some of them were in natural lighting situations, such as from the moment of sitting in a restaurant with my wife, some of them were on sets, either my own or others, and some of them were experiments and exercises I would do to expand my understanding of lighting. All of these moments have become part of my mental lighting arsenal.

As esoteric, uppity and artsy-fartsy as it may seem to say: *light is life*. Unless you are blind, you experience the world through light. Most people have no true concept of the light around them, other than it being bright or dim. But *you*, if you are a lighting professional or want to learn more about lighting, *you* have to learn to *see*. Learn to *see* the subtleties between light and dark. Learn to *see* the hues and saturations of light. If you work at it, if you study, you can learn to see color temperatures of light and intensities of light to stunningly accurate detail.

Anyone Can Learn

When I was in high school, an optometrist diagnosed me with acute color deficiency. Not color *blindness*, mind you, but color deficiency. Put those damn *Ishihara charts* in front of me and four out of five times I can't tell you the hidden number in all those maddeningly colored bubbles. This diagnosis hampered me a bit and I used it as a bit of a crutch early on. I could see colors, sure. I could differentiate colors, but I had a deficiency, you see... how can I really be good with colors when I was handicapped?

When I graduated from high school, the choices of schools in Arizona with film production programs were few and far between. I settled on a community college—the only school in the state with a film production program at the time—with the idea of getting up my grades (which, ahem, were less than stellar) and getting the general classes out of the way to transfer to the legendary USC to learn filmmaking. I stayed in the community college for two years, becoming more and more frustrated with the lack of education I was receiving. I *knew* I had a lot to learn, but I also knew that I already was far more advanced than most of my teachers and I was fairly regularly correcting them. It wasn't really their fault; it was Arizona, for crying out loud, not exactly the Mecca of film production.

At the time I dropped out, in pure frustration (and because I was spending more time working professionally in theater than I was spending time in the classrooms); I was gearing up to make my second short film. I had lost my cinematographer and my producer asked me, "Why don't you shoot it?" I didn't know a light meter from my foot, but I figured I could learn. So I picked up some books. Because I had this color deficiency, I thought I would learn the ins-and-outs of color temperature first, to see if there was some way I could overcome my "handicap." I assumed that understanding color temperatures would be difficult for me.

It wasn't. Nor was learning to see color. (As it turns out, my deficiency is very slight. Differentiating between near hues is a challenge, but I see colors just fine.) I studied hard, and in two weeks I learned more about lighting and photography than I had in two years in school. From then on, I continued my self-education. My home now is filled with books on filmmaking—the basis of my informal education that has taken me to this point in my career.

Why This Book?

Over the years, I've done a lot of teaching. For three years, right out of high school, I taught an extra-curricular program at the school I graduated from, turning the techies into professional theatrical technicians. Since, I have taught a long stream of workshops and seminars on the art and science of filmmaking. I have also been very active on the Internet since the early days of

Bulletin Board Systems before the Web snatched the world in its sticky grasp. And, long before I was even partially qualified to do so, I was answering people's questions about the film industry. Over the years, I have participated in many forums and discussions online and have mentored many individuals who have come to me seeking advice.

When it comes to lighting, invariably, I get asked "Can I use *this* to light with? I can't really afford *real* lights... so... can I use this?"

The answer is: of course you can.

In truth, *anything* that provides any amount of light is fair game for lighting film and video; digital technology makes this even more so. There are technical aspects to consider (color, spectrum, quality, and intensity), but anything from glow sticks to cigarette lighters, flashlights to cell phone displays—all of these things provide light and *all* of them are fair game to use to light any particular scene you might desire.

Not everything is suitable for every moment, of course, and many things aren't technically sufficient to be a *primary* source of light for a given scene, but the only limit to what can be used is in your imagination.

Film Is Dead!

No. No it is not. Not by a long shot.

Contrary to popular belief, motion picture film is still very much alive and kicking—and will be for a long time to come. However, digital technology is here to stay. Digital has nearly completely overtaken the postproduction process. In exhibition, there is still a lot of work to do, but by the end of 2009, only 19% of the nearly 40,000 movie screens in the U.S. were digital.

Origination—that is the actual shooting of motion pictures—is still well ruled by good ole fashioned film *emulsion*. Of the 500 films released in theaters in 2009, again, only 19% of them were originated digitally (up slightly from 14% in 2008 and 12% in 2007). That number takes into consideration only theatrical movies, however, not television, commercials, made-for-cable movies and independent films (both fiction and documentary) that aren't released theatrically; in those areas, digital is king.

There is no question that digital cameras have matured and become viable production tools. With the advent of the DV format in 1995, digital technology began to take a firm foothold in low budget and independent productions. The digital wave took hold of the professional world, as well. With the introduction of the Sony HDW-F900 HD camera in 1999 through the cooperation of Sony, filmmaker George Lucas, and the camera giant Panavision, the age of professional digital origination was born.

Today, there are myriad digital cameras and formats available. Cell phones are capable of shooting high-definition video (and some impressively so). More and more digital tools drive the overall cost of the technology down and down—making it more and more affordable. In 2001, when I first started shooting HD with the good ol' F900 camera, I did some math and discovered that in order to shoot film—only considering the cost of the medium and necessary steps to get the image into the edit room—it cost $75 a minute of footage shot. That included the cost of the film stock, the cost of developing, the cost of the process of transferring that film to video (called *telecine*), and the cost of the video tape stock to get it into the edit room. By comparison, the cost of shooting HD included the cost of the HD tape, the cost of the down-conversion process (converting HD to standard definition because, at the time, edit systems couldn't handle HD footage), and the cost of the standard definition video tape: $4 a minute. Film was nearly 20 times more expensive to shoot than HD!

In the years since, not only has digital technology improved to be much more compatible with the coveted 35mm film image, but those numbers have actually gotten farther apart. Film is now more expensive and digital/HD is even cheaper.

I have no doubt, if you're just starting your journey into recording motion pictures—be that for narrative features, shorts, documentaries, corporate video, weddings, and events or any other genres of production—you will be starting out in the world of digital images. Although all of the principles in this book apply to *both* film and digital recording media, as most new shooters will be working with digital cameras, I'll primarily focus just on digital sensors and those ubiquitous ones and zeros. Should you happen to be fortunate to be lighting to expose motion picture film stock, all of the same principles and techniques covered in this book apply to that medium as well.

Who Should Read This?

Anyone interested in learning more about lighting! For many, the art of lighting is a scary magic that they feel is well beyond their grasp. As I already noted, the advances and cost reductions in digital technology are making the practicality of filmmaking available to more and more people. More new filmmakers are picking up a camera every day—and starting to create material.

This book is for anyone who has a desire to shoot moving images, but isn't looking to spend a fortune on a formal school or fancy equipment. This book starts from the basics of what light is and goes all the way toward building an inexpensive lighting kit.

If you shoot narrative shorts or features, documentaries, corporate videos—even live events—the concepts, techniques, and projects in this book can help you make better images.

Although Hollywood still has a very rigid hierarchy of jobs and positions on the set, the digital filmmaker working on her own is often wearing multiple hats. If you're creating your own material, chances are you're working as a producer, director, cinematographer, and probably your own production assistant, as well. This book will give you a better understanding of how to control and manipulate the image you're recording—for whatever purpose.

What's Covered (and What's Not)

My intention with this book was to make it as complete an entity as possible—with regards to getting started in lighting. I wanted someone who is virtually new to capturing images to be able to pick up this book, and by the time they're done, have a solid grasp on what light is and how to use it and, further, how to make their own lights to use! It's like a cookbook that teaches you how to cook and then gives you the recipes. In these pages, I cover the following:

- Basic tools necessary for lighting
- The science and physics of light and color
- The fundamentals of exposure
- The basics of electricity
- Qualities of light
- Basic lighting techniques
- Creating your own fixtures
- Creating your own basic tools

If you don't know a thing about cooking, this book will get you into the kitchen and making some great meals.

I don't, however, cover the plethora of other aspects of digital production. I also don't cover the other aspects of creating great images—namely the understanding of composition, lens choices, and camera movement. Those discussions are very important, but well beyond the scope of this book. This book is about light and the manipulation of that light to create the best images you can.

The Book's Structure

You'll find that this book has two very distinct parts. The first part, which encompasses Chapters 1–6, is an examination of the basics. These chapters cover the fundamentals of light, color, exposure, electricity, light quality, and basic lighting techniques. These are the building blocks of lighting. I believe it's extremely important to have a strong base of fundamentals to build on. I'll cover a lot of ground in these first six chapters, but I'll do it fairly quickly.

The second part of the book (Chapters 7–11) contains the practical projects; these chapters teach you, step-by-step, how to build figures and rigs inexpensively, to add to your lighting arsenal. These chapters are the nuts-and-bolts portion of the book.

Lighting with a Toilet Bowl

I love to tell this story.

My good friend, Christopher Probst, and I came up together, meaning we started out on our career path at about the same time. I met Chris at the community college in Arizona and quickly identified him as one of the truly serious people in the program. In the years since, we became good friends. We moved to Los Angeles together and worked together on many, many projects. Although directing was always my end-game plan, Chris and I were on parallel trajectories toward being cinematographers—he made his way up through the camera department as an assistant, I made my way up through the electrical department. When I shot my early projects, Chris would be my camera assistant (at times my entire camera department) and when he shot, I would be his gaffer (at times his entire electrical department). We also did a lot of experimenting together, shooting scenes for our respective demo reels whenever we could get our hands on cameras. In those days, it was all film and a *lot* harder to shoot things on your own without hundreds of thousands of dollars worth of equipment.

One of the techniques that I started using early on was to have motion picture film rolled into 35mm SLR canisters (long before Digital SLRs were even a serious dream) so we could use our still cameras to shoot still photos on motion picture film in order to learn lighting and the ins-and-outs of the specific film emulsions. There used to be a lab here in Los Angeles that specialized in developing these small five-foot rolls of motion picture film and making slides out of them, and this process was a major part of my film education.

One night, Chris was house-sitting for a major cinematographer and we had access to some of his lighting equipment. In the cinematographer's home office, Chris and I were setting up a small shoot to experiment with lighting and just off the office was a small bathroom. At one point in the evening, while adjusting lights, Chris accidentally panned a fixture onto the toilet in the bathroom and the light that bounced back into the room was stunningly beautiful! At the same time, we both stopped in awe at what we were seeing. The tiny, amorphous pattern of light reflecting off of the curves of the porcelain seemed to dance about the room like magical little fairies. We shot several frames with that light bouncing off the toilet bowl.

This became an important lesson to us: think outside the box and experiment! You never know what you're going to get. For years thereafter, whenever Chris and I would be in a situation where we were doing something unorthodox or bizarre, we'd call it "lighting with a toilet bowl," and we would remember the inspiration of that night.

So, what's the point of all this rambling and reminiscing, you ask?

Simple.

You *can* learn on your own.

You *can* use anything that creates light to light with.

You *should* think outside of the box.

To turn those aspects into real techniques that you can actually use, I've written this book. Read on and let's have some fun!

1

What You Need

This first chapter discusses the basic tools that you'll need to complete the projects in this book and to journey forward in your lighting career.

Buying the Real Stuff

Before you dive in to the real meat and potatoes, there are a few things to understand and items to make sure you have on hand.

Lighting equipment is expensive, but lighting equipment is cheap.

That seems like a ridiculous oxymoron (jumbo shrimp, anyone?), but it's very true.

Although the professional heavy-duty lighting fixtures carry a hefty price tag, the high-end equipment will last you a long, long time, in which case, their cost is evenly spread over the many years that you'll be using the equipment. That makes such equipment expensive, but cheap in the long run. If a fixture costs you $1,000, but you are able to use it on 100 jobs, that fixture really only cost you $10 a job. Although that initial $1,000 price tag may have the "ouch" factor, the amortized value of that fixture will be much more palatable over time.

My producing partner purchased an Arri *Fresnel* kit in 2004 that consisted of two 150W, one 300W, and one 650W Arri Fresnel along with a small Chimera brand *softbox*. That kit, which initially cost a hefty $3,000, has been used on, literally, hundreds of projects in the last six years.

The equipment, if you keep it well maintained, will last for 10, maybe 20, more years. I have some low-end Altman Fresnels that are 30 years old now and still functioning just fine.

If you have the means, purchasing the professional gear—especially Arri, Mole-Richardson, KinoFlo, ETC, K5,600, and many more—is the best investment you can make, and it will last you a very, very long time. Unlike computers or cameras, lighting doesn't become obsolete. It might be replaced, eventually, by more efficient variations, but there's nothing wrong with using the older equipment. As I'll say time and time again: anything that creates light can be used to light your scene.

All that having been said, you might not always have the luxury of the cash to invest in the high-end product, which means you have to improvise. That's what this book is all about: improvisation. It's about making do with what is readily available.

Although, in the course of my career, I have worked jobs with large lighting trucks full of anything I could wish for and large crews—once, as a gaffer, I had a crew of 18 electricians working for me—most of my career was spent on low and micro budget projects lighting with a bare minimum amount of equipment. I've had to improvise in many more scenarios than I ever had where I had my pick of the equipment litter—and I'm here to help you understand that you can do the same, on a minimal budget, and achieve amazing results.

This doesn't mean that, with this book, you're going to be able to light eight city blocks on $50—there are times when only the big toys will work—but it does mean that I will be able to teach you tips and techniques for lighting small sets and small locations with confidence—all on a budget with tools that you can find anywhere, in practically any town.

Stocking the Store

There are a few things that, of course, you will need to have on hand to delve into the projects in this book and into the world of lighting. Some of these you might already have, whereas others you might have to invest a bit into. Each project in this book specifies the tools necessary to get that job done.

For the projects in this book, you need a small handful of tools:

- An electrical circuit tester (optional)
- A drill
- A pair of wire strippers/cutters
- A box cutter or sharp blade
- A combination screwdriver
- A pair of diagonal cutters
- A pair of pliers
- Clothespins (C-47s)
- Various bolts, screws, nails, glue, tape, and expendables that I'll list on a project-by-project basis

You will also need a basic understanding of do-it-yourself projects. Being labeled "handy" will certainly help with the projects in this book, although I'll do my best to be as clear and concise in my instructions as possible and not gloss over that one elusive step like the origami books of my youth:

Fold in half, and then in half again, now make the parrot. Wait… What?!

I'll do my best to keep things simple, concise, and easy to follow.

There are a lot of things that you can "fake" or make inexpensive variations of, but there are some tools that have been designed for the film and video industries that just can't be replaced. This section covers those all-important tools, one by one.

The C-Stand (Century Stand)

The irreplaceable Century Stand. Legs (A), risers (B), gobo head (C), and arm with gobo head (D).

C-Stands can be purchased for about $130 a piece. They will last you forever and, once you've mastered the art of the C-Stand, you won't be able to work without them. I remember a grip telling me once, when I was a young tyke in the business, that given enough time and stands, a good grip could build a scale replica of the Eiffel Tower—and I do believe that.

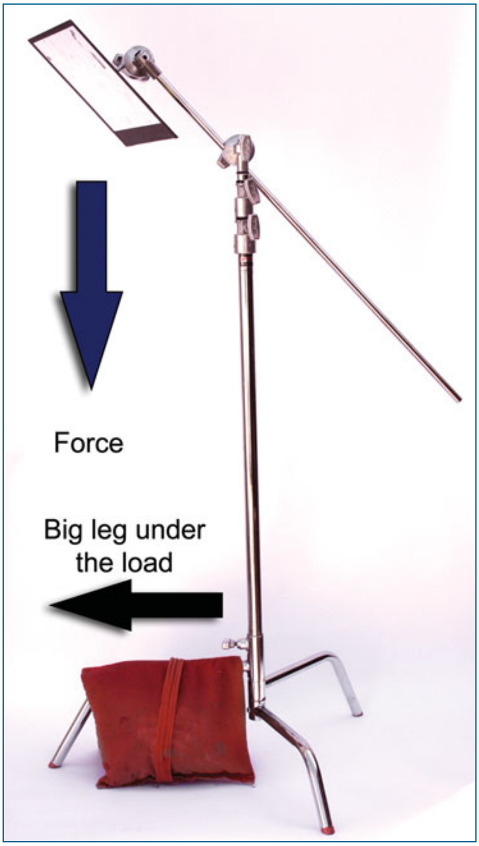
The versatility of the C-Stand cannot be matched. They are robust and incredibly flexible. I would recommend, for pretty much everyone, a bare minimum of four stands, but six to eight is a better number.

The following sections discuss a few things to remember when you're working with C-Stands.

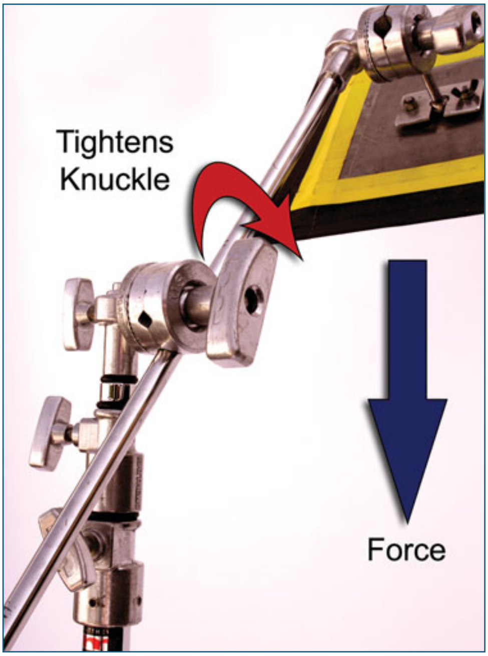
The Big Leg Goes Under the Load

This is the first rule of setting a C-Stand. You'll notice that they have three curved legs: one short, one medium, and one tall. Sometimes that tall leg is also adjustable up and down on the stand (called a *Rocky Mountain Leg*) to position the stand on an uneven surface. The stand should *always* be positioned with that large, high leg *under* the load, as shown in the following image. This means if you're extending the stand's arm out to the left, that big leg is turned to the left and centered under the extended arm as precisely as possible. Wherever the weight is on the stand, that's where the big leg should be positioned. If the weight is centered precisely above the stem of the stand, then the big leg should, in general practice, be positioned pointing toward wherever your talent will be.

The reason for this is pure physics. It is much more difficult for the stand to topple over if the center of gravity is extended by having a leg under the load. The big leg is best for this as when you put a sandbag on it to help secure it, the full weight of the sandbag should hang on the leg, as opposed to resting on the ground. Which leads me to the next point.



The proper setting of a C-Stand.



The main lock-down knuckle on the C-Stand's gobo head is on the right side so that a load extended forces the knob to tighten.

Cut a small 1-inch "X" into one area on the ball, and it will easily slip on to the end of the C-Stand arm and help keep that pointy end from poking out someone's eyeball. 'Cause that's never fun.


A standard tennis ball with an X-shaped cut, so as to fit on the end of a C-Stand arm.

Two configurations of a C-Stand with the load in exactly the same place. The first image shows the arm straight out—at eye height—in a hazardous configuration. The second image shows the stand, configured slightly different so as to put the end of the arm above eye height but keep the object held in the stand in the same position. Whenever possible, configure the stand to avoid a potential accident where someone might be injured by the protruding arm.

Color Correction Gels

Another tool that you really can't fake is color correction gels. These are, unfortunately, not cheap, but necessary tools. You can mimic many kinds of diffusion with other materials, but when it comes to color correction, precision is everything.

There are several manufacturers of color correction gels; Rosco, Lee, and Gam are the big three.

It's very, very important to understand that all colored gels are not created equal. There are two types of colored gels, "theatrical" or "party" gels, and calibrated color correction gels. All three companies make a wide range of "theatrical" or "party" gels—primarily for live theater applications—in a, literal, rainbow of colors. These can be handy, but they can often have unexpected results. With highly saturated color gels, often what you see is *not* what the camera will see. The only way to know for sure is to test, test, and test some more before you decide on using these effects gels.

Calibrated gels are specifically formulated to have a very precise effect on the wavelengths of light passing through them. These are the gels that you'll mostly be working with when shooting, and they fall into three categories: blue/orange, green/magenta, and neutral density. Blue/orange are the ones you will work with most often, also referred to as *CTB* (color temperature blue) and *CTO* (color temperature orange). *Plus Green* (green) or *Minus Green* (magenta) gels are used less often, but should still be an important part of your kit. Neutral density (ND) gels do not change the color of the light, but reduce its intensity. These are very, very handy tools—but there are *some* materials that you can use to create an ND effect to greater or lesser degrees (see Chapter 11, "Accessories and Miscellaneous Tools," for information on nets and net substitutes).

You'll learn about color correction gels in more detail in Chapter 2, "The Fundamentals."

Nail-On Plates

Nail-on plates are specifically designed for the film and video industry. The plate is a piece of plate metal, to which a ⅝-inch in diameter spud is welded perpendicular to the surface of the plate. The ⅝-inch pin is also referred to as a "baby" pin and is a universal standard in the industry. This diameter pin will fit into any C-Stand and into other professional grip hardware. The nail-on plates are intended to be nailed (or screwed) to a wall, ceiling, or apple box to create a spud to mount additional hardware on.

They're the best devices to mount to the back of your lighting hardware so that you can put your hardware on a C-Stand. Can you make your own? Absolutely. Can you, perhaps, substitute a different kind of material for these? Yes. However, I have yet to find a more inexpensive alternative to the real thing.

An Avenger brand nail-on plate with ⅞-inch spud.

Stocking Your Toolbag

There are some additional supplies that I recommend you always have with you. These are the "life-saver" small tools that have a million different uses and will come in handy in a pinch.

The Cube Tap

This is a multi-outlet adapter in a small, compact size. It has one male, grounded *Edison* plug and three female grounded outlets. The cube tap allows you to turn one socket into three without the bulk of a power strip.

Three views of the ubiquitous 125V 15A cube tap.

It's a standard 125V 15A component, but worth its weight in gold. Always be sure you're not overloading any circuit (see Chapter 4, "Understanding Electricity," for more on electricity and calculating power).

Quick-Ons and Add-a-Taps

These two go together like peanut butter and jelly and are invaluable. They're designed for use with *zip cord,* which is an 18-gauge 2-conductor (18/2) single wire. It's often called "lamp cord" because it's mostly used as a power cord for standard household lamps.

Several views of a Quick-On instant plug.

The Quick-On is a male plug in two parts. You squeeze the two blades together and pull them out of the housing. Then you slip an end of 18/2 zip cord through the base of the housing. Spreading apart the blades, you'll notice that they have sharp teeth on the inside of them. You stick the 18/2 zip cord into a slot in the bottom of the blade portion (unstripped) and close the pins. Each pin automatically pierces the insulation of the zip cord and makes connection with the wires inside. Then the blades fit back in the housing, and in seconds you've turned a cut wire into a plug.

The Add-a-Tap is even more amazing. Using the same concept, with teeth inside that pierce the insulation of the wire, the Add-a-Tap is opened using a little lever on the side, and it hinges open revealing sharp metal teeth. You merely select a place along the zip cord and clamp the Add-a-Tap closed on the wire; you instantly have an unpolarized plug. Any number of Add-a-Taps can be added to a length of zip cord at any point along the cord.

Several views of an Add-a-Tap, instant outlet.

The Add-A-Tap and Quick-On applied to a piece of zip cord.

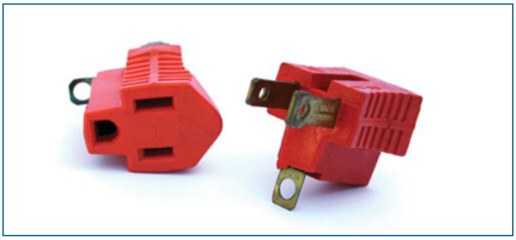
The Pig-Nose and Edison Socket Adapter

Two views of a "Pig-Nose" medium base to outlet adapter.

An Edison plug to medium base light bulb socket adapter.

Ground Lifters or Two-to-Three Adapters

These little buggers tend to disappear like candy on a playground, but they come in handy. They have a two-pin Edison plug on one end and a three-pin (grounded) socket on the other. They allow you to plug grounded devices into ungrounded outlets.



Two different views of a two-to-three or ground lift adapter.

The small metal ring sticking down from the base of the two-to-three adapter is intended to be screwed into the faceplate of an outlet so that the device can connect to ground. In temporary installations, this is rarely possible.

CAUTION

A ground is more clearly explained in Chapter 4, but it is your primary safety device against accidental electrocution. Although you will encounter older locations with electrical wiring that pre-dates the grounding standards of the 1970s, where you'll need to use these devices, always be aware that when you use a ground lifter, you are eliminating the electrical safety factor of the ground connection. This should always be a temporary solution. If you can, remove the faceplate screw from the ungrounded outlet and screw it back through the loop in the ground lifter. If the outlet does have a ground connection, this screw will connect the lifter to the building's ground and maintain safety.

Spring Clamps

These generally come in three sizes, each describing the diameter of object the clamp can grasp onto: #1 (1 inch), #2 (2 inches), and #3 (3 inches) (not pictured). They're great all-around tools for clamping up diffusion, masking, flags, bounces, scenery, or many other things.

Two sizes of spring clamps: #1 (left) and #2.

Circuit Testers

These little devices come in handy when you're first at a location and you're not sure if power is present to outlets or if they are properly grounded.

A ground tester and circuit analyzer. This device tests polarity, grounding, and minimum voltage.

All you have to do is plug in the circuit tester, and the lights will indicate if there is power present, if the polarity of the circuit is correct, and if the circuit is properly grounded.

General Tools

It's always a good idea to have a good, sharp knife capable of cutting all sorts of material: plastic, cables, rope, and cardboard. The best knives are high quality and have a combination serrated and straight blade.

A good multi-tool is wise to have with you. Think Swiss Army Knife, but larger. Pliers, several screwdriver heads, and so on.

Wire cutters/wire strippers. Not necessarily the same tool, but they can be. Most wire strippers have cutting blades in them, too, but a good pair of diagonal cutters can't be disregarded.

Multi screwdrivers are great for small projects. A multi screwdriver typically has at least two sizes of Phillips heads and two sizes of flat heads.

A good comfortable pair of shoes isn't a bad idea, either. Just sayin'.

These are all the basic tools that you should have not just to complete the projects in this book, but always holding a place in your working toolkit. You'll find them invaluable and, once you have them with you, will wonder how you ever worked without them.

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2

The Fundamentals

This chapter discusses the science behind light and color, how to understand what light is, and how people see color.

The Beginning: What Is Light?

I start, as in all good tales, at the beginning. There are a lot of lighting texts that teach the three-point lighting system: key, fill, kicker; 1, 2, 3. This is a sound basis for understanding lighting concepts in *some* situations, but it rarely applies all the time. There's the old saying, "give a man a fish and he'll eat for a day, teach a man the fundamentals of lighting and he'll light for a lifetime...."

Okay, I'm paraphrasing the proverb a bit there, but I hope you catch my drift. In my philosophy of teaching lighting, I don't just want to tell you where to put the lights, I want to help you understand what light is, how it works and, more importantly, how to control it. Once you have a strong basis in those fundamentals, you can figure out where to put the lights for yourself without following some paint-by-numbers sketch.

So, I start from the beginning.

I said it in the intro, and I'll say it again, *light is life*. Everything we see, everything we experience through our eyes, is due to light; or, more specifically, the interaction of light with the objects in our world. Without light, the entire world would be nothing but blackness. More than any other, our sense of sight is what leads us through life.

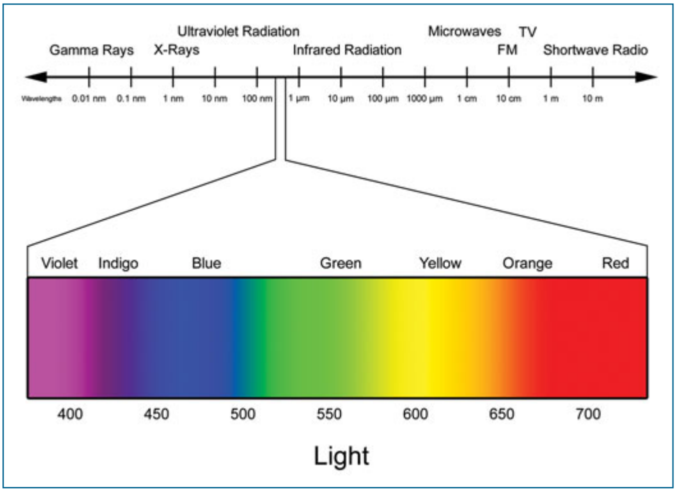
Photography is the art and science of capturing that light. Whenever you take a picture, be it stills or motion, you take a snapshot that documents a point in space and time through the capture of light.

The intriguing aspect of this is that we cannot see light itself. Photons and light rays are invisible to the human eye. We can only see the effect of light after it interacts with objects in our world—and light interacts in three ways when it strikes an object: it is *reflected*, *refracted*, or *absorbed*. I'll get into those three a bit more later in this chapter.

For now, it's time to talk about what light is.

The Electromagnetic Spectrum: We're Surrounded!

We are surrounded, constantly, by a dizzying, dancing, colliding world of waves, which are all part of the *electromagnetic spectrum*. The spectrum encompasses many different types of waves, from gamma to television broadcast.



The electromagnetic spectrum, from 0.01 nanometer to 10 meters, covering gamma rays to shortwave radio. Between 400 and 700 nanometers is the range of light.

In a tiny sliver of the spectrum, sandwiched between ultraviolet radiation and infrared radiation, is light. It is sometimes referred to as "visible light," but that is an incorrect and redundant term. All light is "visible" (through reflection or refraction), and anything outside the visible range is actually radiation, not light.

If you break down this small range of waves—from about 400 to 700 nanometers (billionths of a meter)—you come up with the colors of the rainbow:

Violet, Indigo, Blue, Green, Yellow, Orange, Red

A cute way to remember the colors of the *spectrum* is to look at them backwards and their first letters form a little name: Roy G. Biv. Okay, it's not a real name, but it's pretty easy to remember.

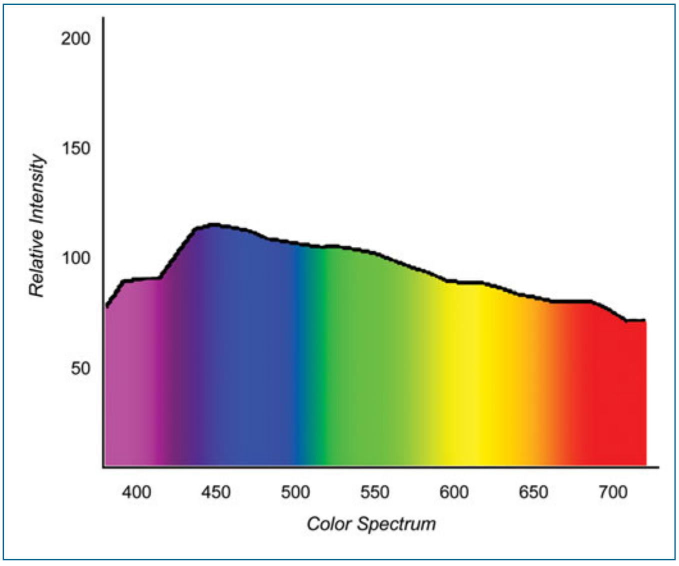
The important point to understand about Roy and the electromagnetic spectrum is that light, as we know it, is composed of all of the colors of the rainbow, what is referred to as the "full spectrum" of color.

Seeing the Light

The combination of the human eye and the brain forms a very, very powerful tool in which light enters the eye, is interpreted by the brain, and the brain forms the visual picture of the world around you. The brain is incredibly flexible in its ability to discern and manipulate the colors that you see. It has the enormous ability to turn a wide variety of colors of light into "white" light.

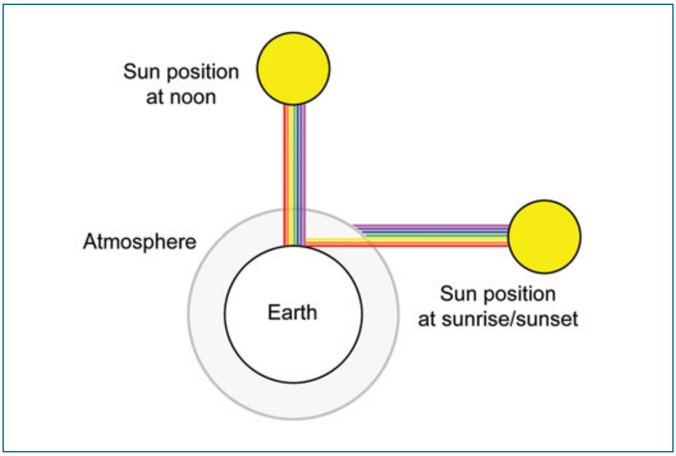
NOTE

Theoretically, "white" light has an equal combination of all of the colors of the spectrum, which doesn't truly occur in nature. Our brains use the primary natural source of light, the sun, as a reference to "white" light.



The spectural distribution of colors in average natural sunlight. Sunlight has a full spectrum of colors, but it is composed of more blue than red wavelengths.

At noon, at the sun's highest point, the direct rays pass cleanly through the atmosphere and you see a more complete spectrum of colors. At the extreme angle of the sun at sunrise and sunset, the atmosphere serves as a filter to cut out much of the blue and green wavelengths to make the light appear much redder.



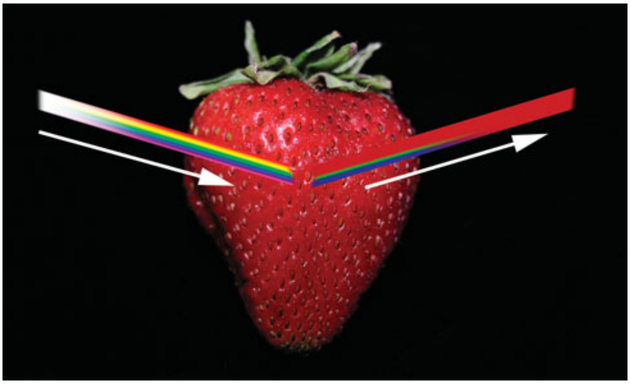
Reflection, Refraction, and Absorption

As I said earlier, we cannot see light itself. What we do see is light reflecting off of, or refracting through, objects in the world. You're looking at light reflecting off the surface of the page of this book, but you cannot see the photons falling onto the page.

Reflection and Absorption

Reflection is the primary way that people see objects in the world. Light strikes the surface of the object and certain wavelengths of light are reflected, or you could say, rejected, from the surface of the object. The wavelengths that are reflected define the color of the object you're seeing.

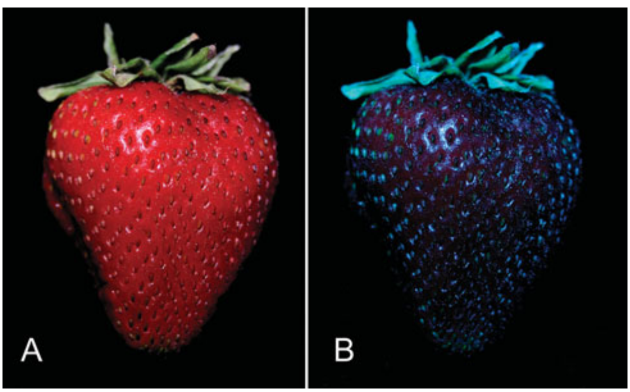
If you're looking at a beautiful red strawberry, the reason you're seeing red is that the surface of that strawberry is *absorbing* the violet, indigo, blue, green, yellow, and orange wavelengths and reflecting back, primarily, red wavelengths to your eye.



The full spectrum of light (left) strikes the surface of the strawberry, but *most* of the violet, indigo, blue, green, yellow, and orange are absorbed. The surface of the strawberry primarily reflects back red, with some blue, green, and yellow (right). The combination of these reflected wavelengths creates the red that we see.

If a camera photographs that strawberry, the sensor receives the same reflected wavelengths of light that the human eye does.

However, if you were to place a filter or *gel* between the light source and the strawberry that stopped any red wavelengths of light from reaching the strawberry, there would be no red light to reflect back, and the strawberry would actually then appear nearly black (for more on how filters work, see the section titled "Addition and Subtraction: The Arithmetic of Color" later in this chapter). This is, sometimes, a very difficult concept to grasp because our color memory is so strong that our brains will fill in the colors for us. We *know* that a strawberry is red, so, even though we *see* it as virtually black, it will still be red in our color memory. The camera, however, has no such ability to fill in the blanks. It will see and record only what is there.



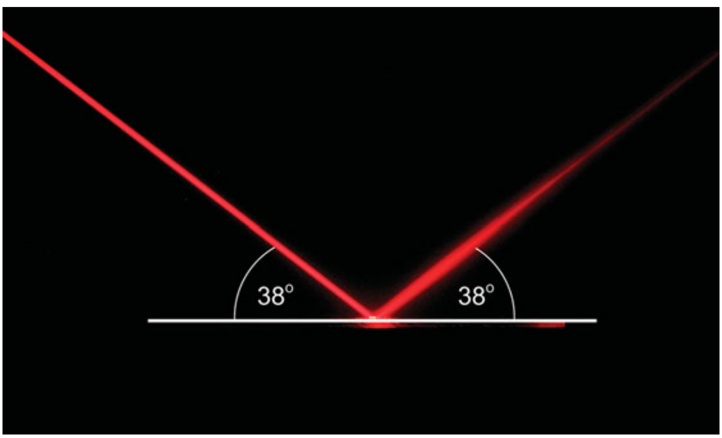
A strawberry (A) photographed under "white" light and the same strawberry (B), whereby the light is filtered through a combination of Rosco CalColor 30 Blue (#4,230), 90 Cyan (#4,390), and 15 Green (#4,415) to cut out as much of the red wavelengths as possible.

This is because that strawberry is absorbing pretty much all of the other wavelengths of light and since virtually no red is reaching that surface, no red is reflecting back, so the strawberry will appear to be mostly colorless. Since there is, actually, some blue and green in the red color of the strawberry (it's not pure red), it won't appear completely black, but the red luster is completely gone. Notice, also, in the image, that the green leaves, although a bit more cyan in the filtered photo (because the yellow wavelengths that make up the natural green color are also cut a bit), are still mostly green because the filters are mostly stopping the red wavelengths, but allowing green to pass through, and thereby reflect off, the leaves.

TIP

All objects have some degree of reflection and some degree of absorption. A piece of white paper might absorb 2% of the light hitting it and reflect 98%, whereas a piece of black velvet might absorb 98% of the light hitting it and reflect only 2%.

An important point to keep in mind with regard to reflection is that the *angle of incidence is equal to the angle of reflectance*. This is most clearly seen on a mirrored surface with a pinpoint of light. The precise angle that light strikes the mirrored surface is exactly the same angle that light will reflect off the surface.



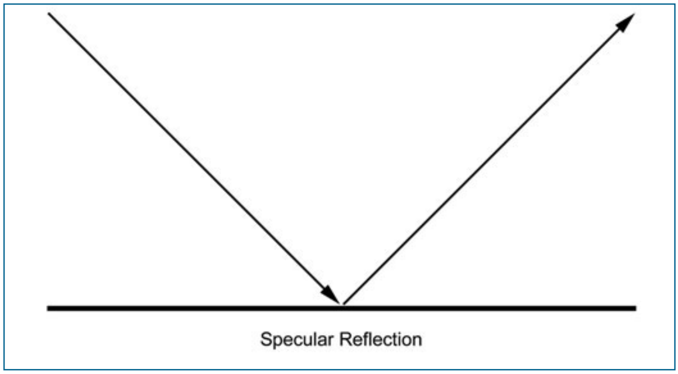
The light from a consumer laser pointer striking a mirrored surface. The angle of incidence (right) that the laser beam strikes the mirror is exactly the same as the angle of reflectance (left) of the laser bouncing off the mirror. (In this photo, a "fog" has been sprayed into the air, allowing the laser to reflect off the fog particles to make the actual beam of the laser visible.)

Different surfaces have different reflective properties, as defined in the following sections.

Specular

Specular reflection is a mirror image of the light source in the object. This happens off a glossy or highly polished surface like glass or chrome. Specular reflections, like in the following photo of the wine bottles, help to define the shape of the object being lit.

A large light source near the bottles creates a large specular reflection of the source and helps to define the curvature of the bottles in the image. This technique is often used in product photography to define the shape of the object through light reflection. Pay special attention to the use of specular highlights in car advertisements.



Line drawing of the effect of a specular reflection.

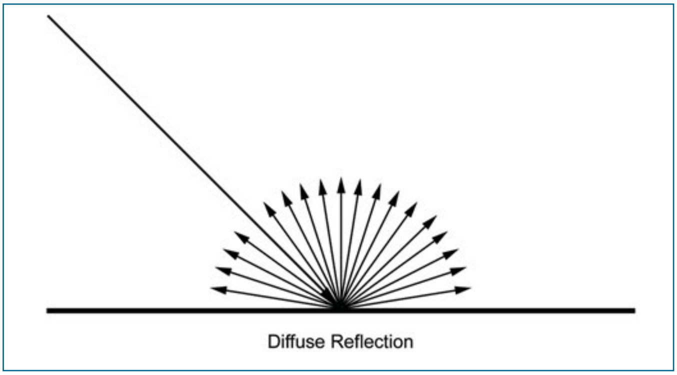
Diffuse

Light striking a diffuse surface is scattered in all directions evenly. This is, often, a porous or matte finish, like a piece of soft white cotton. These materials can serve to soften the light as it reflects off the surface and is scattered over a wider area than the light hitting the surface (more on light quality in Chapter 5, aptly named "Light Quality").

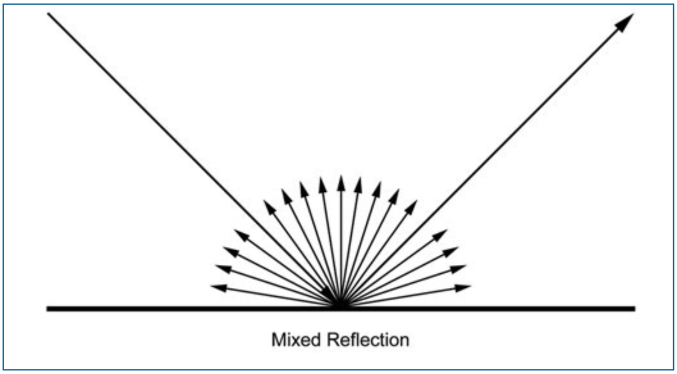
Mixed

Some materials with sheen directly reflect light off some areas, but also have different surfaces that scatter the light. A polished ceramic pot will have a specular reflection at one point, but the many imperfections in the surface will also scatter light in all directions.

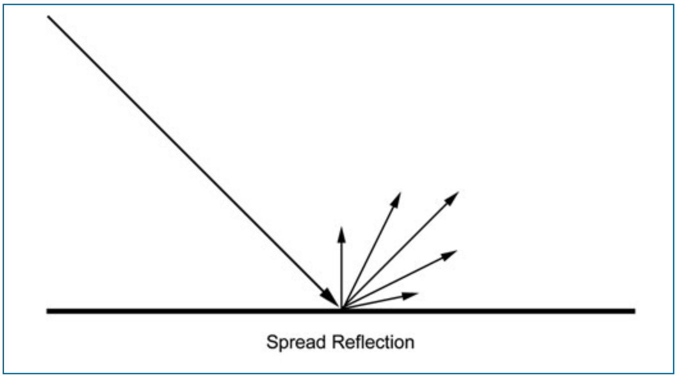
When light strikes a porous or textured surface, it often results in a diffuse reflection, whereby light scatters in all directions.



Mixed reflection is a combination of direct (specular) and diffuse where a polished, but textured, surface will result in scattering of light along with a specular highlight.

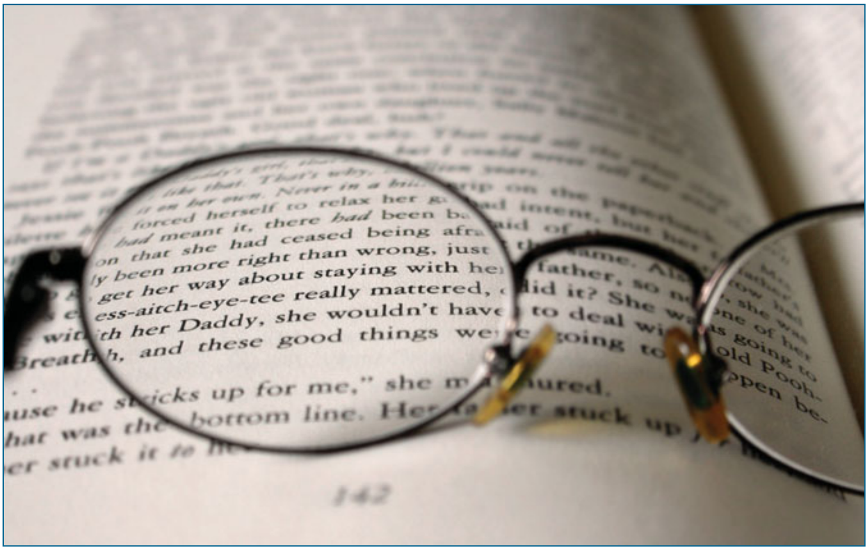


A textured surface can create a combination of diffuse and direct while still maintaining a more direct angle of reflectance.



Refraction

Refraction is a special property of certain objects to alter the direction of light rays. This happens through glass, water, clear plastic, and the like. Light strikes the surface of the refracting object, and its path is altered slightly as it passes through the object and exits the other side of the object, traveling in a new direction. Some people call this "bending" of light, but the light isn't being bent; it is deflected to a new direction. This is the basic principle behind lenses: grinding and shaping a piece of optical glass to a precise angle so that it will refract light to a new direction and, therefore, focus the light rays to a specific point.



An example of light rays being refracted and focused through the lens of a pair of eyeglasses to bring the image into sharper focus for the viewer. Eyeglasses are made of ground glass (or plastic) specifically designed to refract light to a specific angle to correct for deficiencies in the viewer's eyes.

The best example of light refraction is what happens when you submerge one end of a stick into a pool of water. The stick appears to *bend* to one side, although there is no bending happening; what you're seeing is the refraction of the light bouncing off the stick through the surface of the water.

Refraction is also what happens when you see fog. Light is refracting (and reflecting) off moisture particulates in the air, which creates the effect of fog.

Light refracting in water. The stick appears to be broken by the surface of the water in the glass, but it is the refraction of light creating the illusion.

How Hot Is Blue?

Color is incredibly subjective. No one really knows how the brain sees colors. Scientists theorize that the rods in our eyes are sensitive to changes in intensity of light only, but that people have three types of cones in the eye that are sensitive to certain wavelengths of light. One set of cones is sensitive to red, one to blue, and one to green. This is, however, only a theory. No one really knows, yet, how the eye and the brain see colors. To that end, no one really knows if two people really see the same color. Although two people can look at an orange and say, "that color is orange," if I could jump inside your brain and see through your eyes, your "orange" might look quite different from the orange I'm used to seeing. Yet we both call it "orange" because all of our lives that interpretation of that color has been the same. It's a lot like two people from two different cultures who speak different languages. Whereas I look at a tree outside and think "tree," a person born and raised in Mexico might look at that exact same tree and think "arbol."

What makes all of this even more complicated is that color identification, that is, giving names to colors (such as periwinkle or fuchsia), is incredibly subjective. One person might look at a patch of color and call it "periwinkle," whereas another would call it "lavender" and another would call it "pink." Who is right? Can anyone out there tell me the difference between alizarin and amaranth (two pinkish-red hues)?

What *Steel Magnolias* Can Teach You

There's a great moment in the film *Steel Magnolias* (that's right, I'm quoting *Steel Magnolias*; it's a great chick-flick and I am unashamed) in which Truvy (Dolly Parton) asks Shelby (Julia Roberts) what her wedding colors will be.

Shelby replies, "My colors are blush and bashful."

To which her mother (Sally Field) says, "Her colors are pink and pink."

Shelby's final retort is, "My colors are blush and bashful; I have chosen two shades of pink; one is *much* deeper than the other...."

It's a wonderful cinematic example of the subjectivity of color identification.

When I was first teaching color, I used to do an experiment and ask people to identify six color patches by name. They were, basically, Red, Orange, Yellow, Green, Blue, and Violet. People would look at the red and call it: fire engine red, vermillion, rose red, apple red, deep red, and so forth.

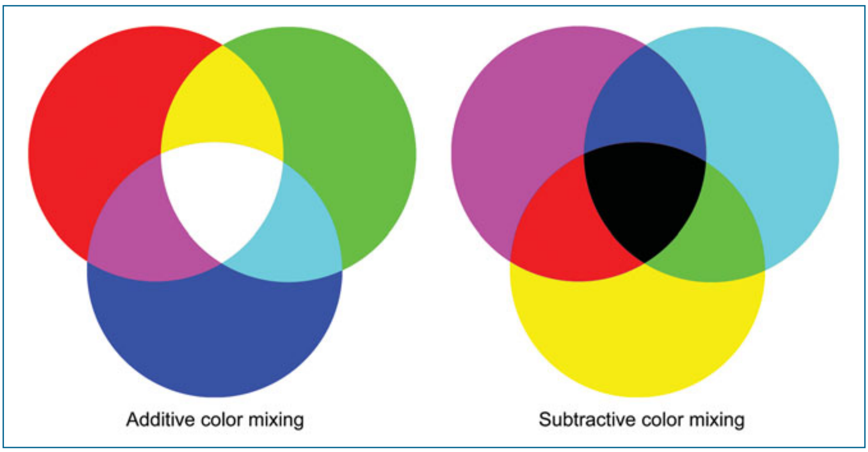
Over time, especially with my color deficiency, I have trained my eyes and brain to see colors in their component parts. I've learned to see the RGB values in a color, to a greater or lesser degree. That doesn't mean that I can look at a color and tell you the exact percentages of RGB, but I can look at a red and say "there's a lot of blue in there," or look at a blue and say "that's blue with a little red and a lot of green...." Any combination of these three lighting primaries—Red, Green, Blue—can create any color in the rainbow.

Addition and Subtraction: The Arithmetic of Color

As children, we grew up learning our colors. We learned the primary colors: red, yellow, and blue. Every child knows the adage: yellow and blue make green! Now, however, I'm here to tell you that the primary colors are red, *green,* and blue. What happened to yellow? How did green get the promotion?

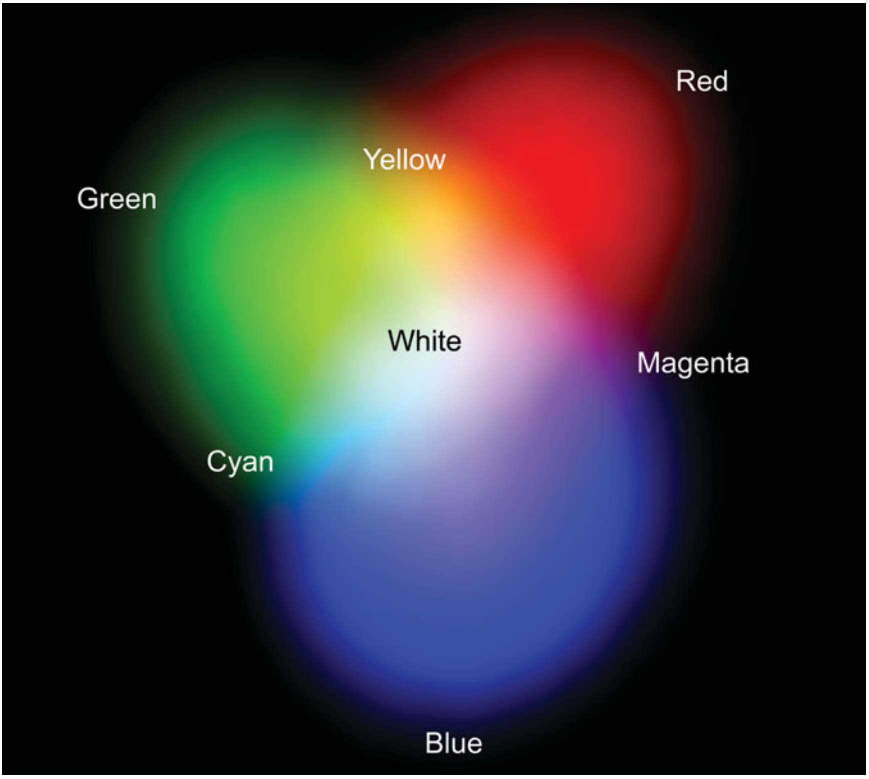
The reality is I am talking about two different aspects of the physics of color: *additive color mixing* and *subtractive color mixing*.

- Subtractive mixing is what happens when you mix paints together. Every new color you add (save white) actually darkens the mixture. If you mix all your paints together, you wind up getting black.
- Subtractive mixing is also what happens when you filter light; depending on the color and saturation of the filter, you are stopping certain complementary wavelengths of light from passing through the filter and thereby darkening the overall image.
- Additive mixing is what happens with light. Each new color of light you're adding actually makes the result *brighter,* and if you add up all the colors of light, it creates "white" light.



The differences between additive color mixing and subtractive color mixing.

A real-world example of additive color mixing. Three sources, red, green, and blue, are shined onto a white surface. The colors blend and combine to create a neutral/white in the center.

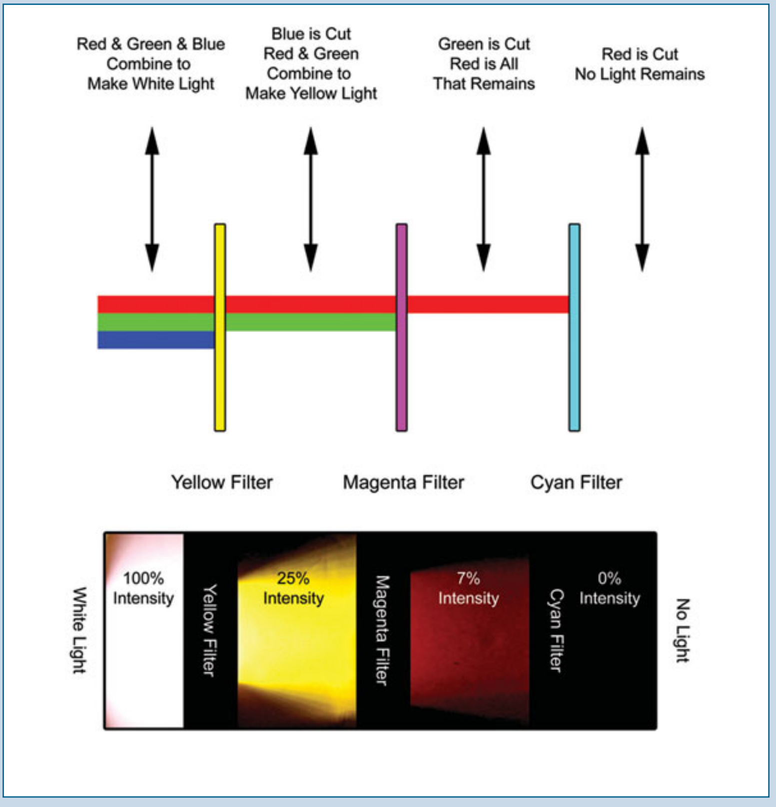


How Color Filters and Gels Work

Colored filters and gels work on the principle of subtractive color mixing and on the basic physics that colored translucent media will stop (or cut) the complementary (or opposite) wavelength of light from passing through the media. To simplify the discussion, I am going to look at "white" light as being composed of only three primary colors—red, green, and blue—as combinations of those three primaries can create any color of the rainbow. As illustrated in the images of the color circles; in additive color mixing, the mix of two colors creates a complementary color. Red and green combine to create yellow, blue and red combine to create magenta, and green and blue together will create cyan.

These secondary colors are the complements (opposites) of the primaries: cyan is the opposite of red, magenta is the opposite of green, and yellow is the opposite of blue.

If you put a yellow filter in front of "white" light, it will stop the blue wavelengths of light from passing through. All that will pass through the filter are the red and green lights (which together create yellow). If you then place a magenta filter in front of that yellow light, it will stop the green light from passing through, and all you have left is red. If you place a cyan filter in front of that, it will cut the red, and you will have no light passing through that final filter at all. Each stage of filtration cuts more wavelengths of light, and each cut therefore reduces the overall intensity of the light as wavelengths are no longer present.



The theoretical aspects of subtractive color mixing (top) and a practical example (bottom). White light passes through a yellow filter, which cuts blue. The magenta filter then cuts the green, leaving only red. The cyan filter then cuts the red so that no light passes through. Note that in subtractive mixing, each successive stage makes the result darker.

Saturated color filters are rarely used on the camera in color photography, but were often used in black and white photography. For example, if you wanted the blue sky to appear darker, you would use a yellow filter. The yellow filter would cut the blue wavelengths from striking the film and make the sky appear darker while still letting green and red pass through untouched so that flesh tones appeared normal.

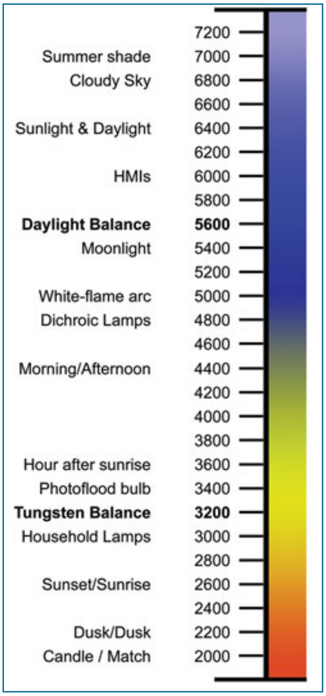
Model Amanda Bolten at sea. The left image is shot clean, without filter. The right image simulates the effect of shooting through a saturated yellow filter to cut the blue wavelengths, making the sky and ocean water appear much darker while leaving the skin tones untouched.

Color Temperature

With all of the subjectivity of color discussed previously, how do you go about defining color? One method is to relate it to a physical temperature on the *Kelvin* scale, originated by British scientist Lord William Thompson Kelvin in 1848. Lord Kelvin theorized that if you take a perfect black body radiator—which is a theoretical material that neither reflects nor refracts light—and you slowly started to apply heat, the radiator would start to glow. It would first glow red, and then orange, and then yellow, and then blue, and then white. In his scale, which started at *absolute zero* (–273°C), he was able to define stages of colors in the visible spectrum by specific temperatures.

When color film *emulsion* was invented—and then the *CCD* and *CMOS* chips much later—it did not have the flexibility to see "white" light as versatile as the human brain. Film and digital sensors have a very small window of temperatures they can see as "white" before colors will read as "false," as you can see in the images later in this chapter.

To combat this, the creators of imaging mediums picked two target points of color temperature that would be seen correctly. These were an average of measured daylight color temperature at high noon, which is about 5,600°K and tungsten incandescent fixtures, which burn at about 3,200°K.



A visual representation of the Kelvin scale with some common temperatures noted.

To Degree or Not To Degree

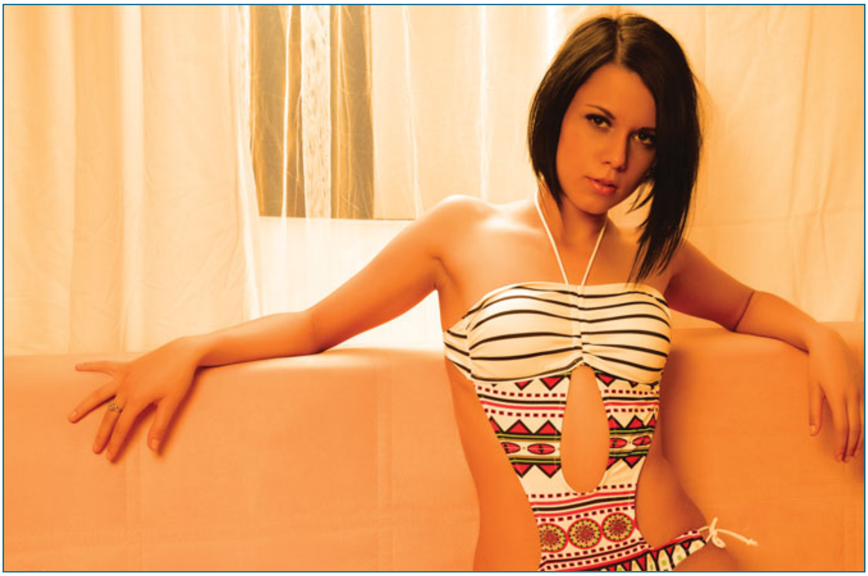
Although the Kelvin scale has a direct relationship to Celsius (zero Kelvin is –273° Celsius), the term "degrees" is incorrect when used with regard to Kelvin temperatures. However, many books and publications use the degree symbol (°) next to the Kelvin symbol (K) to distinguish it from K as an abbreviation of kilo or 1,000. Since discussions of lighting often involve both terms (5K light has a color temperature of 3,200°K), the degree symbol is often used to belay confusion.

These two numbers represent the "indoor" (3,200°K) and "outdoor" (5,600°K) camera settings and have become ubiquitous in the camera world since the invention of color images.

Neither of those numbers is infallible, unfortunately. Daylight is rarely ever exactly 5,600°K and incandescent lamps are rarely, if ever, 3,200°K. But the numbers represent a "close enough" approximation that allows for slight manipulations in color correction later to create the right look.

The “right” look that I’m talking about here is rendering the world—more or less—how it is seen to the human eye. This does not take into account artistic variations thereof, which are discussed later.

Although you may be able to stand in a room lit with tungsten (3,200°K) light at night and see everything “normal” in white light, if the camera is set to see daylight (5,600°K) as “white,” then everything in the room in the image will appear a deep orange. This is because the camera, on “outdoor” setting is programmed to see the higher Kelvin temperature as “white” and when the actual light that is captured is of a longer, warmer wavelength, it will appear a lot redder in the captured image—see the first image of model Alexandra Preda.



A simulation of “false” colors; model Alexandra Preda lit with tungsten (3,200°K) light and photographed with a daylight (5,600°K) white balance. As a result, flesh tones are too orange/yellow, and the whites are all too warm as well. Photo by Claudiu Gilmeanu.

Inversely, if you have your camera set for tungsten (3,200°K) or “indoor” color balance and you have natural daylight (5,600°K) in the picture, the natural daylight is going to appear very blue.

The next image is the same photo under proper lighting and setting; Alexandra is lit by tungsten (3,200°K) and photographed under a tungsten (3,200°K) white balance setting.

The same photo, simulating daylight (5,600°K) lighting under a tungsten (3,200°K) white balance camera setting.

The original photo of model Alexandra Preda under correct white balance.

A basic understanding of color temperatures and how digital sensors see them is fundamental to understanding light and photography.

Why is this so important? Because the camera's sensors are not as flexible as your eye, and understanding how to see different temperatures when you're encountering a mix of lighting will give you solid ground about how to fix the situation: when to use filters, when to use different light sources, and what to expect when color temperatures mix.

White Balance

A seemingly magical function of digital sensors is the ability to break away from the 3,200/5,600°K benchmarks as the only white points and to assign a custom white point. This is what the white balance function of your camera does. All digital cameras will have at least two settings: tungsten/indoor and daylight/outdoor. Most every digital camera out there will allow you to custom—or at least auto—white balance. This is a function wherein the camera's sensor measures the color of what it believes to be the neutral (white/gray) elements of the scene and makes an adjustment to render objects that should be white as neutral; this adjusts the rest of the colors in the scene into what should be a "natural" look.

For home videos, nine times out of ten, the auto white balance is fine, wherein the camera simply looks at the brightest areas of the frame and adjusts them toward a white point. It is, however, always a compromise to allow the camera to do the thinking for you. You are forcing the camera to take an average reading and give you an average result. It is always better to custom white balance to any given scene, wherein you "tell" the camera what exactly is white and to rebalance every time you change the lighting.

White from Gray

The best way to white balance isn't actually off a white object—it's off perfectly neutral gray object. It's a lot harder and, thereby is more precise, for RGB (red, green, blue) sensors to achieve a perfect neutral gray than it is to achieve a neutral white. You can get a calibrated 18% (more on this in Chapter 3, "Understanding Exposure") gray card from a number of manufacturers, but the best I've ever seen is a product called the ExpoDisc (see expodisc.com), which is a perfectly calibrated piece of plastic that fits over the lens of your camera and allows only 18% of light to transmit through it in a perfect balance of RGB to achieve a perfect 18% gray every time. This disc will last 20 times longer than any gray card (which fade and discolor over time and wear), and I've never achieved more perfect results than with the ExpoDisc.

However, barring an ExpoDisc in your bag, or a calibrated gray card, you can fall back on any old piece of white. In a pinch, I've white balanced off typing paper, the side of a truck, a t-shirt.… Not one of these things is optimum, mind you, but they work in a pinch and are often much better than using the auto white balance feature.

When To Correct

It is important to understand that if you are trying to achieve a specific creative effect, say a deep blue moonlight, that you white balance *before* you apply the effect gels to your lights or filters on your camera; otherwise, the process of white balancing will cancel out the effect. For that deep blue night look, you'll need to white balance under "clean" lighting (without gels or filters) and then apply the blue gels to the lights or filters on your camera lens.

You can also fake out the camera to achieve a certain effect by deliberately white balancing off objects that are not pure white/gray. If you white balance off a yellowish or orangeish surface, the camera will "correct" for that color and render the scene in a cool/blue tone. Inversely, if you correct off a bluish object, the camera will render the scene in a much more orange/warm tone. Different manufacturers sell white balance cards that have subtle warm/cool tones in them to achieve these effects. You can also achieve these effects by placing colored gels (preferably calibrated CTO or CTB) over the lens and white balancing off a white or gray card. Be careful, though, that you don't go too extreme with this kind of technique as you can quickly overdrive the camera's color range and end up with artifacts and distortions in your image.

In Mixed Company

Where things get tricky with white balance is in mixed lighting situations. If you have natural daylight, mixed with tungsten lights, you're going to have to pick your approach:

- Alter one of the sources of light to match the other through the use of color correction gels or filters.
- Pick one to balance to, knowing the other will be greatly out of "neutral."
- Compromise on a middle ground.
- Replace the tungsten lighting with daylight color balance lighting fixtures.

If you let the camera make the choice, it will compromise on a middle ground and white balance somewhere between the 3,200°K and 5,600°K marks, more than likely biased toward whichever of the two is the brighter source. If it picks an even middle ground, your indoor lights will be slightly warm and your daylight will be slightly cool, which will rarely be the best solution. In this scenario, nothing is rendered "correctly" as your eye sees it, but rather the entire image is compromised.

If you pick only one color to set as white, the other lighting will be off. If you choose to set your white balance to the daylight, your indoor lights will look very orange. If you set the balance to the indoor lights, your daylight areas will appear very blue. This isn't always a bad situation, though. Depending on your creative choices, having differing color temperatures might be preferable. Sometimes cool blue daylight can give the feeling of a cold day outside, or the warm indoor lights can lend a romantic feeling to the scene.

Replacing the tungsten lighting with daylight color balance lighting fixtures isn't always possible, as daylight color balanced lighting fixtures are, often, very expensive or unavailable. You can incorporate fluorescent fixtures (such as with the fluorescent light project later in Chapter 9, "Fluorescent Fixtures") with daylight color balanced lamps with high CRI (see Chapter 8, "Tungsten Fixtures," for more on CRI), or incorporate LED fixtures, HMI gas-discharge fixtures, or tungsten with *dichroic* (color corrected glass) lenses. These are all specialty fixtures, though, and not always available.

The least expensive solution is to gel one of the sources of light to match the other. "Least expensive" is a relative term, however, because color correction gel isn't cheap. But if well taken care of, a roll of CTB or CTO will last you a long time. The question is which source do you gel? The most efficient method—in this scenario—is to filter the natural daylight to match the tungsten color temperature. You do this by adding CTO gels to the windows to filter out the blue wavelengths and correct the 5,600°K color to 3,200°K.

The reason it is better to gel the windows, rather than the lights themselves, is that due to the subtractive color mixing process, any gels you use will reduce the intensity of light passing through it. CTO gel (Correct to Orange is a good way to remember) blocks out about two thirds of a stop of light, or about 33% of the light passing through the filter. As daylight is usually the brightest thing around you, this isn't too much of a compromise, and it is often desirable to bring the intensity of the daylight closer to the intensity of the artificial lights anyway.

Inversely, if you gel the tungsten lights to match the daylight, you will use CTB (Correct to Blue) gels, which block out the red, orange, and yellow spectrums. CTB gels are much more saturated than CTO gels, and they reduce the light by as much as 75% (two stops). Typically, your artificial lights are already much dimmer than the natural daylight, so cutting them down by 75% is going to make them even more powerless against the light of the sun.

The challenge here, of course, is that color correction gel isn't cheap. You're typically going to spend $140 per 4'×25' roll of gel. If you have a lot of windows to cover, that could get expensive—or impossible, depending on the position, size, and number of windows. It's important to know your options and make the best decision based on your time, resources, and budget.

A fifth option, which I did not mention previously, is to shut off all the indoor lights and use bounce cards and reflectors to light only with daylight. This is, often, the least expensive and quickest—although not always the easiest—solution. I'll discuss more options along these lines in Chapter 6, "Lighting Techniques."

Gels and Filters 101

Color correction comes in four primary "flavors": CTO, CTB, Minus Green, and Plus Green.

CTO and CTB, as I've already discussed, are orange and blue filters. They are specifically designed to vary the color temperature of daylight toward tungsten (CTO) or tungsten toward daylight (CTB). These gels are sold by a number of manufacturers—Lee, Rosco, and Gam being the big three—and they are offered in varying strengths, including Full, ¾, ½, ¼, and ⅛. Each successive fraction will offer less correction, be a less saturated color, and allow more light to pass through.

A rainbow of colors… The sample swatch books of various colored gels from the three major manufacturers.

You can also get color correction filters for the lens of your camera. A Full CTB is the equivalent of a Kodak 80A, and a full CTO is the equivalent of an 85B.

A variation of CTO, called *CTS* (straw), is also available from a number of manufacturers. This serves the same technical purpose as CTO, but it is slightly more yellow and produces a slightly warmer look.

In the next category of color correction, Minus Green is a magenta gel in the same available strengths as CTO and CTB. It is designed to be added to a standard fluorescent light with a lot of green wavelengths in it to correct out the green. Inversely, Plus Green is a green gel intended to be added to tungsten or daylight fixtures to *add* in the green to match the green content of standard fluorescent fixtures.

The varying strengths of all of these gels allow for a lot of finesse in your color correction and color effects work. If it's late in the day, you might have a much warmer temperature of sunlight coming through the windows of around 4,000°K, and Full CTO would actually correct that reddish light to *below* 3,200°K, so you might only need ½ or ¼ CTO to make the correction. If it's a very cloudy day, you might have a much higher color temperature outside, as high as 20,000°K, in which you might need two or three layers of Full CTO in order to correct that high, blue, temperature to tungsten.

Myriad Mireds

Color correction, unfortunately, isn't linear. Although a Rosco ¾ CTO will convert 5,600°K to 4,500°K, which is a change of 1,100°K, the same filter will convert 4,500°K to 3,785°K—a difference of only 715°K.

If you want to get specific about your color correction, the easiest way is to work with mireds, or *microreciprocal degrees*.

Although this requires a lot more math than most people like, it is the simplest and most accurate way to deal with technical color correction of light. It does require that you have a color temperature meter.

Unfortunately, you can't just take a reading of the color temp, look at it, and say, "Oh, it's 5,200°K outside right now. I need it to be 2,975°K to match my indoor lights, so I need a gel that will drop the temperature by 2,225°K!" It isn't quite that simple.

To find a system whereby correction gels *can* be applied mathematically, you have to turn to mireds. A mired is derived by dividing 1,000,000 by the color temperature. Then you take your target mired and subtract your mired to be corrected to get the mired shift needed.

So 5,600°K has a mired value of 179, and 3,200°K has a mired of 313. You want to correct the 5,600°K to 3,200°K, so you take the target mired, 313, and subtract the mired to be converted, 179, resulting in a mired shift of 134. Looking through the manufacturer's specs on CTO, you'll find that Rosco's ¾ CTO (gel #3411) has a mired shift of +131, which is pretty close! Lee's "HMI to Tungsten" (gel #236) has a mired shift of +130, and Gam's ¾, (gel #1546) has a shift of +125. None of them is "perfect," but all will get very close. Rosco, in this case, will get you the closest.*

Note, since most real-world "tungsten" sources are actually lower than 3,200°K (for more on this, see Chapter 8), most Full CTO actually corrects 5,600°K to anywhere from 2,900°K to 3,100°K (+146 to +167 mired), depending on the manufacturer.

In the previous example, if you read your daylight temperature as 5,200°K, which is a mired of 192, and your tungsten at 2,975°K, or 336 mired, you need a shift of 144. No single gel has a mired shift value of 144, so you'll need to combine a couple of gels to get your shift. In Rosco, the ¾ CTO (3411) has a mired shift of 131; plus the ⅛ CTO has a shift of 20 mired for a total of 151. In Lee ¾ CTO (442) has a shift of 123; plus ⅛ CTS (444) has a mired shift of 21 for a total of 144—*perfect!*

When you're correcting from tungsten to daylight, adding CTB, you're going to end up with negative mired shift numbers. For instance, correcting a 3,200°K tungsten fixture, with a mired number of 313, to daylight 5,600°K color temperature, with a mired number of 179. Since, to find the calculation, you subtract the conversion from the target, you're going to be subtracting 313 from 179 to get a mired shift of –134. Rosco's Full CTB has a shift of –131, Lee's is –137, and GAM's is –141

**Mired shift numbers courtesy of David Eubank's pCAM iPhone/iPod application.*

As I mentioned earlier, all gels, with very few exceptions—by the very nature of working in subtractive color mixing—will filter out certain wavelengths of light and, thereby, will reduce the transmission of light through them. In simple terms, every time you put a gel on a light or a filter on your lens, you're going to lose light. Sometimes this is desirable, as in the case of bright sunlight coming through the windows fighting against low wattage tungsten lights; it's actually a benefit to reduce the intensity of the sunlight by filtering it. To that end, you can also get a neutral density (ND) gel, which is a gray or smoke color and does not change the color of light passing through (hence "neutral"), but does reduce the intensity.

ND gel is calibrated in a logarithmic scale of 0.3, 0.6, 0.9, and 1.2, each being a stop of light, or reducing the light by 50%. So a 0.3 reduces the light by one stop, or 50%, a 0.6 reduces the light by two stops or 75%, a 0.9 reduces the light by three stops or by about 85%, and a 1.2 reduces the light by four stops, or by about 90%. See Chapter 11, "Accessories and Miscellaneous Tools," for notes on nets and alternative material you can use in certain cases in place of ND gel to reduce light intensity.

ND filters are also available for cameras and most digital cameras have them built in. These are generally expressed in fractions of light reduction, rather than logarithmic scale. So $1/2$ is a one stop, $1/4$ is a two stop, $1/8$ is a three stop, $1/16$ is a four stop, and $1/32$ is a five stop light reduction.

Now that you have a better understanding of the science and physics of light and color, I'll move on to discussing how to harness this light to create images.

3

Understanding Exposure

To understand lighting, before you consider the actual placement and types of lights, you have to understand *exposure*. With new filmmakers, this is often a confusing and dark territory that they leave up to the camera's automated functions.

For cinematographers, exposure is the main brush in their palette. Exposure isn't just a technical setting on the camera, it is a very carefully considered artistic decision about how to best represent the lighting in the scene to tell the story.

Exposure Basics

Let's take a look at the fundamentals of photography. Photography, as I've already espoused, is the art of capturing light. The real artistry and skill, though, comes from the control and manipulation of that light.

It's important to understand how the digital sensor in your camera sees and interprets that light. Any aspect of the camera's functions that affects the light entering the camera, the period of time at which that light is revealed to the sensor, or the electronic manipulation of the sensor's sensitivity to the light makes up the elements of exposure.

My Cup Runneth

Imagine light for a moment as water. Instead of exposing an image, I want to fill a glass with water. My glass is a fixed size, so I need only so much water to fill it. Too little water and I won't have a full glass; too much water and it'll spill.

There are two major factors that control how I fill my glass: the amount I open the valve on the faucet and the length of time I let that water pour into my glass.

I can fill the glass with a number of combinations of these two: either a wider valve opening and less time pouring water, or a smaller opening and let the water flow for longer.

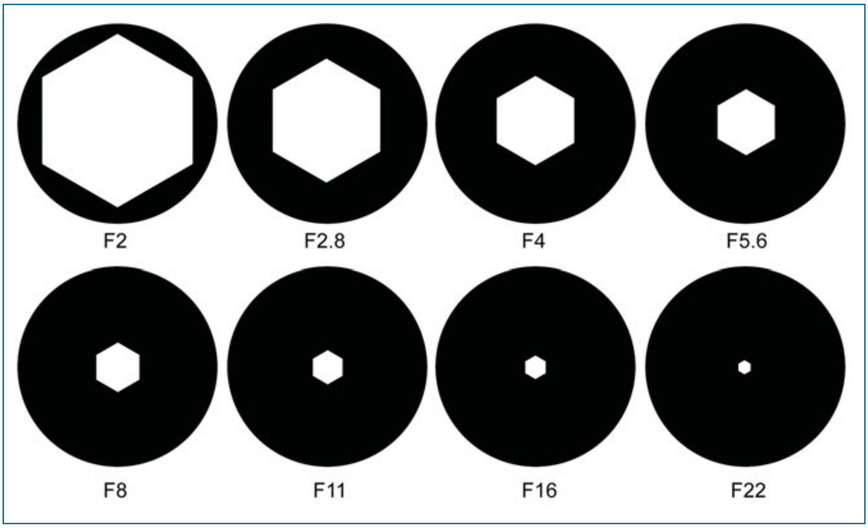
Exposure works this same way; the intention is to fill the glass. Except instead of a glass, it's a digital sensor, and instead of water, you're "filling" it with light. Just like the glass, there's a certain amount of light that sensor needs to be "full" (or to have a "proper" exposure). Too much light and the sensor will overflow. Too little light and the sensor won't be full.

Aperture

One major aspect of exposure is set by the *aperture* (iris) of the lens on the camera. By way of the water/glass example, imagine that exposure is the valve in the faucet. The more you open the valve, the more water flows into your glass. Inside the camera, the aperture, like a valve, is a literal adjustable diaphragm (like the pupil of your eye) that opens or closes to let in more or less light. The size of the opening is calibrated by numbers called *f-stops*, which are determined by a mathematical calculation between the size of the iris at that specific setting and the *focal length* of the given lens, which is most often represented in millimeters (mm). An *f*-stop is a fractional number, so it is an inverse scale whereby the higher the number, the smaller the iris opening (this is a little easier to grasp if you think of all the *f*-stop numbers as the denominator in a fraction with the numerator of 1. Each *f*-stop is actually $\frac{1}{x}$ or "one over" the *f*-stop number—so $\frac{1}{2}$ is much larger than $\frac{1}{22}$).

Standard *f*-stops are *1.4, 2, 2.8, 4, 5.6, 8, 11, 16,* and *22*.

So the higher the number, the smaller the opening, the less water flows into the imaginary glass. The lower the number, the more you're opening that valve and the more water flows.



Some of the most common aperture settings. The smaller the number, the larger the aperture opening, which means more light into the lens.

Each *f*-stop in succession is measured to be exactly half as large in diameter as the previous stop, and so that setting allows exactly half the amount of light through the lens as the previous setting. *f/1.4* is a very large opening, whereas *f/22* is barely a pinhole. The more light in the scene, the smaller the iris needed. In bright sun, you'll be "stopping down" (meaning closing the iris more) to around the *f/22* range, and in a dark room, you'll be "opening up" to the *f/1.4* range (if your lens is capable of opening that much, many digital video lenses are *f/2.3–f/2.8* at their widest).

F to the T

The *f*-stop is a geometric relationship, a pure mathematical calculation between the size of the iris and the theoretical focal length of the lens.

$$f - \text{Stop} = \frac{\text{Focal Length}}{\text{Diameter of Lens Opening}}$$

This is the same for every lens; it's purely a mathematical relationship.

Motion picture lenses are calibrated on a T-stop scale. T stands for *transmission* of light, and this is a much more refined and exacting scale. Each individual lens, after it has been manufactured, is put on a specific table, and the precise light transmitted through the lens is measured to determine the T-stops. T-stops work on exactly the same numeric scale (*1*, *1.4*, *2*, *2.8*, *4*, *5.6*, *8*, *11*, *16*, *22*, and so on) as *f*-stops, but are a more precise representation based on the characteristics of that specific lens. They are, however, treated exactly the same in terms of exposure and are, in essence, interchangeable. T-stops are simply a more precise *f*-stop. If the lens you're using happens to have both T- and *f*-stops, it is always best to use the T-stop scale.

Light

The basic unit of measurement of light is the *footcandle* (fc). A footcandle is the theoretical light emitted from one candle, one foot away from a one-foot square "target." In many other countries, they refer to the basic unit of light measurement as the *lux*, which could also be thought of as the "meter-candle" in a way. 1fc is equal to 10.764lux.

Footcandles are merely a method of measuring intensity, or brightness, of light. Many lighting manufacturers present *photometrics* in their literature, which are charts listing the various intensities (most often in *footcandles*) of light that will be output from a specific fixture at a given distance. With an understanding of how footcandles relate to exposure, you can evaluate how well a particular lighting fixture will serve your needs by simply reading the literature before you buy or rent that fixture.

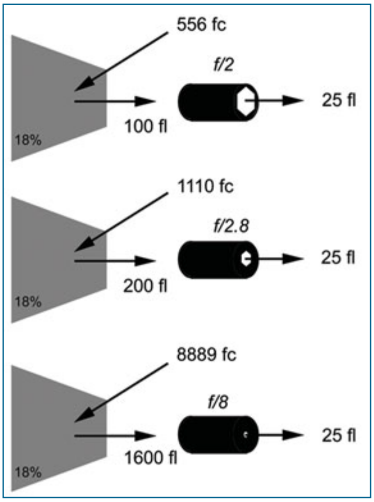
Footcandles are a measurement of *incident light,* which is the light that is falling onto an object. After the light strikes the object and reflects off (this is the light that you can see), you then measure the intensity in *footlamberts* (fl). Both units of measure refer to the intensity of light; footcandles is the light emitted from the source, and footlamberts is the light reflected off the subject.

Footcandles in Action

Just like the valve in the water faucet, the purpose of an aperture on the camera is to control the amount of light that passes through the lens and reaches the sensor inside the camera. Every sensor will have its own specific sensitivity to light, which is just like the size of the water glass. Every sensor needs a certain amount of "water" to fill it. With the "proper" exposure, the camera will see the scene as close as possible to how your eye sees it. Too much light passing through the lens, and your scene will be overexposed, appearing to be overly bright where details will be lost in the bright whites. Too little light and your scene will be underexposed, losing details in the blacks and shadows of the image.

For the sake of understanding this a bit, assume that you have a sensor that requires 25 footlamberts of light for "proper" exposure. By proper, I mean that the elements of the scene are rendered pretty much as your eye sees them. If you were photographing a medium gray wall, under "proper" exposure, that wall would be seen in the final image exactly as it looked to your eye: as medium gray.

For the sake of example, assume that this gray wall has a reflectivity of 18% (more on the significance of 18% later in this chapter). That means 18% of the incident light (footcandles) falling onto the wall will be reflected off (footlamberts), and the other 82% will be absorbed.



Incident light (measured in footcandles) falls onto a gray wall, and 18% of the light is reflected (measured in footlamberts) toward the lens. The aperture setting on the lens restricts the light passing through to allow only 25fl of light to reach the sensor inside.

If the incident light falling on the wall is 556fc bright, and the wall reflects 18%, then 100fl will reach the camera lens. If there were no aperture in the camera, 100fl would reach the sensor inside. Since you've assumed that the sensor needs only 25fl for a proper exposure, this would mean that four times the required light would pass through the lens and overexpose the image. The recorded image would not be a medium gray wall, but rather it would appear to be a white wall.

To make sure the camera sees the wall correctly, an iris is utilized to cut down the light passing through the lens to allow only the required light to strike the sensor. The absence of an aperture—or a completely open aperture would be an *f/1*. Keeping in mind that each successive *f*-stop cuts the light passing through the lens by ½, you will need to stop down two *f*-stops to cut the light down to ¼. Closing the aperture down one stop from an *f/1* to an *f/1.4* would cut the light in half, allowing only 50fl of light to pass through the lens, but that would still be too much light, so you will need to stop down further to an *f/2* (the next smallest stop on the scale) to let in half the light, again, and allow only 25fl of light to pass through the lens and strike the sensor inside. As the sensor requires 25fl of light for a proper exposure, the resulting image will represent the gray wall exactly as it was to the eye: as medium gray.

If there were a brighter source of light striking the wall, say 1,110fc, the light reflecting off the wall (18%) would be 200fl. To restrict that light to 25fl, you would need to cut it down to ⅛ that level. This would require stopping down three stops: the first stop cuts the light in half, the second stop cuts it down to one-quarter, and the third stop cuts it down to one-eighth, or 25fl. This would mean stopping down to an *f/2.8* (from *f/1* to *f/1.4* to *f/2* to *f/2.8* equals three stops, or ⅛ the light).

If the light falling on the wall were even brighter still, say a blazing hot 8889, 1,600fl would be reflected off and you would need to stop down six *f*-stops to an *f/8*, which allows only 1/32 of the light through the lens. 1/32 of 1,600 is 25.

The brighter the scene, the more you need to stop down the iris to get the "proper" exposure, but notice in all cases, the result you're looking for is only the required 25fl passing through the lens to achieve the "proper" exposure—no matter how much light is in the scene, that's the result you're looking for. The amount of light that the CCD or CMOS sensor requires for "proper" exposure remains constant. The water glass is a fixed size and always requires 25fl of "water" to be full, so you have to restrict that faucet size, depending on the water pressure (lighting brightness) in the pipes.

If the amount of light coming off the wall were less than 25 footlamberts, you couldn't open your lens any more to let in more light, so you would have to add more light to the scene or adjust the camera's other functions—such as gain—to make it more sensitive to light.

How Many Feets Is Enough Foots?

There's a great rule of thumb for being able to calculate how many footcandles of illumination you'll need for any given exposure—assuming you're shooting at 24fps with a 180-degree shutter (more on this later in the chapter):

100fc at 100 ISO is an f/2.8

At 30fps (180-degree shutter, or 1/60 shutter speed):

125fc at 100 ISO is an f/2.8

From there, you can calculate pretty much anything, always remembering that each doubling or halving of light is equal to one stop. Each doubling or halving of ISO is also equal to one stop. Tables 3-1 and 3-2 may also be handy for determination how many footcandles are necessary at a given ISO to achieve a specific *f*-stop.

Table 3-1: Footcandles Required at a Given ISO to Achieve a Specific *f*-stop at 24fps 180-Degree Shutter (or 1⁄48 Sec Shutter Speed)

ISO Number	*f*-Stop								
	1.4	*2*	***2.8***	*4*	*5.6*	*8*	*11*	*16*	*22*
25	100fc	200fc	400fc	800fc	1,600fc	3,200fc	6,400fc	12,800fc	25,600fc
50	50fc	100fc	200fc	400fc	800fc	1,600fc	3,200fc	6,400fc	12,800fc
100	25fc	50fc	**100**fc	200fc	400fc	800fc	1,600fc	3,200fc	6,400fc
200	13fc	25fc	50fc	100fc	200fc	400fc	800fc	1,600fc	3,200fc
400	6fc	13fc	25fc	50fc	100fc	200fc	400fc	800fc	1,600fc
800	3fc	6fc	13fc	25fc	50fc	100fc	200fc	400fc	800fc
1,600	2fc	3fc	6fc	13fc	25fc	50fc	100fc	200fc	400fc
3,200	1fc	2fc	3fc	6fc	13fc	25fc	50fc	100fc	200fc
6,400	.5fc	1fc	2fc	3fc	6fc	13fc	25fc	50fc	100fc

Table 3-2: Footcandles Required at a Given ISO to Achieve a Specific *f*-stop at 30fps 180-Degree Shutter (or 1⁄60 Sec Shutter Speed)

ISO Number	*f*-Stop								
	1.4	*2*	***2.8***	*4*	*5.6*	*8*	*11*	*16*	*22*
25	125fc	250fc	500fc	1,000fc	2,000fc	4,000fc	8,000fc	16,000fc	32,000fc
50	63fc	125fc	250fc	500fc	1,000fc	2,000fc	4,000fc	8,000fc	16,000fc
100	32fc	63fc	**125**fc	250fc	500fc	1,000fc	2,000fc	4,000fc	8,000fc
200	16fc	32fc	63fc	125fc	250fc	500fc	1,000fc	2,000fc	4,000fc
400	8fc	16fc	32fc	63fc	125fc	250fc	500fc	1,000fc	2,000fc
800	4fc	8fc	16fc	32fc	63fc	125fc	250fc	500fc	1,000fc
1,600	2fc	4fc	8fc	16fc	32fc	63fc	125fc	250fc	500fc
3,200	1fc	2fc	4fc	8fc	16fc	32fc	63fc	125fc	250fc
6,400	.5fc	1fc	2fc	4fc	8fc	16fc	32fc	63fc	125fc

Frame Rate and Shutter Angle/Shutter Speed

Aside from controlling the valve opening as to how much water flows out of the proverbial faucet, the length of time you let the water run also determines how full the glass will get. In recording digital video, this is the equivalent to *frame rate* and *shutter angle*, both of which affect the length of time that the light is revealed to the sensor. *Shutter speed*, which is a term coined from still cameras, but used in many consumer and prosumer cameras, is actually a combination of frame rate and shutter angle—all of which is discussed in this section.

Frame Rate

Motion pictures are possible through an optical phenomenon called *persistence of vision*. For all intents and purposes, this is a flaw in human visual perceptions that the human mind can see a series of still images in rapid succession and perceive a sense of motion between them.

Motion pictures, therefore, are achieved by recording still images at a fixed number of images per second and then replaying those images at that same speed; this is called the *frame rate*.

The frame rate is the number of *frames per second* (fps) that the camera records the still images. This is typically 24, 25, 30, 50, or 60, but many new cameras can do other variations for special effects. The higher the frame rate, the faster the images are recorded and, therefore, the less light being captured by the sensor. Back to the water example, the higher the frame rate, the less time the faucet is open to allow water to flow. This concept will be a little clearer in the discussion of *shutter speed*.

Each time you double a frame rate, you let in half the amount of light as the previous rate. 48 frames per second lets in half the amount of light to the sensor than does 24 frames per second. If you want to maintain an equal exposure and you were shooting at an *f/2.8* at 24fps, but then changed to 48fps, you would have to open the iris up one stop to an *f/2* to let in twice as much light to compensate for the speed capturing only half as much. Then your exposure will remain the same.

Why Different Speeds?

At the time of the invention of motion pictures, it was determined that 18fps was the minimum speed at which images could be presented to achieve the effect of persistence of vision. The minimum speed was preferred as it used less film and was, economically, more efficient. With the advent of sound, this speed changed to 24fps, which was the minimum speed at which the film could travel and reproduce quality sound. For many, many years—and still in the theatrical motion picture world—24fps was the standard speed.

Television required a different standard. It was settled on 30fps for television in the US and, because of electrical frequency differences, 25fps in many other countries.

To achieve a normal sense of motion, images are recorded at the same speed they are presented; if the image is recorded at 24fps and played back at 24fps, the motion will appear normal.

However, there are times that a special effect is desired. If the image is recorded at 48fps, yet still played back at 24fps, the image will appear to move at half the normal speed. This is how slow motion is achieved. The playback speed is fixed, but the recording speed can be increased and, as an end result, alter the perception of movement and time to the audience. An image recorded at 96fps, but played back at 24fps will appear to be a quarter of the normal speed. Inversely, if you record the image at 12fps and play it back at 24fps, the image will appear to move twice as fast.

Additionally, although video traditionally runs at 30fps in the US, technology advancements have allowed more digital cameras to shoot at 24fps to achieve a more "film-like" quality to the image.

Shutter Angle/Shutter Speed

Shutter angle is a film camera term; *shutter speed* is a still and video camera term.

Shutter angle refers to the literal degree of opening in a rotating shutter in a motion picture camera.

To help you understand the concept of shutter angle, I'll step away from digital cameras for a second here and talk about motion picture film cameras.

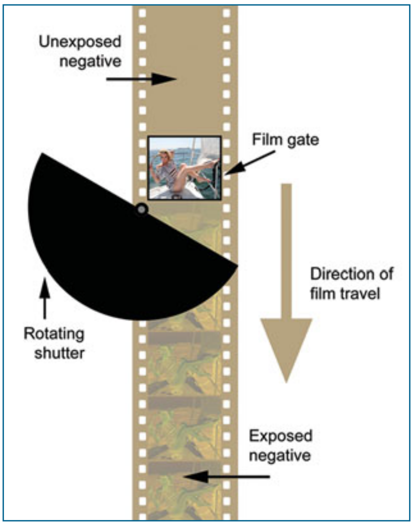
The inside of any camera is a light-tight box. No light gets inside the box except through a designated window, called the *gate,* which is behind the lens, covered by the shutter. That shutter opens, very briefly, to allow light to expose one single frame of film through the gate (leaving the rest of the film untouched), and then the shutter closes again to seal the camera from light. If the shutter weren't in place, light would always be striking the film and the image would be extremely overexposed. Keep in mind that film (and digital sensors) are very sensitive to light and require only a mere fraction of a second of exposure to that light to record a "proper" image.

Inside a motion picture camera, the film travels through the camera (normally) at 24fps, but it doesn't just run through smoothly. Again, motion pictures are made up of a succession of still images, so each individual frame needs to be stopped in the gate and held still while the shutter opens to allow light to expose that frame of film. In that fraction of a second, the motion picture camera is acting just like a still camera, exposing a still image onto a single frame of film. Once the exposure happens, the film is moved to the next frame. If light were hitting the film the whole time, the image would just be one huge blur.

In a still camera, the shutter is a curtain of light-proof material that moves horizontally to "open" the gate and then returns to a closed position. Like a sliding door.

In a film camera, the exposures are happening so quickly, and need to do so for the full length of time that the camera is running, the traditional "door" or "curtain" shutter won't work. In addition, the very loud shutter sound of the typical still camera would never be acceptable in a motion picture camera, which has to operate around sensitive sound recording equipment.

Instead, a motion picture camera uses a circular shutter. This is a circular piece of metal that sits between the gate and the lens. A portion of the circle is cut away to allow light to pass. The shutter spins at a given speed for the particular frame rate, and the solid portion of the circle covers the gate while the film advances through the camera. The film is then held in place, momentarily, during which time the shutter rotates to an "open" position to expose the film to the light and then "closes" again. The film then advances to the next unexposed frame.



The inner workings of a motion picture camera. The half circle (180-degree shutter) rotates constantly. The film advances one frame during the period when the circle completely covers the gate, and the film remains motionless during the period when the shutter is open, exposing the frame of film behind the gate to light from the lens.

Most film cameras have a circle with half of it cut out. Since a circle is 360 degrees, with half of it cut away, it becomes a 180-degree shutter. This is the *shutter angle*.

In some cameras, you can adjust this opening. If you make it 90 degrees (one-half of 180), the film is exposed for half as long as it is at 180 degrees (the shutter stays rotating at the same speed, but only one-fourth of it is now "open"). In a motion picture camera, a 360-degree shutter (completely open) is not possible, as you would have no shutter to cover the film as it moved, and the image would just be one big vertical blur. Somewhere in the neighborhood of 270 degrees is about as open as you can get, but some cameras allow you to close the shutter down to less than 45 degrees.

The *shutter speed* is the combination of frame rate and shutter angle together. This is a term taken from still cameras where the shutter speed represents the literal fraction of a second that the shutter curtain is open to expose the film to light. A $\frac{1}{100}$ shutter speed allows the shutter to be open for $\frac{1}{100}$ of a second.

If your shutter angle is 180 degrees (which is half of 360) and your frame rate is 24fps, your shutter speed is $\frac{1}{48}$ of a second. The formula for that is

$$\text{Shutter Speed} = \frac{360(\text{fps})}{\text{Shutter Angle}}$$

Multiply your frame rate by 360 (degrees in a circle) and divide the product by your shutter angle to get the shutter speed.

Okay, back to digital video. Most video cameras don't have a real shutter; they have an electronic shutter that tells the sensor to stop collecting light and "dump" the information into a frame buffer before writing it to whatever media you're recording on. Although there isn't a physical shutter in most digital cameras, the effect is exactly the same: one still frame of digital video is exposed in a fraction of a second. In most prosumer and consumer cameras, this is merely represented by a shutter speed. Video runs (in the US) at 30 frames per second. A 180-degree (theoretical) shutter gives you a $\frac{1}{60}$ shutter speed. If you increase this to, say, $\frac{1}{500}$ shutter speed, you've effectively changed your shutter angle to 21.6 degrees (because you're still recording at 30 frames per second). This is a very, very small shutter. The faster your shutter speed, the less time you will expose the image and the sharper you will make the overall image, which will make action sharper and more pronounced. The tighter the shutter, the more light you will need because you're exposing the sensor to the light for much less time, so you need more light to get the "proper" exposure. Back to the faucet analogy, if you open the faucet for $\frac{1}{60}$ of a second, you'll need a certain amount of water flowing to fill the glass in that time. If you open the faucet for only $\frac{1}{500}$ of a second, you'll need a valve opening about three times as large to let the same amount of water fill the glass.

Most consumer and prosumer cameras identify *shutter speed* in fractions of a second: $\frac{1}{30}$, $\frac{1}{60}$, $\frac{1}{200}$, and so forth. Some forgo the numerator and just represent the denominator (30, 60, 200).

To get a grasp about what shutter speed does, take a look at the picture of the fan, which shows three images of a fan in motion, taken at different shutter speeds. In all three images, the fan is spinning at the same, constant, speed. The image on the left shows the result taken at 1⁄60 of a second; the blades of the fan are spinning so fast that during the 1⁄60 of a second exposure, they travel enough distance to completely blur into one solid blade. There is no way to discern the individual blades. The middle image shows that same fan at 1⁄1,000 of a second. The duration of the exposure is much faster and, during that period of time, the blades travel only a fraction of an inch, so the exposure nearly "stops" the blades of the fan. At 1⁄4,000 of a second, shown on the right, the exposure is short enough so that the blades do not move at all, and they appear to have completely stopped. The blades, in all three exposures, were moving at the same speed, but the shorter the duration of exposure, the shorter the distance the blades travel during that time and the sharper the picture will be.

The blades of this oscillating fan are spinning at a constant speed in all three frames.

Sensor Sensitivity

Returning, once again, to the faucet/water glass analogy, sensor sensitivity is akin to the physical size of the glass. A very small glass would represent a very sensitive sensor that doesn't require much light (water) to be full. A very large glass would represent a much less sensitive sensor that requires much more light to be full. In common terms, the more sensitive a sensor is to light, the "faster" it is.

Since I came from the world of film before delving into digital video, I tend to lean toward some old-school film terms and concepts. ISO/ASA/EI is one of those holdovers.

ISO (*International Standards Organization*) is the new *ASA* (*American Standards Association*) and is the same as *EI* (*Exposure Index*); they're three names for the same scale. This is a scale whereby the light sensitivity of a particular sensor or film emulsion is measured. Lower numbers represent less sensitivity to light ("slower"), and higher numbers represent more sensitivity ("faster").

Like *f*-stops or shutter speeds, ISO/EI also works on a doubling system whereby each time a number doubles it is the equivalent of twice the sensitivity, or one additional stop of light. A 100 EI or ISO camera is half as sensitive as a 200 EI or ISO camera.

Most video camera manufacturers don't use the ASA/ISO/EI standard, but instead represent their camera's sensitivity in terms of *lux*. As mentioned earlier, lux is merely a metric representation of footcandles (1fc = 10.764 lux). This number is then the minimum amount of illumination required for an exposure. This is much less informative than ASA/ISO/EI, because what a particular manufacturer considers a reasonable "exposure" is rarely what is practical in any sense. Also, many manufacturers will supply the minimum lux for exposure with the camera's full gain included, which is rarely, if ever, desirable—more gain means more electronic "noise" in the image. These specs are more often a marketing ploy than actual useable technical information. Determining a camera's base ISO/EI setting without electronic manipulation is a much more grounded piece of information on the camera's overall performance capabilities. For more on determining your camera's ISO, see the following sidebar.

Determining Your ISO

To find the ISO of your camera, you're going to need a few things: an evenly lit 18% gray card, a light meter, and your camera. If your camera has an auto-iris mode that actually displays the *f*-stop, fantastic! This is going to be very easy! If the *f*-stop is not displayed in auto mode, you're going to also need a waveform monitor to find your ISO. A waveform monitor measures the visual signal from the camera and represents the intensities of the signal on a scale from 0–100, with 0 being black and 100 being white. These steps are called IREs (Institute of Radio Engineers).

If your camera shows the *f*-stop when you auto iris, follow these steps:

1. Make sure your camera is "zeroed" out: No gain, set at your preference for 24fps or 30fps, shutter at 180 degrees or equivalent (generally 2x the frame rate), normal gamma settings, no ND filters inserted, and so on.
2. Evenly light the gray card.
3. Point the camera at the gray card and zoom in until the card fills the frame.

4. Auto iris the camera and take note of the *f*-stop. Make sure that the auto setting is not changing the ISO, shutter speed, or gain controls, only the *f*-stop.
5. If you have an incident meter, take a reading at the card's position with the ping-pong ball facing the camera. If you have a spot meter, from the camera position, take a reading of the center of the card.
6. Now adjust the light meter's ISO until the *f*-stop on the meter matches the auto iris *f*-stop on the camera. This will be your camera's base ISO.

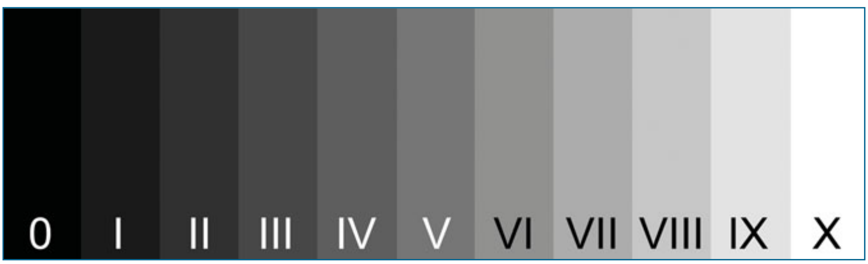
If your camera does not show the *f*-stop when you auto iris, you'll need to hook the camera up to a waveform monitor. Use Steps 1–3, and then adjust the camera's *f*-stop until the waveform reads 50–55 IRE and take note of that *f*-stop.

Finally, use Steps 5 and 6 to determine your base ISO/EI for your camera.

Seeing in Black and White

The easiest way to understand the basics of exposure is to forget about color for a minute and think only about black, white, and shades of gray.

The great still photographer Ansel Adams created what he called the *Zone System,* and I'll use a greatly simplified version of that here. Basically, by using an 11-step gray scale from pure black to pure white, you can represent 11 stages, or Zones, with each Zone representing one *f*-stop, or twice the brightness of the previous Zone.



An 11-step gray scale from black to white denoted with Zones from 0 to X, with Zone V being in the middle of the contrast range.

Each of these Zones numbered 0 through X represents steps between pure black (0) and pure white (X). Pure black is the point at which an image, or a portion thereof, is so underexposed no detail can be made out; it is nothing but solid black. Pure white is the point at which the highlights are overexposed so that they no longer contain any details, but are pure white.

Attitude of the Latitude

All photographic mediums have specific *latitudes*, also called the *dynamic range*, which is the range of values between pure black and pure white that the camera can represent while still maintaining detail.

In nature, the latitude of light is huge. During the sunny day, you can easily have a bright highlight that is 100,000 times brighter than the deepest shadow (100,000:1). The human eye, theoretically, is capable of seeing only about 16,000:1 in any given moment. Next time you're outside on a bright, sunny day, take a moment to recognize what you can see: highlights bouncing off car windshields; the sun lighting the sidewalk and pavement. But, how about under the cars? That's just pitch black under there, unless you lean down and shade your eyes from the bright sun. Your eye can see only so much detail in the white to black range before it has to adjust to one or the other.

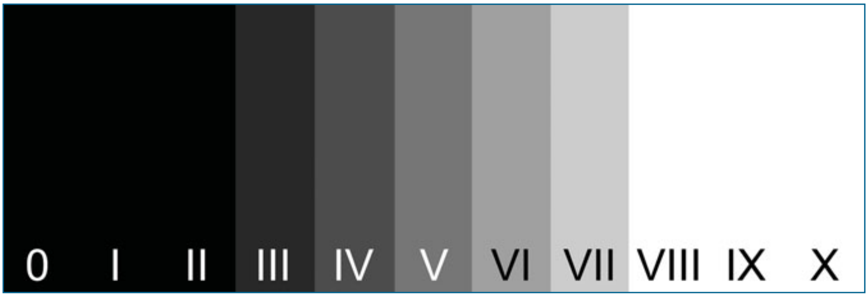
Photographic medium is even more limited in its ability to represent these values. Many digital sensors cannot represent any more than about 250:1, which means that the darkest shadow can be only 250 times darker than the brightest highlight before they become pure black or pure white and lose all detail; therefore, you have to control the exposure. You have to decide which is more important: the shadow range—in which case you open your aperture to favor those deep shadows and the highlights will lose detail, or the highlights—in which case those shadows will go deep black and you'll lose detail.

The 11-step Zone scale represents a 2,000:1 latitude range. There are some modern cameras that have a wider range than this, but most do not.

The cornerstone of this 11-step scale is Zone V, called "middle gray." This is the 18% reflectance Zone, and it is here that you have "proper" exposure. This is the point at which your water glass is perfectly filled.

Assume for the sake of this exercise that you have a video camera with a five-stop latitude (a mere 32:1 latitude/dynamic range). Although in real-world applications, most digital cameras have more shadow sensitivity than highlights, for the sake of this example, I'll say that the latitude is even, meaning that the camera can represent two Zones, or four times the amount of highlights, above "middle gray" (two stops), and two Zones, or four times the shadow detail, below "middle gray" (two stops). Remember that each "stop" of light is twice or half the previous stop (always a factor of 2). For this theoretical camera, all Zones above VII and below III fall to pure white or pure black, no matter how they look to your eye.

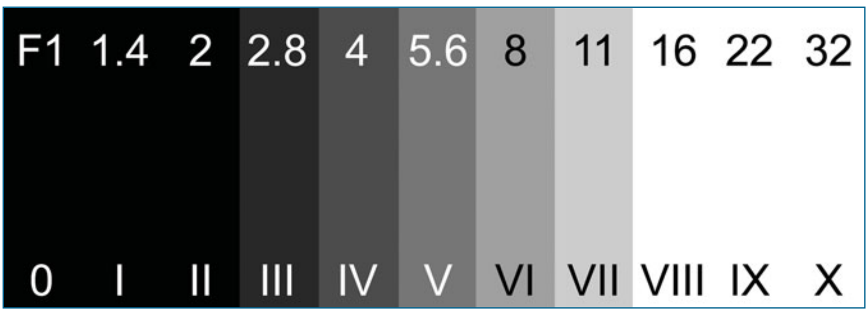
If you look at such a camera's latitude on the Zone scale, it would look like the scale presented here—where you can discern value differences in Zones III to VII, but everything below III is just black and everything above VII is just white.



The same 11-step gray scale representing a camera with only a five-stop latitude range. Anything outside this range is represented as pure black or pure white.

Note how, after the two stops under Zone V (middle gray), it becomes completely black. There is no longer a difference between Zones 0, I, and II; they're all completely black. That's the loss of detail below the lowest range of the latitude. And two stops over Zone V, it becomes completely white. Again, there's no difference between the values of Zones VIII, IX, and X because the camera cannot represent those values beyond two stops over the exposure.

Remember that each Zone here represents one stop on the camera. So, let's assume that the camera's meter, reading the average of the scene, says you need an *f/5.6* to "properly" expose this scene. *f/5.6* would then fall at Zone V, and then the rest of the scale would fall in as shown in the third scale, now with *f*-stops for each Zone.



The same 11-stop gray scale with *f*-stop numbers representing one stop per zone.

Understanding Light Meters

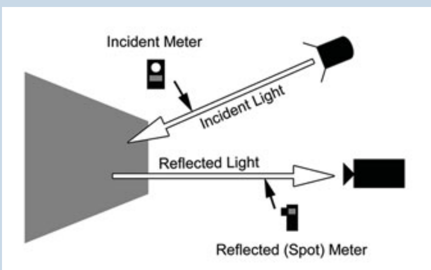
The question of whether you need a light meter when shooting digital video is addressed later in this chapter. For now, let's assume that you do—and discuss the different categories of meters and how to use them. There are two primary types of light meters: incident and spot meters.

Several different light meters.

An incident meter is recognized by the tell-tale "ping pong" ball. It measures the light falling onto an object—the *incident light*.

A spot meter, which you will look through and see the object you are metering, measures the light reflecting off an object—the *reflected* light. All internal meters in cameras are spot meters.

You can quickly tell the difference in meter types: incident meters always have a "collector" on them, whether it's a flat white disc or the half "ping-pong" on them. Reflected, or spot, meters have a viewfinder to look through and target the object to be metered. All meters inside cameras are, by definition, spot meters; they read the reflected light coming off the subject.



The correct positioning of the two types of meters: incident meters measure the light falling on the subject, whereas reflected (spot) meters measure the light reflecting off the subject.

In order for a light meter to work, it needs to have a goal. All light meters, whether they're hand-held incident or spot meters, meters in still cameras, or meters in video cameras, have the same goal: they all want to expose the scene in middle gray (Zone V). This is the area of optimum density and is called the "key" exposure point (this is a "key" thing to remember). Middle gray is where the image is "properly" exposed to render the most appropriate tones closest to human vision. Remember that Zone V is the equivalent of the perfectly filled glass of water. But this is an incredibly presumptuous average and may not always work for your intended effect.

This is how a spot meter can trip you up a bit. Assume for a moment that a given camera requires 25 footlamberts of light to achieve a Zone V exposure. If the subject you're photographing happens to be a perfect 18% gray wall, the spot meter will tell you exactly how to expose that wall to achieve a result that perfectly represents the 18% gray. However, what happens if you're photographing a pure white wall?

If you go by the spot meter reading in the camera and let it do the adjusting, you may be surprised by the results. Remember that the internal light meter's goal is middle gray, meaning that the spot meter *assumes* that what you are actually photographing is an 18% gray wall. If there are 100fc of light falling on the wall and, being white, the wall is reflecting back 95fl instead of the presumed 18 and yet the camera needs only 25fl of light for Zone V. The spot meter is going to see the wall as "overexposed" and tell you to stop down two stops, which will allow only 25fl of light (approximately) to enter the lens. If you follow the camera's internal spot meter's instructions, it will actually *underexpose* the white wall and you will get exactly what the camera thinks you are shooting: the white wall will be recorded as *medium gray*. The internal spot meter wants only enough light to fill that glass perfectly, even though, in this case, the sensor needs more light to actually represent the wall as it is in reality, which is white.

Inversely, what happens if you're photographing a black wall? The same thing, actually. Assume that the same 100fc of light is falling on the black wall, but only 6fl of light is reflecting off. The camera still assumes that the wall is 18% gray, and it needs 18% gray for Zone V exposure, so it will tell you to open up the iris two stops and you will wind up overexposing the wall to record a *medium gray* wall. Once again, the internal spot meter wants that full glass of water, so it's going to adjust the faucet to be more open to fill that glass, but in reality, you want only a small portion of water to represent the dark wall as it is in reality. Here, the meter will tell you to *overexpose* the scene to achieve the medium gray.

See the problem? The meter/camera assumes what you're shooting is a medium gray wall, so it tells you to adjust the exposure properly to show that wall as medium gray. Using a spot meter, if you want that wall to appear white, you'll have to mentally compensate for its value and set your own exposure. In the case here, two whole stops different from what the meter wants you to do. In order to properly record the wall as white, you *want* to overexpose from what the internal meter is telling you. You want more light to hit the sensor, so that the wall is properly recorded as white. In addition, if the wall is black, you want *less* reflected light to hit the sensor in order to intentionally underexpose the image (according the internal meter) and render the wall intentionally black.

An incident meter is much easier to use. An incident meter has the same goal, 18% (Zone V) gray and, just like the spot meter, assumes that the object you are photographing is an 18% gray object. However, since the incident meter measures the light falling onto the subject and does not take into account the subject's actual reflectivity/absorbance, it will actually tell you the correct *f*-stop to use to correctly record the object.

Using the same example as I did with the spot meter, if 100fc is falling onto the 18% gray wall, that is the brightness that the meter will read. With the proper settings in the meter, it knows that your camera requires only 25fl of light for proper exposure, so it is going to tell you to expose that wall at a given *f*-stop to record that wall as an 18% medium gray. If the wall is reflecting back only 18% of the light—you'll get exactly what the meter thinks you will: a gray wall.

If, however, the wall is actually white and it is reflecting 95fl back at the lens, that's actually five times more light reflecting off that wall than the meter thinks. However, the meter is looking only at the light falling on the wall, so it doesn't know that the wall is reflecting back more light than it assumes. If the light source remains constant at 100fc, the meter will give you the *same f*-stop to shoot at as if the wall were medium gray. So what will happen? If you set your camera to the meter's suggestion, the camera will receive a lot more light off the wall (about two and one-fourth stops more) and the wall will be "overexposed" (according to the meter). It will be recorded as a white wall.

Likewise, if the wall is black, the meter doesn't know or care. The incident meter assumes 18% reflectance and, seeing the same 100fc of light, it will suggest the exact same stop. Since the black wall isn't reflecting back the necessary 25fl of light for a "proper" exposure, but only 6fl, it will be "under-exposed" (according to the meter) by two stops and will appear black.

Now, let's look at the scene that you might be shooting with this imaginary camera. In this scene, you have a woman sitting in front of a window. To most clearly illustrate the dynamic range of these images, let's take color out of the equation for a few minutes and look at an image only in black and white.

This first image of model Mason Rae shows a number of incident meter readings for various light values throughout the areas of the image. This image, for the sake of illustration, has a wider dynamic range than the mere five stops of the theoretical camera I'm discussing, and you see a lot of detail in both highlights and shadow areas before going into pure black.

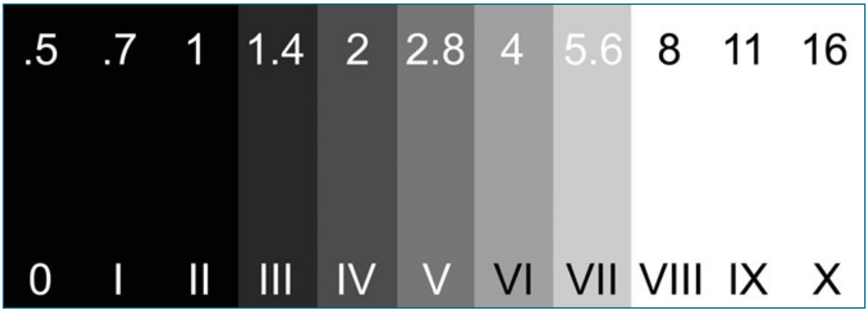
In this photo, rendered black and white for simplicity, model Mason Rae is in front of a window. The numbers on the photos represent incident light meter readings in those areas.

The light outside the window is very bright. You take an incident meter reading outside the window, pointing the meter toward the sunlight, and it tells you the light outside is an *f/22*. Then you take a light meter reading in the shadow near Mason's leg and you get a reading of *f/1*.

Now, between those two is an 11-stop range of brightness to shadow. Your camera, however, can represent only five stops, less than half that range. If you expose in the middle of this range, at say *f/5.6*, the shadow on the couch will be pure black and the light outside will be pure white; there will be no detail in those areas of the frame.

If you decide that her face and the shadows are more important to see than the outside, you might decide to expose this scene at an *f/2.8*, two full stops more open than the middle range of the scene.

When you change the stop, you change the "key" moving *f/2.8* now to the Zone V slot, meaning that any light values at *f/2.8* will now be "properly" exposed. This moves the entire scale on the camera's latitude range.



The same 11-stop scale, with *f/2.8* in the Zone V position.

The same shot of model Mason Rae, exposed at *f/2.8.*

Notice that the light value outside, *f/22,* is now completely off the scale. The world outside is, without question, "nuclear" white. Where you previously saw *some* detail in highlights at *f/8* and *f/11*, those are now gone to pure white as well. The highlight on the woman's face, which meters at *f/5.6,* is now at the upper end of the scale, meaning it's pretty bright, but there is still some detail. Look what also happens to the shadow range; previously, anything below *f/2.8* was in pure blackness, but now you have detail in the shadows two stops below that.

Inversely, if you exposed for the world outside, say at an *f/22*, the world inside would just be silhouette.

The 11-stop scale with *f/22* in the Zone V position (top). A photograph taken at that exposure (bottom). Notice all the detail inside is below the range the latitude can represent, yet detail can be seen in the highlights out the window.

How Can You Ever Have It All?

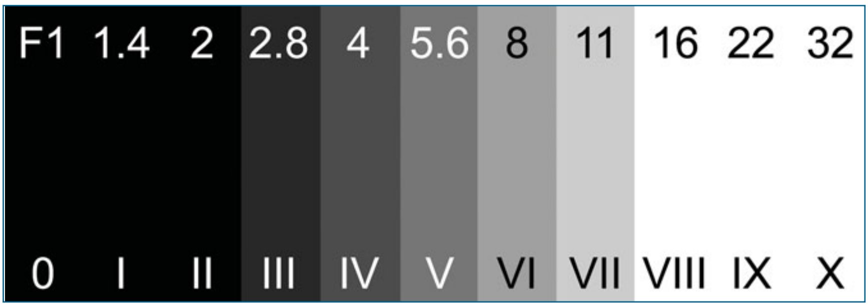
In this scenario, how could you possibly ever have it all? You're either going to have underexposed shadows or have extreme white outside! Is it ever possible to get it all?

Of course it is. This is the fundamental reason why photographers manipulate light.

A good solution in this scenario is to add light into the room to bring the intensity of light on the model closer to the intensity of light outside. By increasing the level of light in the room, you can narrow the 11-stop difference between outside and inside.

Bringing in light might be beyond your means. It's going to take a lot of light to fight that bright sunlight out the window. So the best solution is a compromise: bring down the light coming through the window *and* add light in the room.

Look back at the original scene scale, exposed at *f/5.6*.



The original 11-stop scale with *f/5.6* in the Zone V position.

You want to narrow the gap between the deepest shadow and the brightest highlight. If you place some ND 0.6 gel (to cut two stops or one-fourth the light passing through the gel) on the window, that brings the *f/22* light outside down two stops, to *f/11*. Now it's in Zone VII, and you're able to see detail outside. It's still bright, but it's not pure white; you'll be able to see buildings and trees and whatnot.

Then, you can bring a light into the room. You kick on a light and bring the darkest shadow in the room up to an *f/2.8*, which brings it to Zone III, within the latitude of the camera. By combining these two steps—reducing the light through the window and increasing the light in the room—you can artificially reduce the overall contrast or dynamic range of the scene to be within the range that the camera's latitude can properly represent.

The final photo of model Mason, now in glorious color, shows a combination of both techniques, reducing the light through the window and adding light into the room to create this final beauty shot.

The final shot of Mason shows a middle ground between lighting in the room and reducing the amount of light through the window to get all levels of exposure within range of the camera's latitude.

This is how exposure relates to control of latitude and how you place various values on the exposure scale.

Not Everything Needs To Be "Proper"

I've put the term "proper"—in relation to exposure—in quotes as it is, for all intents and purposes, a subjective and artistic decision. You aren't always required to have the principal subject exposed in the Zone V "proper" area. Actually, that is the next step in the creative control of exposure: deciding which values, in any given scene, you want to be "key." That is, which values in the scene you want to fall into Zone V.

In reality, every scene has many, many glasses of water. If they were all filled up, you would have a very boring, flat image. Contrast brings interest and dynamic energy to a composition. It's okay to have deep, dark shadows and bright highlights in an image, as long as those elements serve the mood and story you're trying to tell.

Maybe this is a very dramatic, dark scene and you *want* the woman in front of the window to be in silhouette for the effect. Then you would expose for the highlights and let the shadow range fall off the latitude scale, and maybe *not* light the room at all.

Maybe this is a dream-like sequence and you want that world outside to just be pure white, so you'd expose for the shadows and let the highlights go, and—once again—not light the room.

Where you place your exposures and when you bring in lighting or augment existing lighting is the principal creative control you have over the image. This is where the real artistry comes into cinematography. You have to decide what is important to see and how that should be seen. Exposure is the main tool in a cinematographer's creative arsenal. It should never, ever, be decided upon arbitrarily.

In most of my photographic career, I was shooting people. By personal choice and artistic decision, I rarely, if ever, exposed people's faces at "key," but rather usually put Caucasian skin at about a stop *under* key. It gave the images, in my opinion, more dimension, and more of a sense of reality. That was my artistic choice, and I would never let a camera's internal meter dictate my exposure.

Finding Your Camera's Latitude

With a properly calibrated monitor (see details later in this chapter), you can easily find out your particular camera's latitude range.

To do this, you need a bright white object with a fine pattern (I prefer to use a piece of white lace) and a dark black object with a fine pattern (I often use my Sekonic light meter's pouch, which is a textured black nylon).

Make sure your monitor is properly calibrated and in a suitable viewing environment. With even lighting on the white lace, use the camera's internal meter (or your own spot meter) to expose the lace at Zone V (middle gray). Here you don't want the lace to appear white on the monitor; you want it to appear as neutral gray. Then, slowly open the aperture one stop at a time until you can no longer see detail in the lace on the monitor. Write down the number of stops you were able to open before you lost detail.

Repeating the same process with the textured black material, expose it at medium gray (Zone V) and then stop down until you can no longer see detail in the monitor in the black material. Note the number of stops before you lost detail.

Add the two numbers together, plus one, and this is your camera's latitude range. Most digital cameras will have less range in the highlights than in the shadows; these won't necessarily be equal numbers. Many times you'll see that your camera has a two-stop range in highlights, but three or four stops in the shadows, this is normal—and indicative of the medium of digital sensors.

Most digital cameras have a range between five and eight stops. High-end professional digital cameras can have between 11 and 13 stops of latitude. Knowing your camera's latitude is key to understanding how best to light and expose for that particular camera.

Do You Need a Light Meter?

Yes. Absolutely. And, more than likely, never.

How's that for an answer?

The truth is that a light meter is a fantastic tool and never a bad thing to have in your arsenal, but one of the beautiful aspects of digital technology is the ability to see exactly what the image is going to look like immediately, even before you shoot it. This does require a calibrated monitor and a careful viewing environment to judge an image correctly, but digital technology affords you the opportunity to see your final image before you record it. Back in the world of film, there is a certain voodoo involved in understanding the photochemical process that required the cinematographer's knowledge and experience to know—ahead of time—exactly what will eventually come back on the exposed film.

To that end, most digital cinematographers light "by eye," meaning they forgo the meter and merely set the lighting ratios and quality to their eye and by what they see on the monitor. They can instantly see what is over- or underexposed or what is too saturated or what isn't being seen that needs to be. These adjustments can be made quickly, with precision, by looking at a calibrated monitor in a proper viewing environment.

This means most digital cinematographers don't use their light meters. The meter, whose main function is to evaluate and report on light levels to allow the cinematographer to make exposure judgments, is rendered mostly obsolete by the ability to see the final image instantly.

However, there are additional uses for a light meter that aren't so easily replaced. As I explained earlier, determining the base sensitivity of a camera requires a light meter. Also, if you have to shoot at a location one day and then come back another day and match the lighting, the best tool to be able to re-create the lighting levels is your light meter. You take note of the levels and positions of the lights on your first day and use the meter to dial them back in when you return. You may also find yourself in a situation where you have to pre-light a location before a camera or monitor is available, in which case a meter will be invaluable.

All that being said, if you're shooting digital video and you have a proper, calibrated monitor, you don't need to spend a fortune on a light meter. An inexpensive analog meter is a wonderful tool to have in your kit and won't cost you hundreds of dollars like the fancy digital models.

You May Already Own a Meter

In a pinch, you can also use your *SLR* or *DSLR* camera with its built-in meter as a spot meter. Remember that any meter that you look through to get a reading is a spot meter. You can also operate any spot meter like an incident meter if you have an 18% gray card. If you position the gray card where your subject would be and use your spot meter to focus on that gray card to get a meter reading, this is, basically, the same as using an incident meter. In this case, you're actually spot metering off what the camera assumes is there—that 18% gray card—and ignoring the actual subject. When the card is removed and the actual subject is photographed under the same lighting, the subject's natural reflectivity will be properly recorded by the camera.

You can use your still camera as a meter, as long as the ISO and shutter speed of your still camera are set the same as your digital video camera. If you've already got an SLR lying around, this is a perfect meter that you may already own.

If your meter inside your digital video camera shows you *f*-stops, you can use that, along with a gray card, as an incident meter as well. As long as you're pointing the camera at a gray card, you are turning the internal spot meter into an incident meter. If you point the camera at anything other than an 18% gray card, you're using it as a spot meter and you have to mentally adjust the readings accordingly. If you've got that 18% gray card, just focus the camera on the card in the position you want to read and, voila, you have your own light meter already.

How to Use an Incident Light Meter

The basic design of an incident meter, with the half ping-pong ball on it, is meant to simulate the shape of the human face. The meter is designed to be held at the position of your talent and pointed at the camera. The dome then takes an average of all of the light falling on it and reports a stop at which to expose that average range at Zone V.

This is, basically, the same as shooting on auto iris, and not the best way to use your light meter.

The light meter should be used as an information-gathering tool. To do this, you want to take the meter to the position of your subject and point the ping-pong ball *at each individual light source* falling on your subject. It is best to shade the ball with your hand from any other extraneous light so that you measure the brightness of only *one light at a time*. Start with a measurement of your "key" (main) light falling on one side of your talent's face. Let's assume it's an *f/2.8*. Okay. Now turn the meter and measure the backlight hitting your talent on the back of his head and shoulders; that's an *f/4/5.6* "split" (meaning an *f/4* and a half, or right between *f/4* and *f/5.6*); good! We like that backlight a little hot. Next, take the meter and hold it where your talent's shadow-side cheek would be. You have no lighting there, but you point the meter off into the empty space to read the *ambient* light. Your meter tells you the ambient light here is an *f/0.7*. Hmmm… That's a little too deep of a shadow for this scene, so you ask your grips to bring in a *bounce* card (see Chapter 5, "Light Quality," for more on bounces). The bounce card catches some of the light from the talent's "key" light and reflects it back into the talent's shadow side, increasing the light levels on that side of his face. Now you put the meter back at the shadow cheek—now pointing it toward the bounce card and take a reading. It's an *f/1.4/2* "split"—perfect. You decide to shoot this scene at an *f/2.8/4* split, to put the key light on the talent's face a half stop under exposed! You're ready to shoot!

Some meters, instead of the ping-pong ball, have a "flat disc" option; this is a flat white disc that allows you to more easily read light from single sources without worrying about outside light affecting your reading. It's roughly the same as shading the ping-pong ball with your hand, but I generally still shade the flat discs as well—just to be anal-retentive (that's how I roll…).

Calibrated Monitors

I mentioned several times that you don't need a light meter if you have a professional, calibrated monitor.

I can't stress the importance of this enough.

As I talked about in the previous chapter, color is incredibly subjective. In order to represent color, latitude, and exposure values correctly, you need a professional monitor with built-in calibration tools.

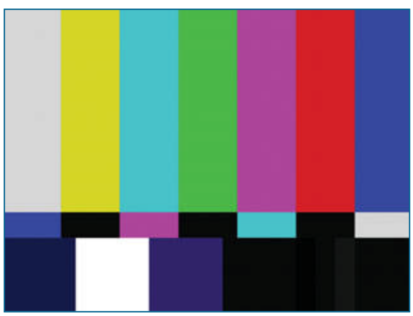
The worst thing you can do is just run out into the field and start shooting with nothing more than your camera's viewfinder and/or a flip-out LCD screen. These little screens are great for composition, following the action, focus (sometimes), and for the most basic, rough ballpark evaluation of the exposure and color, but they're not sufficient for fine evaluation of your image.

Professional grade monitors have a lot of legs up on the consumer-grade variety, not the least of which is better resolution and color fidelity in addition to more consistent repeatability of color. In any case, if you've got the right monitor, it has a "blue only" or "blue check" function, which is of paramount importance.

The key to calibrating the monitor is in having your camera generate color bars fed to the monitor. Not just any color bars will do—SMPTE (Society of Motion Picture and Television Engineers) style color bars are your best bet. To be even more specific, use the SMPTE Engineering Guideline EG 1-1990 color bars.

In a perfect world, you want these color bars to be generated by the camera that you're using. Most professional, as well as many prosumer, cameras are capable of generating exactly this style of color bars. There are, however, many cameras out there that *don't* generate the SMPTE bars, but rather, if they generate bars at all, create a variation thereof. Without the three distinct rows of bars in the SMPTE EG1-1990, the color bars are relatively useless for field monitor calibration.

If your camera isn't able to generate these bars, I recommend using a piece of editing software that can create the SMPTE bars and export them to whatever media your camera uses. Keep that recording in your camera bag at all times, and simply play it back on location from the camera in order to calibrate your monitors. It's not the best solution, but it is better than nothing.



Standard SMPTE color bars with the three sets of vertical bars necessary to properly calibrate a monitor using a "blue only" function.

The top portion of these bars, the first two sets of colored blocks, are paramount for setting the color balance of your monitor. The first set of colored bars, which take up about two-thirds of the image, are seven large bars at 75% intensity (white, yellow, cyan, green, magenta, red, and blue). Below that is a chipset of another seven, smaller, bars (blue, black, magenta, black, cyan, black, and white).

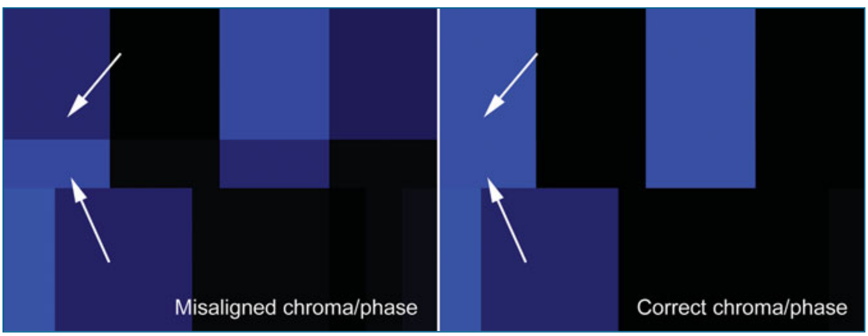
The last area of the color bars is the final row of chips at the bottom. It consists of two large squares of blue and one square of white, followed by five areas of black and gray values.

You can start the monitor calibration with this bottom row of chips in order to set the contrast value. It is important to note that your monitor should be in an ideal viewing environment (discussed later in this chapter).

You start your calibration with your contrast setting. Generally, you're going to want your contrast to be as high as possible before overdriving it. To do this, you turn the contrast all the way up and look at the three large squares at the bottom-left corner of the color bars. The second one in is a large white box. If you're overdriving your contrast, this box will "dance" a bit, or vibrate, seeming to be animated, or will "plume," meaning that the white edges will bleed into the blue blocks a bit. Just turn down your contrast until that animation stops, or you have sharp, well-defined edges to the white box.

Next, look at the top two sets of color chips to set the chroma and phase color adjustments. You do this by turning on the "blue check" function on your monitor.

When a monitor is set to "blue check" or "blue only," the red and green colors are turned off so that the image is monochromatic blue. When this happens, the top two sets of color bars appear as alternating blue and black. When chroma and phase (color and tint in consumer terms) are correctly aligned, the two sets of bars (top and bottom) blend into one another with the blues matching. In a perfect situation these bars blend so well that you cannot discern the two distinct rows. In *NTSC*, this rarely happens, but you get it as close as you can. When the colors are improperly calibrated, these rows will appear as very distinct variations of blue. To properly calibrate the phase and chroma, make small adjustments to each while watching the two sets of bars. You'll need to alternate between chroma and phase to get it as precise as possible, but you'll see the bars get closer and closer in hue until the blues in the two rows are as close to matching as you can get them.

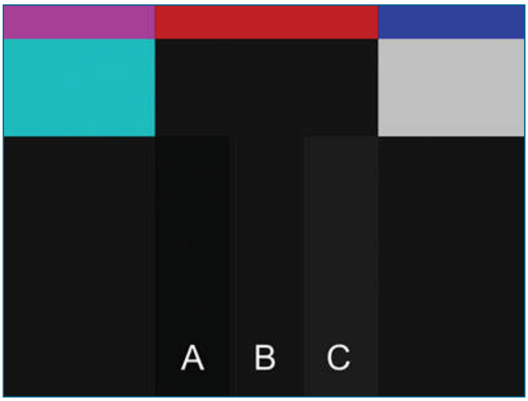


A portion of the SMPTE color bars under "blue only" option. Note in the left image that the chroma/phase is incorrectly set and there is a discernable difference between the large blue and small blue rectangles. In the right portion of the image, chroma and phase have been correctly adjusted so that both rectangles smoothly blend into one blue tone.

Once you've set your contrast, chroma, and phase, it's time to set your brightness. Turn the "blue check" off so you're seeing full color bars again. Now you're looking at the bottom row of chips again, but only the five chips to the far right—and specifically, only the three rectangles in the middle. This area is called the PLUGE (picture line-up generation equipment).

These three blocks represent blacker-than-black (A), black (B), and lighter than black (C). To properly set the monitor's brightness level, start by turning the brightness all the way down and then slowly adjust the brightness control up until you can *barely* just see the third block (C). The other two should blend into the surrounding black so that you are just *barely* seeing the third block only.

Now you've properly calibrated your monitor. The phase, chroma, contrast, and brightness levels are properly set, and you're ready to rock and roll.



The SMPTE color bars' PLUGE area.

Monitor Environment

In order to be able to utilize your monitor as a calibrated viewing tool, the environment in which the monitor is being viewed needs to be controlled carefully so that your eye is not biased by extraneous light or color and you can make a critical judgment based purely on the image on the screen.

In a perfect world, your monitor is set in a location where there is no extraneous light hitting the screen. This often requires building a tent around the monitor to keep all light off it. This is the best-case scenario, but it's not always possible. It's also important to understand that, in a best-case scenario the monitor shouldn't be in *total* blackness. It's best to either have a soft glow (optimally of 6,500°K, which is the base color temperature of most monitor screens) behind the monitor or a little light hitting the front frame of the monitor *without* hitting the screen. This takes some careful positioning of a small light fixture with barn doors so that the light just skips across the frame of the monitor. The glow behind or the light on the face is important to give your eye a neutral reference and keep your eye refreshed, especially if you have the monitor in an otherwise pitch-black tent.

You probably won't always have the option of providing a perfect environment for the monitor, however, so you have to make do. Protect the monitor from stray light as much as you can and remember to calibrate it *every time* you move the monitor to a different location. If the monitor stays in one location all day long, you need to calibrate it only once per day, or once in the morning and once after lunch. If it moves around from set to set and location to location, you need to recalibrate every time you put it in a new space.

If you do not have a monitor with a "blue check," you can purchase a blue filter that you can look through to accomplish the same task, although not as precisely. A Kodak Wratten 47B filter is best for this, or you can use a Wratten 98 filter. While looking at the color bars, hold the filter to your eye for a few seconds as you adjust your chroma and phase. You want to do this for only a few seconds at a time, as your eye will start to compensate for the blue and bias your judgment of the monitor calibration.

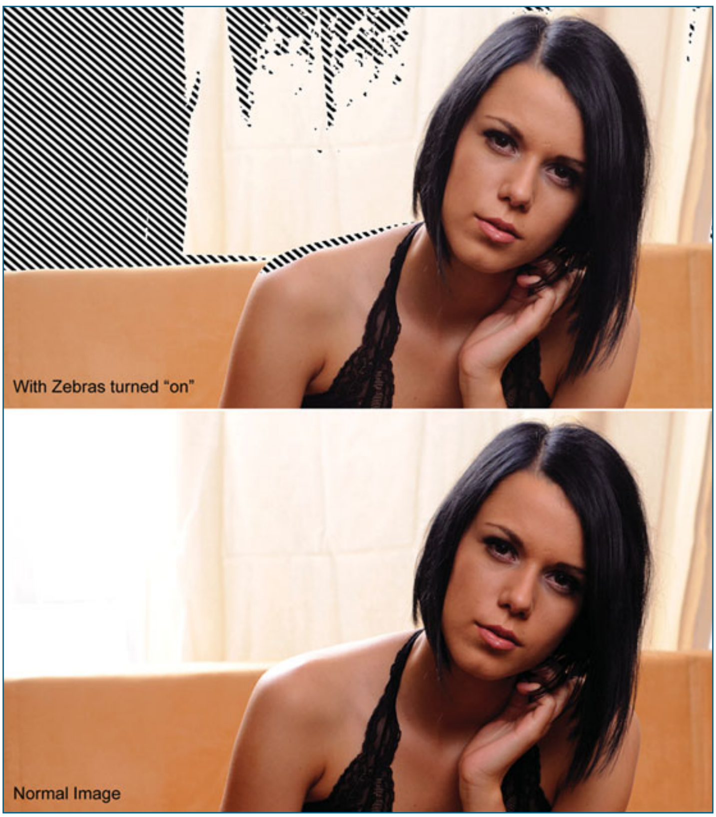
Using Your Viewfinder to Judge Exposure

If you are away from a field monitor when you're shooting, you can certainly use your camera's viewfinder and/or flip-out LCD screen, but know that you're seeing a compromised version of your image.

I highly recommend that you use the same methods you would use for calibrating a monitor to calibrate those viewing devices as best you can; at the very least, set your contrast and use the PLUGE to set brightness level. If you're using your viewfinder, you probably need to do this only once a day, as your "environment" is pretty stable inside the eyecup. If you're using your flip-out LCD screen, you should check your calibration often. Also, be extremely conscious of the angle of the LCD screen to your eye. By the very nature of Liquid Crystal Displays, especially small and inexpensive ones, the optimum viewing angle is very tight. Looking at the screen off angle can significantly alter the apparent brightness and color saturation. Look at the screen as flat on as you can so that you're not looking up or down or from the side at the screen.

The real key to judging exposure from your viewfinder or LCD is to test, test, test. When you're in prep for a shoot, or when you have downtime, set up your camera with a professional, calibrated monitor. Adjust your viewfinder as best you can and compare the two images. How "off" is your viewfinder? Is it, typically, a little dark? A little bright? Does it represent less contrast than the actual image? Only testing and experience can train your eye to interpret what you see to what you will get. You should test under various lighting conditions—dim, normal, and a bright sunny day—as every LCD will perform differently in different lighting conditions.

Many video cameras have *zebras* in their displays. The zebras are graphically imposed slash lines that are not recorded onto the image but show up in the viewfinder to show the operator that a specific area is above a designated exposure value. These values are usually based on the *IRE* (video exposure) scale of 0–100% (0 being pure black, 100 being pure white, and 50–55 being middle gray). If you can preset the zebras, you can usually set them to show anything more than 80%, 85%, 90%, 95%, or 100% (some cameras allow a greater range of zebra options than others). These show you that those areas with the zebras, when you're looking through the viewfinder, are above your selected range. If you have these zebras on a face, for instance, you might want to close the iris down until they go away to avoid overexposing the face. In the five-stop example discussed in this chapter, anything Zone VIII or above would be 100%, and anything Zone II or below would be 0%.



A graphical representation of what zebras look like in a viewfinder. Here, in this photo of model Alexandra Preda, the zebras indicate the areas of the frame above 100 IRE (overexposed). Photo by Claudiu Gilmeanu.

The bottom line is that, in order to best utilize digital video's WYSIWYG (what you see is what you get) capabilities, you need to have the proper calibrated monitor to see the best image; otherwise, you have to do the best you can based on testing and experience to use other kinds of monitors in the field.

Moving Ahead

I cannot place enough importance on the cinematographer's understanding of exposure. Having a solid grasp of your camera's latitude and how to control the elements of any given scene to fall within that latitude range how *you* want it to is the fundamental job of the cinematographer. It is not just a technical decision. How exposure is used is as much an art form as it is a science. Exposure and manipulation of dynamic range are two primary reasons why lighting is used in the first place.

Yet, before you dive into building your lighting fixtures in order to manipulate that dynamic range and control your images, it's of vital importance that you understand how electricity works—to make sure you're working safe and avoiding any unwanted shocking results.

4

Understanding Electricity

Before you can get into creating your own lighting fixtures, it's of paramount importance that you have a fundamental understanding of how electricity works. Most people are scared to death of electricity because they see it as some magical voodoo that they don't understand, yet know is lethal. Most people, in that sense, are partially right: electricity can be lethal. Worse, it can be lethal in very, very small amounts. The amount of electricity you'll be working with on a daily basis is anywhere from 10 times to 200 times the potential lethal amount. Take a second to ponder those numbers: they're important.

Even with that understanding, however, electricity is not something to be afraid of. It is something that you should have a healthy respect for, but not fear. Understanding how electricity works and how to control it will help you have a better respect and help allay those fears, thus keeping you safer.

A Horror Story

Years ago, when I was a gaffer, I had a horrible experience one night at the end of a very, very long music video shoot. We were 20 hours into the day and most of the gear had been wrapped, but the generator was still running and providing the only power to light basecamp for everyone to finish wrapping out. I was very tired and wanted to get home, so I made the poor decision to remove the power lugs from the generator (where the cables feeding power to the set had been connected to the generator) while it was still hot. This entails taking a metal adjustable wrench and loosening a copper bolt while it's attached to a live connection.

In general, not a great idea.

As I was taught, I always worked around live electricity with one arm behind my back. This is a literal statement as—if something goes wrong—it is preferable not to have the electrical current travel from one arm to the other—across your heart. So, with one arm behind my back, I took the wrench to the blue (hot) leg and thought in my head: "This is live. This can kill you. Take it slow."

That was also a habit. A mantra, if you will, to make sure I stayed concentrated. With the blue lug removed, I moved on to the red (hot) and repeated the same procedure. Once that was done, I moved to the black (hot). Those were successfully removed, and I then moved to the white (neutral). Again, I repeated to myself, in my head: "This is live. This can kill you. Take it slow." With the neutral removed, I had the ground left. I was tired. It had been a long, frustrating day and I lost my concentration. The mantra in my head switched to "Screw it; it's the ground."

I went at it a little too fast. The wrench slipped and, by pure dumb luck, I let go. The wrench spun sideways, connecting the ground to the black (hot), leg, and the ensuing electrical arc literally severed the wrench in half. The generator groaned slightly, and I stood dumbfounded, looking at two parts of my wrench lying at my feet. Had my hand stayed connected, at best I might have lost an arm. At worst, I wouldn't be here to write this now.

Electricity is, without a doubt, the most dangerous element that you'll work with on a daily basis when shooting. Take your time. Think it through. If you learn to respect electricity and always be cautious and take your time, you'll be fine.

Caution

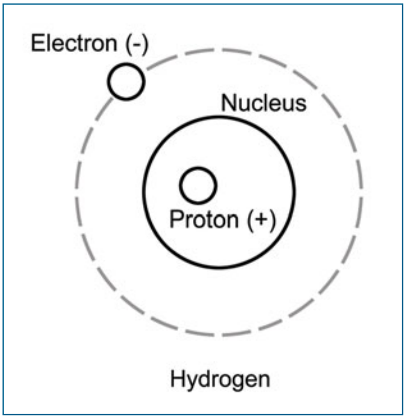
Always work on your lighting fixtures *without live power*. This should go without saying, but any work around electricity should always be done "cold"—meaning that no is power connected. Keep these basic safety rules in mind:

- Never work inside a fixture's components with live electricity.
- When working around electricity, keep your hands dry.
- Replace any broken or damaged electrical components immediately.
- Always take your time; never rush it.
- If you're unsure of what you're doing, stop. Get clarification and then proceed.
- In the event of an electrical accident, call 911 immediately, no matter how benign it seems to be.

The Basics of Electromotive Force

To understand how electricity works, you need to break it down into its most simplistic form. This means you need to take a little journey back in time to high school science class and revisit atomic theory. Don't worry; you won't stay there long.

The hydrogen atom is the simplest of all atomic compounds: it has a nucleus, with one proton at its center (which is positively charged) and one electron (negatively charged) orbiting around it.



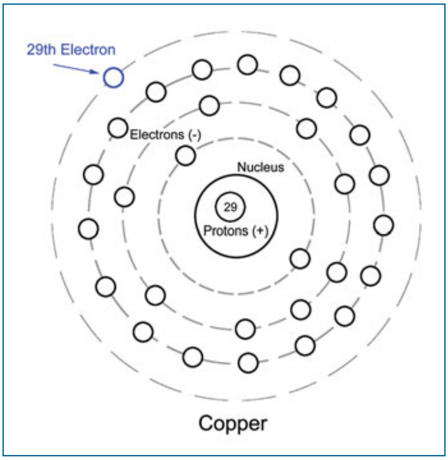
The construction of an atom of hydrogen with one proton (+) in the nucleus and one electron (–) orbiting the nucleus.

Remember from high school science class that the number of protons in any particular atom, which are positively charged, is always equal to the number of electrons orbiting the nucleus, which are negatively charged. The positive protons cancel out the negative electrons, thereby making the atom electrically neutral.

However, when you have one lone electron out in its own orbit, it can become easily dislodged. This, in turn, changes the polarity of the atom from neutral to positive. Atoms, as it turns out, don't like to be imbalanced, so this little atom will now steal the electron from a neighbor atom to make itself neutral. This starts a chain reaction of moving electrons right on down the line from atom to atom, and this exchange of electrons is called *electromotive force* (also known as *voltage*), and it's the fundamental aspect of electricity. All *conductors*, which are materials that easily allow the electromotive force, have this free electron in its own orbit. The best known conductors are metals: silver, gold, copper, and aluminum (in that order). Copper is one of the most common conductors used, as it has the best balance of conductivity to cost, although aluminum was used quite heavily in the 1970s and '80s and in some cases may still be found.

Insulators are materials that do *not* have a free electron and thereby resist electromotive force. These include dry air, ceramics, wood, rubber, and plastic (in that order).

If you take a look at the atomic structure of copper, you see that copper has 29 electrons and 29 protons, but that the 29th electron is in its own orbit and is easily dislodged.



The construction of an atom of copper, with 29 protons and 29 electrons in four separate orbits around the nucleus. Note the last electron is in its own orbit.

One important point to remember is that a by-product of electromotive force is heat. The transfer of electrons generates heat. Heat, of course, in high enough amounts, can cause fire. Mishandled, the flow of electrons through a conductor can easily cause materials around it to melt or burst into flames. This makes, next to electrocution, fire one of the greatest hazards in electricity. I address this issue in more detail later in this chapter.

Elements of Electricity

There are four principal elements of electricity: volts, amps, watts, and ohms.

Volts

The *volt* is a measurement of electrical potential between two points; it basically defines how many free electrons are available to pass from point A to point B.

Returning, again, to an aquatic metaphor, if you think about the flow of electricity like the flow of water, some of these components are easier to understand.

Imagine a large bucket of water with a hose spigot attached at the bottom. If the bucket is resting on the ground and you open the spigot, water will spill out onto the ground at a certain pressure. If you raise this bucket into the air, say, 20 feet, and attach a pipe to the spigot, the water pressure at the ground level is going to be 20 times that of when the bucket was on the ground. This, in its most simplistic terms, is the same principle behind voltage. Voltage, another term for electromotive force (thereby often abbreviated by the letter *E* in a mathematical equations), is the measurement of the "pressure" of electrical flow.

Amps

The *amp* (also referred to as *intensity* and often abbreviated with an *I* in mathematical equations) is the measurement of the flow of electrons, or, more simply, how many electrons are flowing past a given point in a given point of time. Amperage describes the capacity of a conductor, representing the number of amps that conductor can safely allow. Imagine amperage as the diameter of the pipe connected to the bucket; a pipe with a ½-inch diameter is capable of allowing half the flow of water as a pipe with a 1-inch diameter.

Watts

The *watt* (or *power*, abbreviation *P*) is the measurement of the work done—basically, the amount of water you're collecting at the base of the bucket. That amount of water is a direct property of the pressure and rate of flow; thereby, watts are the product of volts multiplied by amps ($W = V \times A$ or $P = I \times E$; more on this later in this chapter).

Ohms

The final element is *ohms* (*resistance* or *R*), which are the measurement of resistance to electromotive force. All materials have some resistance to the flow of electricity. Metals (conductors) have the least resistance, whereas dry air, dry wood, and dry rubber have the most resistance. Ohms can be thought of as twists and turns in the pipe coming from the bucket, reducing the flow of water, regardless of the pressure or diameter of the pipe.

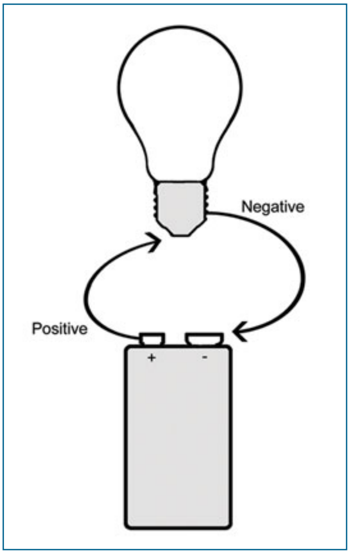
Notice that I specified that dry air, dry wood, and dry rubber have the most resistance. That's because (yes, one more step back into science class) water, if you remember, is two parts hydrogen and one part oxygen. The hydrogen molecule, with one electron, is a fantastic conductor of electricity. Now I'll diverge to high school health class for a second and remind you that the human body is 60%–70% water, which makes people pretty good conductors of electricity. The key to avoiding using your body as a conductor is to avoid completing a circuit with your body. I get into how that works now.

AC/DC

No, I'm not talking about the great rock band here; I'm talking about two forms of electrical service: *alternating current* and *direct current*.

Direct Current (DC)

Direct current, which is primarily used in batteries now (but at one time was a major consideration for standard electrical delivery and, for a long time, was the primary form of electricity used in film studios), consists of one positively charged (+) cell and one negatively charged (–) cell. When the two are connected, it creates a flow of electrons from one to the other. The device situated between these cells, allowing the flow of electricity through it, will be powered by that flow of electrons. If it's a light bulb, the flow of electrons through the filament will create heat and light from that heat. DC is still often used in situations where electricity has to be around water and people. Because DC is a closed system, there is much less danger of the water conducting the electricity; you must have direct contact with both the positive cell and negative cell for a circuit to be complete.

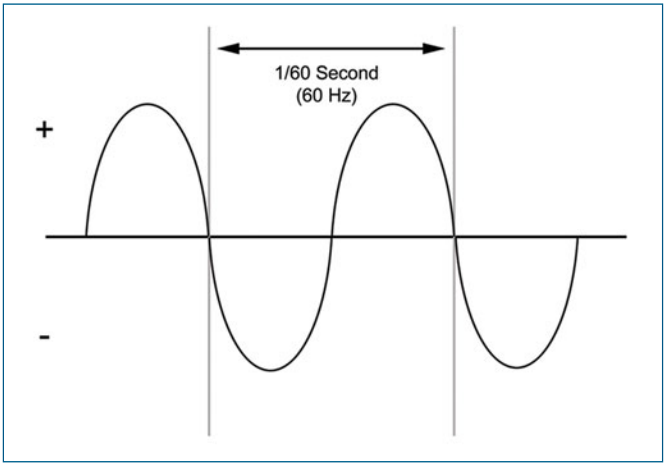


The bulb is powered by a flow of electrons through the filament. The electrons travel up the positive (+) lead, through the filament, and down through the negative (–) lead to complete the circuit.

The voltage in a direct current circuit will remain consistent, but in the case of batteries, it will diminish over time and usage until there aren't enough free electrons to move from one cell to another to power the device.

Alternating Current (AC)

Alternating current is another story. Alternating current is the principal method for delivering electricity in the United States and in most of the world. In alternating current, the flow of electricity in a single conductor alternates from positive to negative many times a second. In the United States, this happens 60 times a second (60 Hertz [Hz] or cycles). In many European countries, it happens 50 times a second (50Hz). It is a smooth transfer from positive to negative in a sinusoidal pattern.



The polarity of an AC conductor changes negative to positive and back to negative many times a second.

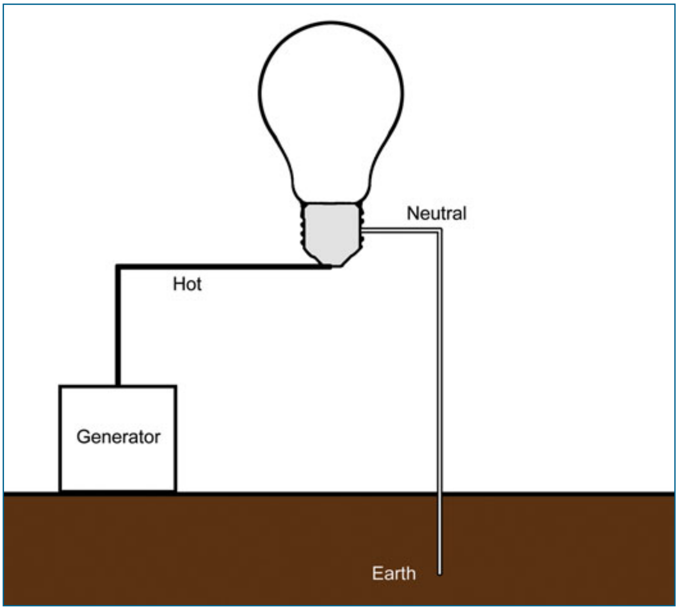
The illustration shows a visual representation of alternating current. The wave pattern represents the alternation between negative (lower end of the horizontal bar) and positive (higher end) polarity. Between the two gray vertical lines is the representation of what happens in one cycle ($^1\!/_{60}$ of a second in the US), where the current makes a full cycle from neutral to negative to neutral to positive and back to neutral.

Efficiency of AC

The alternating flow in a single conductor is what makes AC a much more efficient system to transport over long distances. As every conductor has some resistance to the flow of electricity, over great distances—such as the miles and miles of power lines across the country—voltage can drop considerably. The nature of AC being a single conductor, it is fairly simple for power companies to utilize transformers to "step up," or amplify, the voltage to very high levels to cross the distances (typically 100,000 to 700,000 volts or higher) and compensate for ohmic resistance in the wires that contributes to voltage drop. When the wires reach a place where they need to connect to a building, the power companies utilize a "step-down" transformer to reduce the voltage to 120V for the service.

Having positive and negative current in a single conductor in AC isn't enough to make a circuit. There has to be a path for the electrons to flow in order to create a circuit. In DC, that path is from positive through the device to negative. In AC, with both polarities in one conductor, the electricity needs a path to travel to after the device it's powering—and that becomes the Earth.

The Earth is a great absorber of electricity. Any connection to the Earth will provide a path for the flow of electrons and complete the circuit. In AC, this connection to the Earth is called the *neutral*, whose sole purpose is to provide a path for the electricity to flow to the Earth. The neutral is, quite literally, just a wire that is connected back to the Earth.



The elements of an AC circuit. An electrical source sends current through the hot leg to the device, and the current continues on to the Earth through the neutral. In an actual circuit, these wires are side-by-side, and both connect to the power source where the neutral is connected to metal rod, which is buried in the Earth.

Although the neutral is connected to the Earth, it is not to be confused with a *ground* wire. Although they are practically the same thing, they serve very different purposes.

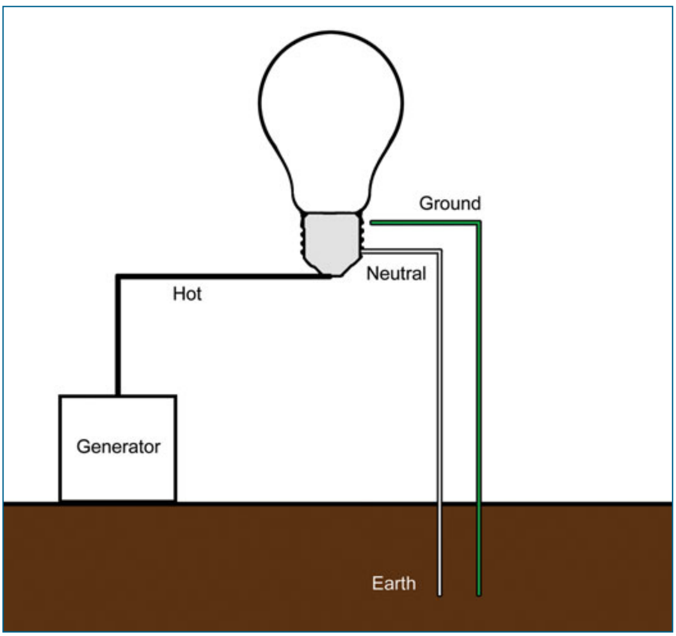
The Ground

Electricity is lazy. It will follow the path of least resistance. Especially in AC current, the electricity will look for any convenient path to the Earth.

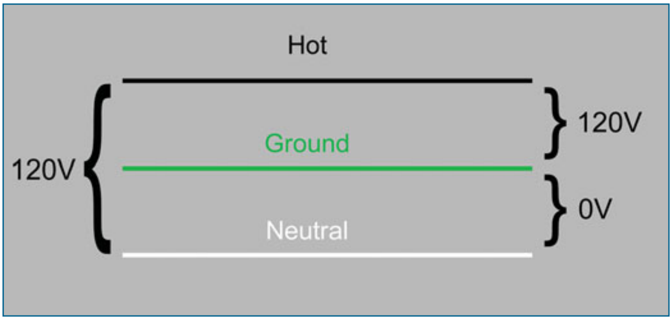
Let's say you have a light fixture on a metal stand outside—something that *often* happens in digital video shooting. Now you have your *hot* (current-carrying) leg providing electricity to the fixture and your neutral allowing a path for the electricity back to the Earth (at the power source, *not* where the fixture is) to complete the circuit. But in AC your hot leg provides *both* positive and negative flow in a single conductor so any connection to the Earth will complete the circuit. Let's say that, inside the fixture, the insulation on the hot wire has worn away and the wire is touching the metal of the fixture. Now the metal of the light fixture will conduct electricity, just like the wire will. You come along and touch the metal of the light and, since you're standing on the Earth, being a fairly good conductor of electricity, you form a pathway for the flow of electrons and they will flow right through you. In a best-case scenario, this is a painful, uncomfortable experience. In the worst-case scenario, this will kill you.

This is where the *ground* comes in. A ground wire is *not* connected to the circuit at all. The ground is a wire that connects to all the metal parts of the device that you're working with and links back to the Earth (to the same place the neutral goes). The idea being, with a ground attached, if a hot wire comes in contact with the metal of the fixture, the ground wire—which is also connected to the fixture itself—is actually a better conductor of electricity than you are and, as electricity is lazy and will follow the path of least resistance, the electricity will flow down the ground wire and *not* through you. A ground is intended to act as a neutral in the event of a failure to avoid electrocution.

In the previous example, if that same light is on that stand outside and the insulation on the hot wire has come in contact with the metal housing of the light, those electrons would travel down the ground wire. If you touch the lamp, because the ground has less resistance than you, you will—at the most—receive a light electrical buzz off the fixture, but the ensuing shock will most likely not be fatal.



A light bulb, powered by the hot line coming from the generator and the neutral providing a path for the electricity to the Earth. Additionally, a ground line, a direct connection to Earth, is connected not to any working parts of the circuit, but to all of the metal—and potentially current-carrying elements—parts of the device.



The elements of a circuit: hot, neutral, and ground.

As illustrated, an AC circuit is made up of the hot (current carrying) line, which alternates between positive and negative, and the neutral, which provides a path for the flow of electricity to the Earth. Between the hot and the neutral, you have a potential (in the US) of 120 volts. The ground is unnecessary to complete the circuit—it exists only to provide a path for electrons if there is a failure in the fixture and the metal components should become energized, in which case the potential between the hot and the ground is the same 120V.

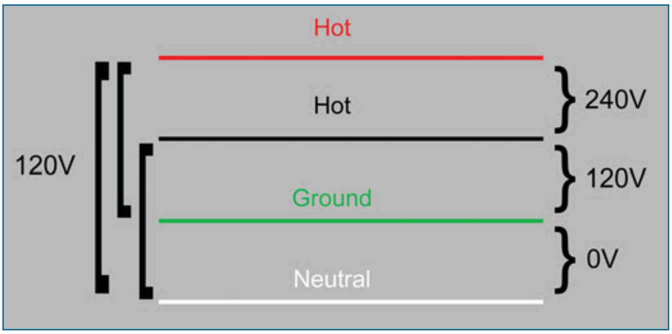
However, as neither the neutral nor the ground is a current-carrying component without the hot, the electrical potential between them is 0V. The coloring of the components in the image is standard: black = hot, white = neutral, and green = ground. Hot can also be red or blue. In some situations, you can run into a multitude of colored wires that represent hot legs, but black, red, and blue are the most common. Ground wires, in addition to being green, can also have no insulation and may just be bare copper or aluminum wiring.

TIP

It's important to note that voltage, although being *somewhat* of a constant, does fluctuate based on the peaks and valleys of power consumption and specific distribution methods. Therefore, it can be written or labeled several ways, all referring to the same thing—110, 115, 120, and 125 are all representations of the same voltage standard, which is made up of one hot line and one neutral. 210, 220, 230, and 240V refer to a different configuration in which two hot current-carrying components, without a neutral, combine to create a higher voltage circuit.

Quite often, electrical service offers two hot legs, a red and a black, one neutral and one ground. This means that the electrical potential between the black and the neutral is 120V and the red and the neutral is 120V, but as alternating current fluctuates between positive and negative in a single conductor, it is possible to connect the two hot legs to form a complete circuit and get 240V, in which case there is no neutral; the two hot lines form their own circuit. Higher voltages allow for lower amperages for the same wattage (for more on understanding how to calculate amperages, see "Pies in West Virginia" later in this chapter).

This is typically seen powering large appliances in your home such as the dryer, stove, and air conditioning units, all of which require very high wattage and are typically powered by 240V to reduce the amperage load.



The components of a circuit with two hot lines. The potential between the two hots is 240V and between either hot and the neutral is 120V.

Dual hot service also allows the usage of smaller wires to the service panel as the two amperages can be added together. As opposed to needing one wire that can deliver 120 amps to a service panel, they can break that into two, smaller, wires that can each provide up to 60 amps and achieve the same results.

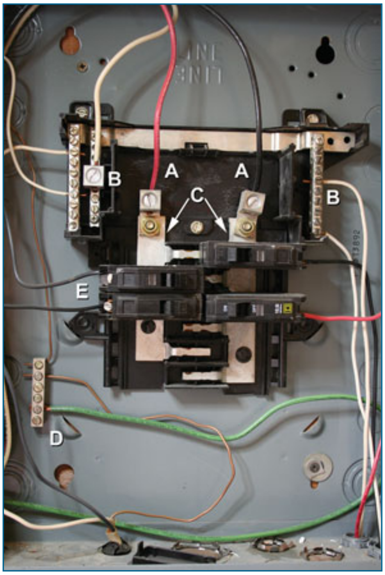
There are, of course, other forms of electrical distribution for larger commercial applications, but they're not something you're likely to have to worry about until you start working on much bigger sets, in which case the do-it-yourself aspect goes a little out the window.

Seeing Circuits in Action

You've read about all of the elements of a circuit; now it's time to look at real-world applications.

The Power Panel

Looking at the photo of a typical residential power panel, coming from the top, you'll see the two hot legs (A) feeding the main breaker *bus bars* (C). These red and black wires are slightly larger than the rest as they're a larger gauge (I'll discuss this in a little bit) to handle the total ampacity of the box (75 amps).



A standard power panel in an American apartment building. Something, as you shoot on various locations, you'll see on a constant basis. Here, I've removed the protective faceplate to get a look at what is happening inside the box.

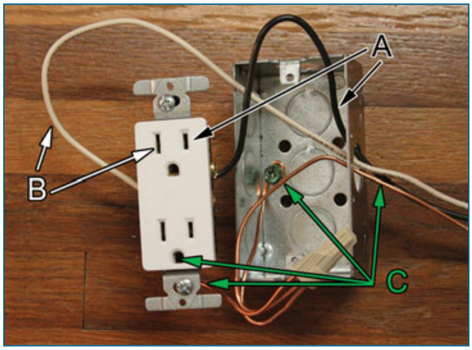
Looking back at the picture of the power panel, behind the breakers (E) are the bus bars (C). These are merely strips of metal. One bus bar is connected to the red wire (hot), and one is connected to the black wire (hot) coming from the power company. Each breaker (E) connects to one of two bus bars and then has a hot wire that then leads from the breaker to the devices it is powering in the location (along with a neutral [B] and a ground [D] wire).

Each breaker (E) represents a single circuit feeding the outlets, switches, lighting, and appliances in the location. The electricity travels from the main feeds to the bus bar to the breaker to the hot wire to the devices inside location. The breaker sits between the bus bar and the hot wire feeding the location and, if "tripped" or turned off, the breaker cuts the flow of electricity between the bus and the wire so that the power is turned off in the location downline of that circuit. Breakers are covered in more detail later in this chapter.

At the top right and left in the picture of the power panel are the neutrals (B), and in the lower left is the ground bus bar (D). The white wires are the neutrals, and the green is the ground.

Now the next biggest piece of information you can get from the panel is the size of the breakers, and therefore the size of the individual circuits. It's written right on the breaker, typically right on the head of the breaker's switch or on the face of the breaker. In this case, there are three 20A and one 15A breakers. Typically, you'll find either 15 or 20 amp breakers per circuit in most residential and commercial locations.

The Outlet



A typical US household outlet straight out of the wall. Hot (A), neutral (B), and ground (C) wires.

Following the stream of power in a location, it is delivered by the power company to the building through the power panel. The power company's wires connect to the panel's bus bars, and individual breakers connect to the bus bars to deliver power to individual circuits in the location. At the end of the circuit, in many instances, is an electrical outlet. The picture of the outlet here shows an outlet and its gang box pulled directly out of the wall so you can see what is happening inside.

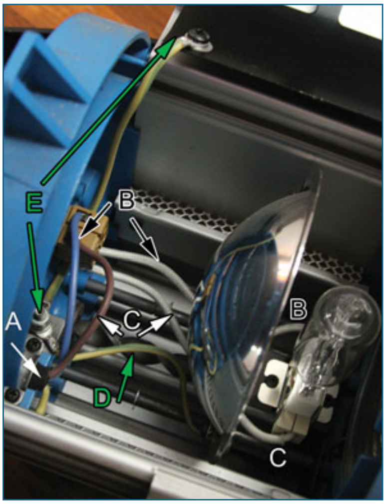
The wires come from the breakers in the power panel to this outlet, and you see a black (hot) wire (A), a white (neutral) wire (B), and bare copper (ground) wires (C). Notice that the ground wire is bare copper here; there is no insulation. This is typical in building wiring and is, actually, beneficial. As the purpose of the ground is to connect to all of the non-current-carrying metal components of a circuit, the bare wire helps ensure more connection points along the path. Also note that the metal gang box has a grounding screw connected to it and a wire connected to that screw. That wire is connected to the ground wire attached to the outlet and the ground wire coming from the power panel via a wire nut.

The neutral wire simply connects to the neutral side of the outlet and to the neutral portion of the socket. Likewise, the hot wire connects to the hot side of the outlet and to the hot portion of the outlet's socket.

When a plug is inserted into this outlet, it has one blade that connects to the hot, one blade that connects to the neutral, and one rounded pin that connects to the ground (see more about plugs later in this chapter). Electricity travels from the hot connection, through the device being powered, and back through the neutral. The ground sits dormant in case of an electrical failure in the device being powered.

The Fixture

After the outlet, the final result of the electrical circuit is the device being powered. In this case, it's a 650W Fresnel fixture from Arri. The power cord of this fixture features three wires wrapped into one: hot, neutral, and ground. Those three wires connect to the building's power through the outlet.



The inner workings of a lighting fixture, showing the hot, neutral, and ground components. Cable (A), hot (B), neutral (C), ground (D), and ground connections (E).

Unfortunately, Arri doesn't follow the US standard color-coding of wires, but the same functions apply. Here, at point A in the picture, the power cord comes into the fixture with its three wires: blue/hot (B), gray/neutral (C), and green/ground (D).

The hot (B) and neutral (C) wires go to a permanent wire connector (the same idea as a wire nut, but secured safely to the body of the fixture) to connect to the hot (A) and neutral (B) wires connecting to the fixture's bulb.

Pay special attention to how the ground (D) is configured here. Notice that it is not connected to the bulb, but actually connected directly to the metal of the fixture at several points (E)—remember the ground is there in case the hot wires break loose and connect to the metal of the fixture; otherwise, the ground is dormant and not an active part of the circuit.

The GFCI

Starting in the early 1970s, Ground Fault Circuit Interrupters (GFCI or GFI) became a standard for electrical outlets around wet locations: bathrooms, kitchens, outdoor patios, pools, and so on.

A typical residential GFI in a kitchen location, meant to break connection to the power in the event of a ground fault. GFIs are identified by the two buttons (one for testing the device and the other for resetting the device after a trip) in the middle of the outlet.

The GFCI or GFI is a specially designed outlet with a type of circuit breaker inside that is designed to trip, or break, the electrical connection if a ground fault is detected. This means, if an accident should happen and the ground should become energized, the GFI will actually shut off the power to that outlet within a few milliseconds. As electricity follows the path of least resistance, a person in water can have less resistance than the actual ground wire, and therefore electricity around water is very, very dangerous. These devices are designed to keep people safer when electrical outlets are located near water by killing the power if a fault is detected—and they are highly sensitive devices. Portable GFIs are often used on sets near wet locations. By the mid 1970s, the National Electrical Code required GFIs to be installed in all kitchens, bathrooms, and outdoor outlet locations.

It's All About the Amps

Unless you're getting into designing electrical circuitry or large distribution, you can forget about ohms—they don't have any bearing on your practical work. Watts are easy, because the wattage for any given device is always a constant. A 75W bulb will always be a 75W bulb, no matter where you use it. Wattage doesn't change. Voltage is, for all intents and purposes, also a constant. In the US, that voltage is 120V. Remember, as I said before, voltage does vary in any given circuit and can be anything from 100V to 130V at any given moment and not adversely affect most components powered on that system. Fluctuations beyond that can be damaging to whatever is connected to that electrical service. Most residential and commercial applications in the US are generally constant in the 110–125V range.

What really matters is amperage. Amperage is important for many reasons, not the least of which is amperage is the lethal component of electricity (remember voltage is a *potential* between two points; amperage is the actual measurement of how many electrons are flowing).

When it comes to danger and lethality of electricity, it happens in surprisingly small amounts: 0.001 or 1 milliampere (mA) can cause a tingling sensation—kind of like what you feel when you stick your tongue on the terminals of a 9V battery. At 75–200mA or 0.075 to 0.2A, electricity is potentially lethal. A 100W bulb in a 120V circuit is 0.833 amp. A circuit creating 100W to power a standard household lamp is moving enough electrons to be 4 to 11 times the lethal level. Imagine how dangerous a 1,000W lamp is.

Dealing with an Electrical Shock

In the event of an electrical emergency, it is of vital importance to follow these steps:

- DO NOT TOUCH the victim yourself.
- Have someone immediately call 911.
- If you can, immediately disconnect the power. Do NOT attempt to shut off the power at the device causing the electrical shock. If it is safe to do so, pull the plug. If not, switch off the power at the breaker box.
- If you cannot switch the power off, stand on any dry, insulating material, such as wood, rubber, or a stack of paper, and push the victim's limbs away from the electrical source with something non-conductive. Wood is often most easy to quickly locate (a chair, a broom, and so on).
- Once the connection is broken, check the victim's airway: is he breathing? If not, and you are qualified to do so, administer CPR.
- No matter how minor the electrical shock may seem, always contact medical authorities to see to the victim. It is possible that even a small shock can cause unseen internal injuries.

Amps in Action

To reiterate, amperage is your most critical concern in dealing with electricity. To that end, to further illustrate the importance of amperage, I'll concentrate just on amps for a bit here.

Again, amperage is the measurement of how many electrons are actually flowing past a given point in a given period of time. Also, remember, that a by-product of this flow of electrons is heat. Due to this creation of heat, every element of an electrical circuit has an ampacity rating—that is the limit of amps that component can safely handle before it starts to get dangerously hot. This is a number that you need to be keenly aware of in every component of a particular project or scenario you deal with. Like the weakest link in a chain, the lowest ampacity element in any given circuit or device will determine the maximum amps that circuit or device can safely handle.

Fuses and Breakers

The first stage of defense in over-amping any circuit is to use fuses and breakers. These devices, which are different yet serve the same purpose, are deliberately designed to be the weakest links in a circuit. They are *designed* to fail if the circuit is over-driven, for any reason, and their failing will break the circuit and stop the flow of electricity before the situation reaches a dangerous point.

Fuses

A fuse is, in its most simplistic form, a small, thin piece of conductive metal that sits at the beginning of an electrical circuit. The thin piece of metal is designed to easily withstand the heat of the flow of electrons up to a certain amperage, above which the ribbon will quickly melt. Once the ribbon melts, it breaks the electrical connection and thereby stops the flow of electricity to everything after the fuse. Once a fuse has been "blown"—the ribbon inside has melted—it can no longer be used. It must be discarded and replaced with a new fuse.

Caution

Always replace a "blown" fuse with one of the same ampacity. NEVER, EVER replace a fuse with a new fuse of a larger ampacity.

Breakers

A circuit breaker, which was examined practically earlier in the chapter, serves exactly the same purpose as a fuse, except that it isn't destroyed when it is "blown." The elements of a circuit breaker are far more complex than the simple metallic ribbon in a fuse, but the principle is the same. In the event of ampacity of a circuit exceeding a set limit, the circuit breaker's mechanics will "trip" or "blow" the breaker and sever the contact of the electrical elements inside, thereby cutting off the flow of electricity to all components after the breaker. The major difference between a fuse and a breaker is that the breaker can be reset. You can correct the problem that tripped the breaker and then reset the breaker, thus allowing the flow of electricity again.

Caution

If a breaker "blows," don't just go back to the breaker and reset it. Always investigate what caused the breaker to blow, fix the problem, and then reset the breaker.

Returning again to water as an example, you can think of both fuses and circuit breakers like an imaginary safety valve at the plumbing service into a home. When everything is fine, it is open and allows water to flow through the plumbing all through the house. However, if the valve detects that too much water is flowing and a flood is possible, it closes, shutting off the flow of water to the house until the problem can be found and fixed and the valve safely opened again.

Other Component Amperages

Unfortunately, fuses and breakers are, for all intents and purposes, the only automated portions of any given electrical circuit that are going to cover your rear. After that, it's your responsibility to make sure you're not overloading a circuit or any given component in a circuit.

When Breakers and Fuses Won't Help You

If a breaker on a circuit is rated for 20 amps, that breaker will keep the circuit closed (on) and allow the flow of electrons until the entire circuit exceeds 20A. However, if you plug an extension cord into that circuit that is capable of handling only 6 amps and you plug a device into that extension cord that is going to draw 10 amps, the breaker isn't going to protect you. The breaker is going to "see" only 10A passing, which is well within its safe zone, so it won't protect you. The extension cord, having no fuse or breaker of its own, will overheat very quickly and—most likely—will start on fire.

How do you avoid this? You have to know the amperages of all the components you're working with and you have to know how much power you're really drawing.

Every electrical component has an ampacity rating, and that rating should be clearly marked.

Pies in West Virginia

Mmmm… Pies… unfortunately, I'm not talking about tasty baked goods here; I'm referring to two different ways to express an algebraic formula: $P = I \times E$ (also known as the "pie" formula: remember that the mathematical abbreviation for wattage is P, amps is I, and volts is E) or, in simple abbreviations: $W = V \times A$ (also known as the "West Virginia Rule"). These two formulas represent the same expression, just using different abbreviations for the same elements (as I discussed earlier). For the sake of simplicity, let's kick the official mathematical formula to the curb and just look at the common expression:

$$W = V \times A$$

As I stated earlier, watts are the product of the voltage (pressure or electromotive force) and amperage (intensity or rate of flow). Since you already know that wattage is a constant and never changes for any given device and you know that voltage is, mostly, a constant, you can clearly see that this formula is primarily used to find amperage. Using the same formula to find amperage, you get the following:

A = W/V

There's actually an even simpler way to determine amperage *and* to build in a safety "fudge" factor into your calculations. Since voltage does, in fact, fluctuate, you can *assume* that the constant US voltage is 100V, not 110, 115, 120, or 125, but good ole, nice round (and easily divisible) 100V. This is also referred to as "paper" calculation of amperage.

If you plug 100V into the formula and keep it a constant, you'll see that every 100W is equal to 1A [100W/100 V = 1A]. In reality, if you're using a 120V system, 100W is *actually* 0.8333A, but by using the "paper" calculation and *assuming* that the voltage is 100V, you're not only simplifying the math, you're also assuming a higher amperage draw and building in a safety factor to make sure you're not overloading its circuits.

TIP

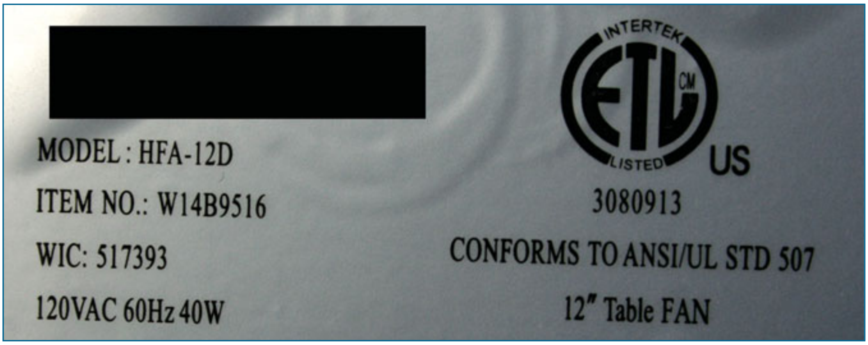
If you always keep the paper calculation in mind and presume that every 100W is 1A, you can quickly determine how much amperage you're drawing in any given scenario without pulling out a calculator. By always over-estimating the load, you are safer from ever over-amping a circuit.

Let's say that you have eight 100W bulbs, one 250W bulb, and three 75W bulbs lighting a scene. Add that up and you get 1,275W of power, which, by paper calculation, would be 12.75A (with voltage actually at 120, the load would only be 10.63 amps, but by using paper calculation, you're building in a safety factor of over two amps). If you have a 15A circuit *with nothing else connected to it*, you would be safe to light your entire scene from that one circuit.

Reading Devices

Every electrical device that has a plug will draw amperage on a circuit. When you have a simple light bulb, you already know what the wattage of that bulb is by looking at its markings. How do you know, however, what the wattage is of, say, your digital camera or a clock or a computer plugged in?

All commercially sold electrical devices have labels on them giving you this information. The sticker is generally on the back or bottom of the device, or on the power transformer on the device's cord.



The label on the bottom of an electrical device provides the necessary information to determine the device's electrical needs.

Looking at the base of the fan that I used for the shutter speed demo in the previous chapter, the sticker tells me the necessary electrical information to calculate this device's load. In the lower-left corner, you'll see the following:

> 120VAC 60Hz 40W

So, this fan runs on 120V (AC as opposed to DC), 60Hz, and requires 40W of power. Using the simple paper calculation, 40W is 0.4A, a pretty low power requirement.

Tracking Circuits

Starting with understanding the ampacities of any given location, it's always a good idea to check out the breaker/fuse panel before you start to do any lighting. What are the ampacities of the breakers and/or fuses? 10A? 15A? 20A? In most modern installations, residential breakers are rated at 15A per circuit and commercial locations are 15A or 20A.

There are two very important points to keep in mind when you start to work in a location: the first is that the actual division of any particular circuit is quite often voodoo. It depends on the original electrical contractor who wired the building and any alterations/renovations/additions that have happened since. Every outlet is not its own circuit, but rather each circuit in any location encompasses many outlets, permanent light fixtures, and appliances. You can be safe to assume that any modern residence (built after 1980) will have a separate circuit for the kitchen and a separate circuit for the bathroom(s) (both with GFIs; see the sidebar titled "The GFCI"), although several bathrooms can be on the same circuit. Further, as a general practice, there will be a separate circuit for every two rooms of living space. These are not infallible rules but are general guidelines. In any location built before the 1970s, all rules are out the window.

The second important point to keep in mind is that—at any given location—there are going to be things already plugged in that are drawing power on any given circuit. Household lamps, appliances, TVs, computers, clocks—anything that uses electricity is drawing amperage on the circuit. Never assume, unless you can verify it with 100% certainty, that you have the full amperage of any given circuit available to you in a practical location—this is also why always using paper calculations is a safer bet, to help compensate for unknown devices drawing power on a circuit you are planning to use.

Creating a Circuit Map

The only way to know which outlets are on which circuit is to map it out manually. All methods of doing this are time consuming. One method is to take a standard lamp, plug it into an outlet, and have one person stand and watch the lamp while another person shuts off all the breakers until that lamp goes out. Then you know that outlet is on that circuit controlled by that breaker. This method, unfortunately, requires a constant interruption of power to the entire location, which can be damaging to anything that is powered at the location—especially computer systems.

The second method, which is much less invasive, is to use a circuit finder system.

These are available at most hardware stores and at any electrical supply store. They are two-part systems where you plug one component into a wall outlet and then take a battery-powered second component to the breaker box. Using the second component and holding it over the breakers will cause it to "ring" or beep when it lands on the breaker that the plug component is plugged into. These tools do not require you to turn off the power to that circuit in order to track it down. If you take the time with these tools, you can map out an entire location and know, exactly, what outlets go to what breakers.

TIP

Many times you'll find a power panel with a sticker label identifying what each breaker or circuit controls. This information can be handy but is quite often unreliable. Changes to a location over time (repairs, renovations, additions, and so on), as well as mislabeling or misinterpretation of the labeling, can often lead to mistakes. It is always a good idea to create a circuit map and never blindly trust the circuit labeling.

One point to remember is that outlets can also be switched, meaning that the outlet may not be powered unless the appropriate switch is turned on. Quite often, only half of an outlet is switched and the other half has constant power. In practice, the top plug is normally the switched plug, but there is no set standard. If you plug in your lamp or your circuit finder and it does not show power to the outlet, first try the other plug in the same outlet. If that shows power, the first plug is switched. If the entire outlet is cold, investigate the switches in the room to determine if any provides power to that outlet. Be very careful if you find a switched outlet that is controlled by a dimmer. This is fine for incandescent fixtures, but it can destroy fluorescent or LED fixtures.

Cords

The next thing to be conscious of is your cabling and cords. In any electrical setup, you're going to plug something into an outlet, whether that be a cord connected directly to a device or an extension cord. Cables and cords are, basically, the same thing—a wire that is composed of several different wires (multi-conductor) wrapped in a single, flexible insulation. Semantically speaking, cables are just larger cords. To that end, I'll refer to most everything from here on out as cords.

In the digital video industry, there are a lot of different types of cords. The smallest is called "lamp cord" or "zip cord" or, more officially, 18/2 wire (more on this later in this chapter). The largest are 4/0 ("Four Ought") single-conductor cables that are each about a ½ inch in diameter and weigh about 65 pounds per 100-foot run. More than likely you'll be dealing with standard household or industrial grade extension cords intended for use with 120V systems; these are often called *stingers*.

The Code

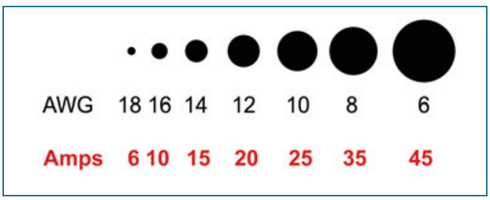
Although we have had codes in place to regulate building and electrical safety standards for centuries, the motion picture industry had been, for the most part, ungoverned for the majority of its existence. With the exception of permanent installations, such as sound stages, film is a transient industry. We move in, shoot, and move out, which makes it difficult for any authority to really see what was going on. In a lot of cases, lighting and electrical distribution meant a mish-mash of borrowed components from other industries cobbled together to "make it work" for any given shoot.

In 1984, when the summer Olympics came to Los Angeles, a lot of the motion picture resources in the city were tapped to help handle the massive events. Suddenly the tools and practices of the industry that usually happened far from the eyes of fire marshals and *OSHA* experts were out in full display—and in direct interaction with millions of people—and the cat was out of the bag for the industry. Experts determined that many of the standard practices in motion picture electrical distribution, at the time, were unsafe. Following the Olympic experience, in the late '80s, the National Electric Code (publication 70 from the National Fire Prevention Association), which is the basis for state and federal safety laws, began to govern the film and video industry. NFPA70 NEC chapter 530 deals specifically with motion picture studios and similar installations. A lot of leeway is still given to the film and video business because whatever we do, it's only for temporary installation. It doesn't have to last years and years, but only a few hours to a few weeks at most. The codes are much stricter on cables and hardware that are sealed permanently behind walls and in ceilings and floors than they are on temporary uses. Although the chances are very good that your adherence to the NEC Chapter 530 will never be called into question, it does establish a bare-minimum safety guideline that everyone should follow, and it's a good thing to read and understand.

Gauges

Wires and cables are classified in *gauges*, a scale of measurement (inversely proportional) that describes the physical size of a conductor and the amperage that conductor can handle.

The US system is called the AWG or American Wire Gauge. Gauges are typically even numbers with a higher number describing a smaller conductor.



A visual representation of wire sizes, gauges, and the ampacities for each gauge.

TIP

Ampacities differ depending on what source you're looking at and what the actual intended use for the cord is, but the ampacities shown in the figure here are those listed in the NEC with regard to the maximum overcurrent rating for a circuit (meaning this is the maximum safe load for these gauges).

As I said earlier, the smallest cord you'll probably work with on a regular basis is 18/2 ("zip" or "lamp" cord). "18" is the wire's gauge and "2" describes the number of conductors in that wire. 18/2 "zip" cord consists of two, small conductors covered in plastic insulation and mounted side-by-side in one cord. Looking at the illustration of gauges and ampacities, you'll see that the 18/2 "zip" cord can handle an ampacity of six amps, which is a mere 600W by paper calculation.

So, when you have any cord in your hand, how do you know the ampacity? Well, luckily, all wires, cords, and cables manufactured for commercial or residential use in the US have their AWG printed directly on them; you just have to look carefully.

Examples of several different types of cords and the information printed on them.

UL 12/3 Type SJOW 90°C Type SJP 90°C

In the examples in the picture, you can see the identification information on three different cords and, below that, a sample of kind of information you'll find on cables. Breaking down that information: the "UL" stands for Underwriter's Laboratories, which is a testing facility that denotes this piece of electrical hardware has passed and conforms to rigid safety testing. The "12/3" tells you the gauge and number of conductors, which in this case is 12AWG, with three conductors in the cable: a hot, a neutral, and a ground. Inside the outer insulation, each wire is individually insulated and then wrapped together with some kind of paper or fiber protection.

A cut wire showing the individual wires enclosed in the outer insulation.

Also noted in the cord information is the cable type. In the example I've used a common type identified as SJOW. Each letter describes a different aspect of the cord; in this case SJ stands for "service junior," meaning this is a light-duty service cord. O stands for oil resistant and W stands for Weather resistant. SJOW, SJO, and SJP are often the orange extension cords you see at any hardware store. They're designed for household and yard use and not really designed to stand up to heavy-duty industrial use.

Following the letter designation is a temperature rating—this is the highest environmental temperature that the cable can safely operate in. Generally, this is designated in degrees Celsius. Finally, sometimes there is an alternate cable type designation. All the information you need about that cable is right there on the outer insulation, but the most important piece of information is the gauge. Commit your gauges and ampacities to memory and always be sure you're working with cords and extensions that are of a sufficient gauge to handle your total ampacities.

Plugs

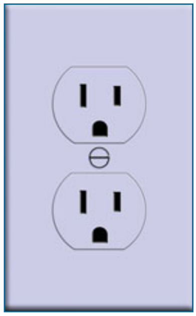
There are myriad electrical connectors out there, but the ones you'll be dealing with most are the 15A "Edison" variety. These are your standard household plugs with two parallel blades (hot and neutral) and one U-shaped, curved pin (ground). These plugs are also called *Hubbells* after Harvey Hubbell, the actual two-pin plug designer at the turn of the 20th century. Starting in the 1950s, these plugs started to become "polarized," meaning that the neutral blade (most often silver in color) is slightly larger than the hot (most often gold in color) so that it cannot be plugged in backward.

Many Edison plugs have only two blades, hot and neutral, while others have a third, ground, pin. The ground pin is slightly longer than the hot or neutral, which allows the ground to be connected before power is applied to the device.

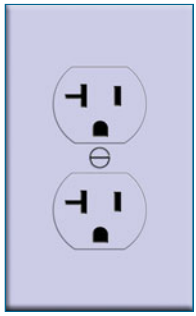
It is important to note that whenever you see a standard Edison or Hubbell plug with two parallel blades, this is a 15A plug. Likewise, if you see an outlet in the wall with two parallel slots, that is a 15A outlet.

Even if the outlet is connected to a 20A circuit, you cannot draw 20A on one outlet because that outlet is rated only for 15A. There are 20A Edison plugs and outlets, but they have a horizontal neutral pin.

An Edison ("Hubbell") plug with a ground pin.



The 15A Edison outlet has two parallel slots.



When you see an outlet with a horizontal slot like the one shown here, you can safely assume that is a 20A circuit.

Caution

5

Light Quality

Aside from intensity and color, the greatest aspect of light that cinematographers have control over is its quality. Light quality is typically defined in two ways: *hard light* and *soft light*.

To understand the difference, you have to look, primarily, at the attributes of the shadows created by the light source, specifically the transition point between light and shadow.

A sharp, crisp, short transition between light and shadow is indicative of a hard light source. Hard lights create well-defined shadows; the transition is easily discerned.

Soft light, on the other hand, creates a diffuse, long, and wide transition between light and shadow. The transition is more gradual, and the shadows are much less defined. A very soft light source might even cast no shadow from the subject.

The quality of light is created, primarily, by the size of the light source relative to the subject.

That may be the golden ticket as far as light quality is concerned: the quality of light is derived from the *size of the light source relative to the subject*. The second part of that statement is very important because a large light source, far away from the subject, decreases its relative size and thereby hardens the light emitted from that source.

Hard light creates a sharp, well-defined shadow.

Soft light creates much more gradual, less-defined shadows. In super soft light, you can have almost no shadows at all.

Hard Light

Noon sun on a cloudless day is a perfect example of hard light. Although the sun is a gargantuan light source (more than 100 times the size of the Earth), it is very, very far away (about 90 million miles). The farther away an object is, the smaller it looks—hence the farther away a light source is, the smaller its physical size relative to the subject, and the harder its light will be. Cloudless sunlight is very hard light. It creates very sharp shadows and narrow, defined shadow transitions.

A sunny Sunday afternoon. San Diego Chargers running back Michael Bennett sizes up the competition under harsh sunlight that casts deep, sharp shadows on his face.

Likewise, if you look at a clear glass light bulb, the *filament* inside the bulb is very small, what is called a "point source," and it will create a very hard light from that small point.

Hard light is, by nature, very high in contrast. It can create bright highlights and deep shadows. Depending on the direction of the light, it can reveal the texture of an object. If you *rake* (or side-light) a hard light against a textured object, the light and shadows will distinctly define the texture of the object.

The hot filament of a clear tungsten light bulb creates a point source of light and very hard, sharp shadows.

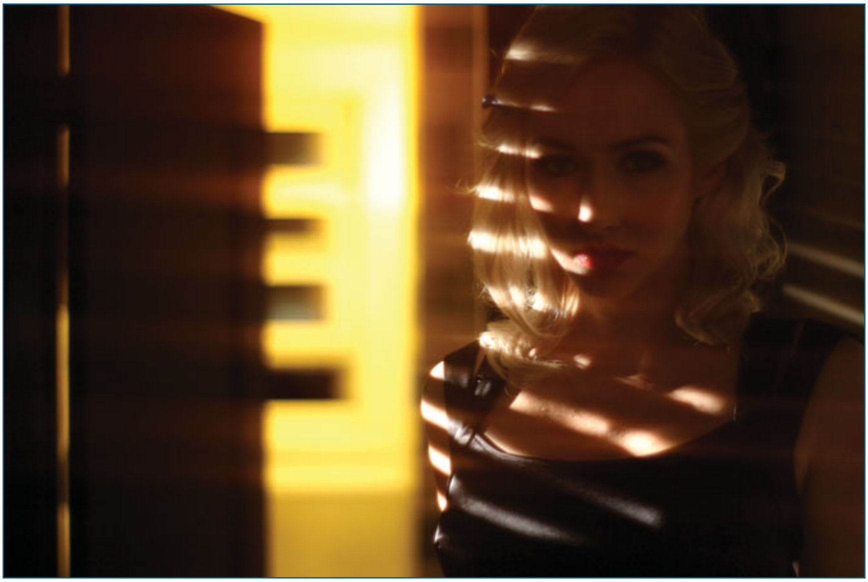
By its nature, hard light is very directional. Because of that, hard light can be easily localized and controlled. Spotlights are, by nature, hard sources. Their beams are distinctly defined, and they can be focused to a very small area without spilling light onto other areas.

A piece of stone with rough texture is side-lit with a very hard point source. The quality of the light serves to accentuate the surface texture of the rock.

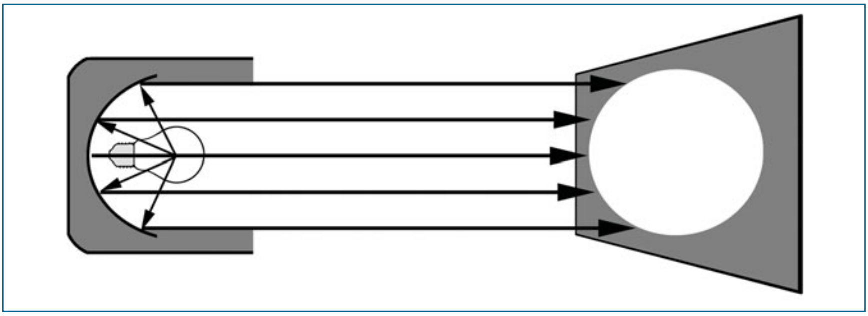
A large part of the cinematographer's job is just as much about what *not* to light. Controlling unwanted light and keeping light out of areas you want to remain dark are important aspects of the cinematographer's trade. Hard light is easily controlled. Because it creates sharp, well-defined shadows, it is easy to place objects into the path of the light to cut the light off areas you don't want it to hit.

Cutting light will typically happen with *barn doors* on the fixture itself or with *flags,* which are opaque pieces of black material stretched around a wire frame designed to block light. A *gobo* is a name for any object placed in the path of a light beam intended to cause a shadow. Flags are a type of gobo, but you can also have gobos in shapes, like Venetian blinds or a cucaloris (for more on a cucaloris, see the sidebar titled "Grip vs. Electrician").

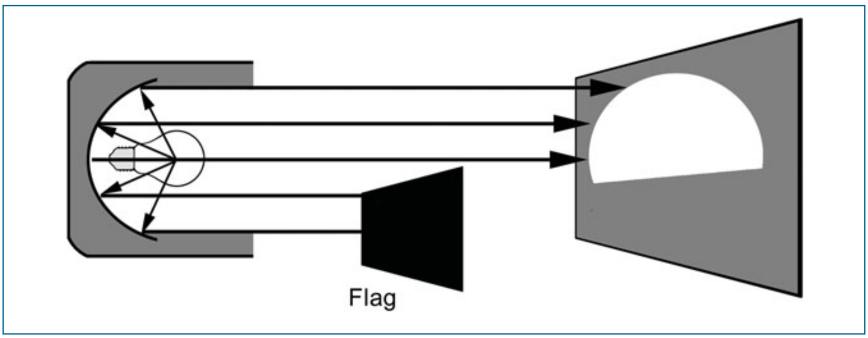
In many lighting fixtures, the reflectors positioned behind the light source help to focus the light rays to create a harder, more defined source. A parabolic reflector forces the beams of light into a parallel configuration, which creates a very, very hard source. You can see a distinct circle of light on the wall with sharp, defined edges. Again, that transition between light and shadow, in a hard source, is crisp and well defined.



Model Heather "Sparrow" Carr is lit with a Venetian blind pattern to create a classic noir look. This effect is created by placing a pattern in front of a hard source to create the shadows indicative of horizontal blinds.

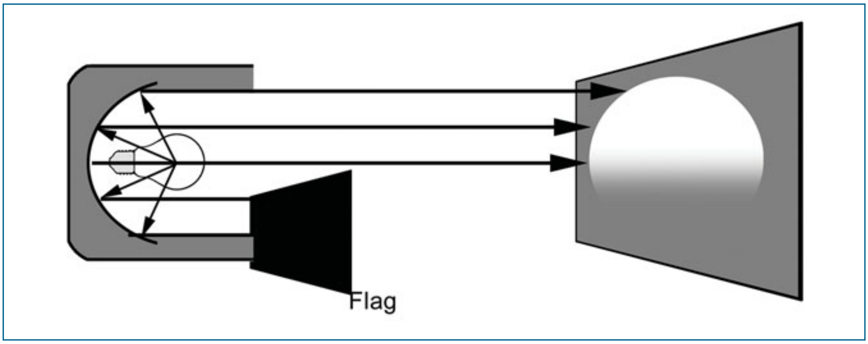


A hard light projects a clean, well-defined shape onto the wall.



By placing a flag in the bottom of the light beam, between the source and the wall, you cut off light, and you can see, by the path of the beams, that you cleanly block the light to form a very sharp cut.

The farther away the flag or cutter is from the light source, the sharper and more defined the cut will be. Even with a very hard light source, if you move the flag too close to the light, you will allow light rays to scatter around the edge of the flag and soften the definition of the cut.

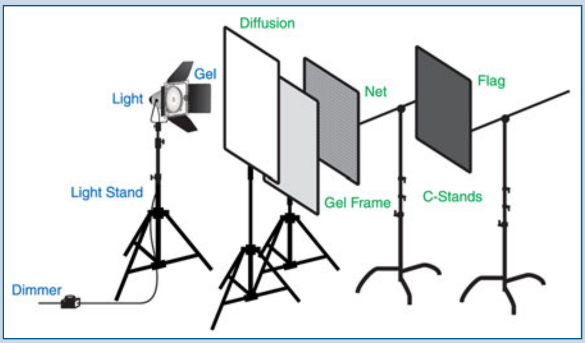


When the flag is moved closer to the source of the light, the shadow becomes less defined and less sharp.

Understanding that, you should be able to visualize the effectiveness of barn doors on hard sources. Although they can be handy, they will not provide as sharp and defined a cut as a flag positioned away from the light. They're most often used for basic adjustments with flags being used for more fine adjustments.

Grip vs. Electrician

In the motion picture industry in the United States, there's an adage: the electricians make the light; the grips make the shadow. The delineation between what each role does can sometimes get fuzzy, but here's a general rule of thumb: if it has a plug and provides light, it's the electrician's territory. If it attaches to the light itself, such as gel or diffusion clipped to the fixture, it's the electrician's territory. Anything positioned away from the fixture falls into the grip's territory.



A depiction of many of the accessories that are commonly used in lighting. The items identified in blue are the electrician's responsibility while the items identified in green are in the grip department's control.

Grips will place flags, large diffusion (not connected directly to the light), large gels on stand-alone frames, bounce cards, reflectors, and so on. The electricians will control the barn doors (attached to the light), but the grips will shape the shadow through the use of flags, nets (pieces of material that reduce intensity of light without changing its color or quality; I discuss these in more detail in Chapter 11, "Accessories and Miscellaneous Tools"), or gobos. The most common gobo, aside from the Venetian blinds discussed previously, is a *cucaloris* (called a "cookie" for short), which is a piece of wood (sometimes a semi-transparent piece of wire or plastic) with amorphous shapes cut into it to create a kind of leafy, non-defined shadow pattern.

The most common gobo is a cucaloris (called a "cookie" for short), which is a piece of wood with amorphous shapes cut into it.

For many years the motion picture industry's primary artificial lighting source was the carbon-arc fixture, a very, very hard light. In the early days of filmmaking, the emulsions available were very, very slow and required the power of daylight or very bright carbon-arc sources to achieve an exposure. To that end, most of the older films before the 1950s were lit with very hard sources. As film emulsions improved, it allowed the use of less light and allowed for more refined and softer sources.

Today, you have a wide variety of lighting sources to choose from and, with digital technology, you have exceedingly more and more sensitive chips with greater latitudes.

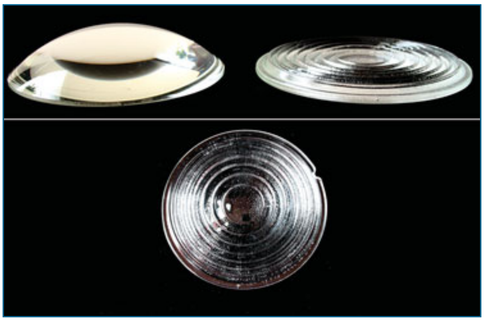
That being said, hard light is still a viable tool and often used in a variety of situations. Some common hard lighting fixtures are discussed in the following sections.

Open Face Fixtures

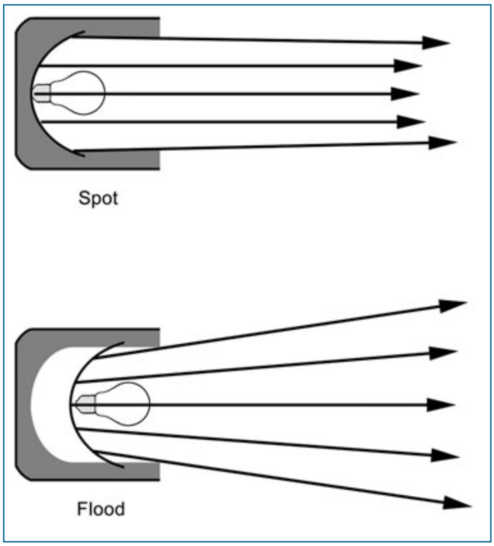
These fixtures are merely a housing and a lamp. Typically, they have *PAR* (Parabolic Aluminized Reflector) lamps in them, which typically have a parabolic-shaped reflector built into the bulb itself, but some can feature regular tungsten-halogen globes (more on these in Chapter 8, "Tungsten Fixtures") with the reflector as part of the fixture. They have no additional lens and, typically, are very hard sources. These can be inexpensive to purchase because of their simplicity.

Fresnel Fixtures

The *Fresnel* is one of the most common lenses in motion picture and theatrical lighting. Derived from the most simplistic form of lens, the plano-convex, the convex side is planed down in a series of concentric circles to create the Fresnel lens. This is done to reduce the weight and slightly soften the overall beam of the fixture, but provide a very smooth, controlled beam of light.



The plano-convex lens (top left) and the Fresnel lens (top right and bottom) crafted from it. The Fresnel maintains the same light-focusing qualities of the plano-convex while serving to soften the light slightly and reduce the overall weight of the lens. Fresnel fixtures are often focusable, meaning that the beam of light can be tightened (spotted) or widened (flooded).



The position of the lamp and reflector, in relationship to the Fresnel lens, forces the light rays to converge (spot) or diverge (flood) to create smaller or larger beams of light from the fixture.

Fresnels, by nature of the lens and more complicated components, are more expensive than open face fixtures. Fresnels come in many different sizes and can house lamps of many different wattages, from 150W to 20,000W.

Spotlights

Spotlights fall into many different categories. One of the most common portable spotlights is the *ellipsoidal reflector spotlight* (ERS), also called a Leko. These fixtures are designed to create very sharp, defined pools of light. ERS fixtures feature a system of plano-convex lenses to focus the beams of light into a tight circular formation. They often also feature shutters or cutting blades inside the fixture that can be adjusted to shape the light or cut it off places where it's not desired. Although these blades are behind the lens, the focusing of the light beams allows them to create very sharp cuts with the internal blades. Most ERS fixtures have four shutters: top, bottom, left, and right.

An Altman Leko fixture and (right) looking down the barrel of the fixture at the shutter gate (blades penetrating the circular opening), lamp, and ellipsoidal reflector behind the gate. A gobo pattern can also be inserted into the gate position to be projected by the spotlight.

ERS fixtures are available in different degrees, representing the spread of the light beam. The higher the degree, the larger the projected circle of light.

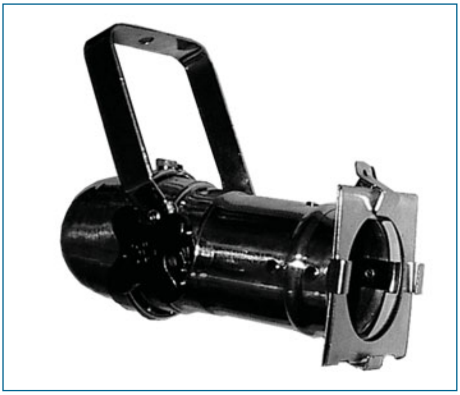
PAR Lamps

Parabolic Aluminized Reflector (PAR) lamps are the fourth category of hard light fixtures. These are also classified as spotlights. Some PARs are self-contained with the reflector built into the globe (bulb) itself. These are available at any hardware store in two primary shapes.

The light from a PAR is an oblong-shaped beam, and PARs come in several different focal widths: spot, narrow, medium, and wide, each creating a larger, wider beam of light.

PARs are also available in high-end fixtures, which feature a lamp in front of a parabolic reflector and separate interchangeable lenses (spot, narrow, medium, and wide).

PAR cans are very simple, open face fixtures that take PAR lamps.



A photo of a typical PAR can fixture; quite literally just a round housing with a yolk (mounting handle) to attach to other hardware.

Soft Light

But soft… What light through yonder window breaks…

Soft light, as you might expect, is the opposite of hard light and is defined by long shadow transitions, or lack of shadows. A completely overcast day is a perfect example of the softest light you can have. With the sky completely covered in clouds, the clouds themselves now become your light source. The size of the light source has gone from a tiny dot in the sky (the sun) to a source that fills the entire sky—quite literally. This massive light source creates an incredibly soft light with, quite possibly, no shadows at all.

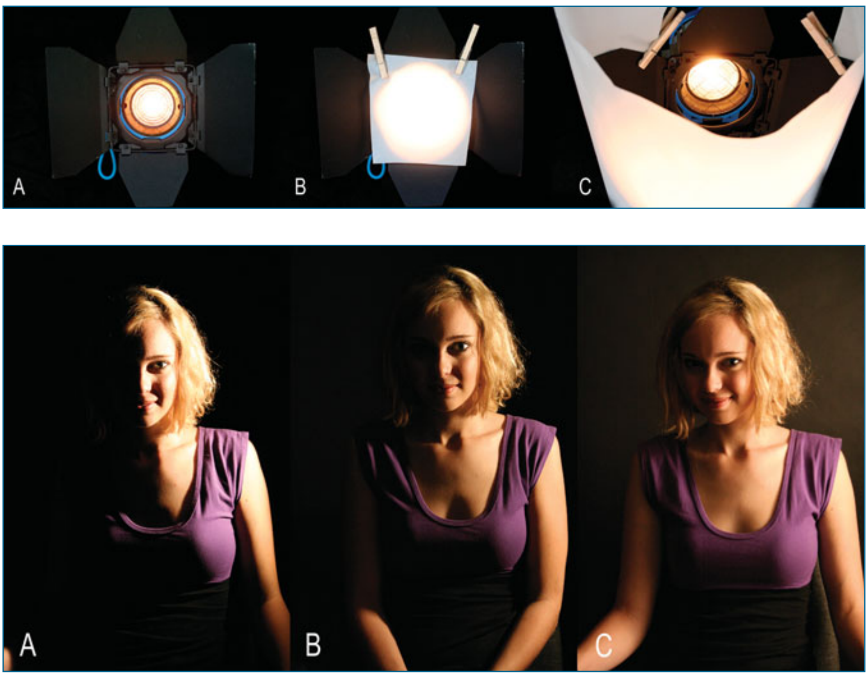
Although natural sunlight is a very hard source, when cloud cover diffuses the direct light of the sun, it creates very soft light.

Remember the key: the larger the light source, relative to the subject, the softer the light will be. It's also important to understand that when you put a translucent material in front of a light, that material now becomes the *effective* light source. As in the previous example, even though the sun is the origin of light, with complete cloud cover, it is now the clouds that become the effective source of light.

This is also true anytime that you *bounce* light off a material—the bounce material itself becomes the effective light source.

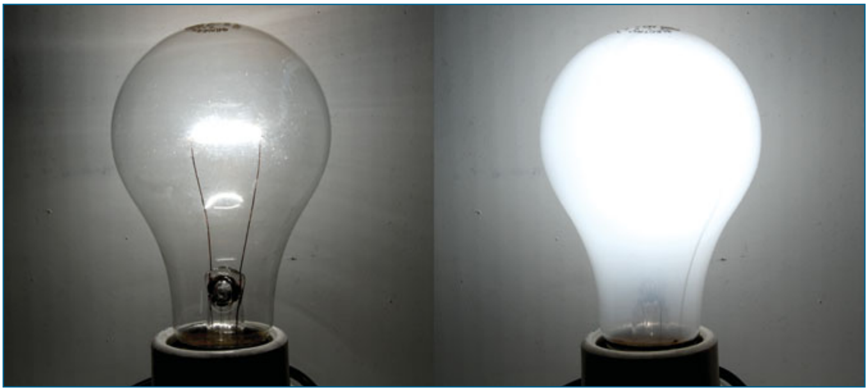
However you decide to soften your lights, you're always looking to increase the effective size of the light source. If you simply take a piece of diffusion and clip it directly to the face of a 6-inch Fresnel light, although you may scatter the light slightly through the diffusion, you haven't increased the physical size of the light and, therefore, you haven't really softened the source. If you take that same kind of diffusion, cut an 18-inch square and clip it to the ends of the barn doors, you're increasing the size of the light source by a factor of ×1.5 and creating a slightly softer source.

If you go further and cut a 4-foot square of diffusion and move it 3 feet away from the light so that the light evenly fills the diffusion, you have increased the size of your effective light eight times, from 6 inches to 4 feet—and considerably softened the light quality.



Looking at effectively attaching diffusion to a Fresnel: first clean (no diffusion) and then diffusion clipped directly to the face of the fixture, which does not increase the effective size. Then diffusion clipped to the ends of the barn doors, which does slightly soften the source. On model Amanda Bolten, a clean 650W Fresnel (A) with no diffusion, then with diffusion clipped to the end of the barn doors (B), which does little to change the quality of the light. Finally, with the diffusion clipped to the ends of the doors (C), the quality of light is notably different.

Recall the earlier discussion about a standard clear bulb? That is a point source, or a very hard source of light. I'm sure you've seen the "Soft White" bulbs that many manufacturers make as standard household lamps. What they've done with those is to coat the inside of the *globe* (bulb) with a translucent white to increase the size of the source from the size of the filament to the size of the entire bulb.



A standard clear bulb (on the left) is a very hard point source. By coating the inside of the bulb, the manufacturer increases the effective size of the bulb and creates a softer, more pleasing light source.

This considerably softens the light emanating from the bulb. However, remember that the softness of this new bulb is relative to its distance to the subject. If you place this bulb more than a few inches away from a subject, that light is going to harden because of the distance and its physical size, relative to your subject.

Soft light is, by nature, very low in contrast. It creates a very fine gradation between light and dark and can hide the textures of objects, even at extreme angles.

Fluorescent lights, by their very nature, are soft sources. The large glass envelope increases the effective size of the light source. There is also no point source in a fluorescent tube, compact or otherwise, so it starts as a soft, diffuse source.

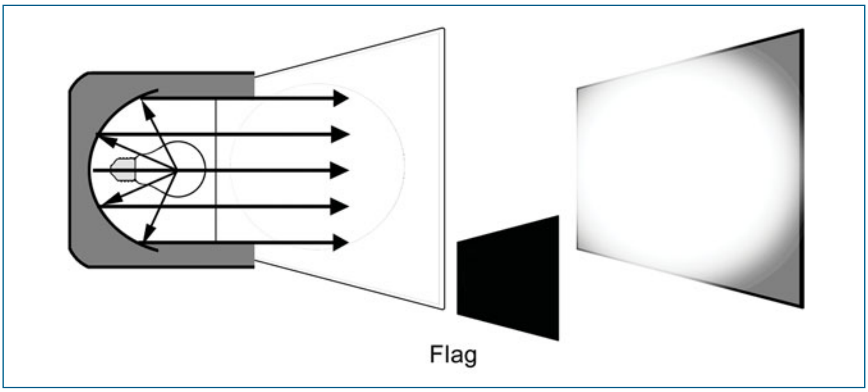
The same textured rock from earlier, but this time, a 4-foot piece of diffusion was placed in the position where the light was, previously, and the light itself was backed off so that it filled the frame of diffusion, creating a much softer source that wraps more into the crevices of the rock, hiding some of the texture of the stone.

Japanese paper lanterns (also called China balls) are simple white paper spheres that you insert a standard light bulb into. These are naturally very soft sources of light, as they quickly increase the size of the source. The larger the lantern, the softer the light. More on these tools in Chapter 7, "Soft Lights."

A paper lantern in action. On the set of *2 Million Stupid Women*, co-cinematographer Jayson Crothers (far right) and myself (second from right) discuss the coverage for a scene which was lit with a single paper lantern to create a very soft, intimate feel. Seated from left to right: Jackie Sollitto, Amanda Bolten, Josh Morrow, and Meghan Bradley. Unit photography by Shannon Lee.

Contrary to hard light, soft light is non-directional. Light is scattered every which way from the source and is very hard to control.

Putting flags in front of a soft source can be a lot like trying to stop an ocean wave with a 2×4. Since light is scattering in all directions, getting a clean, sharp cut from a soft source is difficult to impossible. Controlling soft sources requires much larger flags, which can take up a lot of space.



With diffusion in front of a lighting source making it a soft source, a small flag has nearly no effect on the final shape of the light. The soft light scatters in all directions around the flag making soft sources very difficult to control.

On a green screen stage for the "Gettin' Over You" music video for David Guetta and Fergie. Large 4'×8' flags are employed to attempt to cut the extremely soft light coming off a very large 12'×12' bounce source.

If you look around you, in daily life, you'll see myriad examples of soft lighting in architectural situations. Interior designers are always looking for ways to soften the lighting in rooms, make it more *ambient* and *sourceless*. This starts with lampshades, which are nothing more than decorative diffusers for standard light bulbs. From there you look at torchiere lamps, which direct their hard light *up* to bounce off the ceiling and give the room a soft glow. Architectural designers will hide lighting in recessed areas so that the people in the room don't see the actual fixtures, just the glow of the light bouncing off the walls.

Not every light can easily be made into a hard source, but any light can be made into a soft (or, at least soft*er* source) by adding *diffusion* material or by *bouncing*.

Diffusion

Introducing diffusion media between the light source and the subject is one way to create a soft source. There are many types of diffusion from the lightest (and most translucent) to the heaviest (most opaque).

The Real Stuff

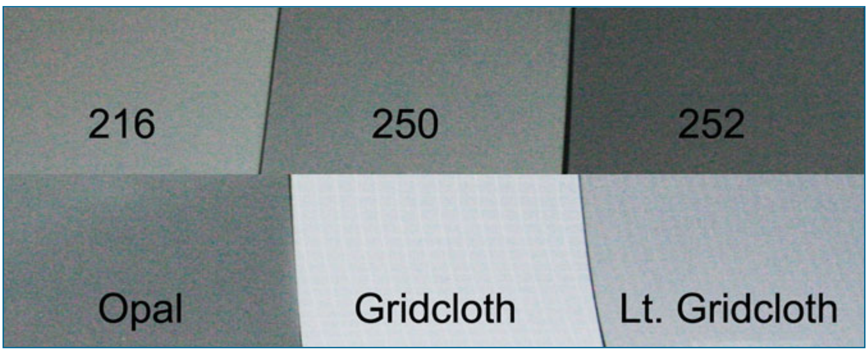
Professional diffusion media comes in many "flavors," from Hampshire Frost to Full Tough White diffusion. The more opaque the material, the more it will soften light, but also the more light is lost. Rolls of diffusion generally sell for about $140 for a 4×25-foot roll of the material.

The same manufacturers of gels are the primary manufacturers of diffusion materials: Rosco, Lee, and Gam. There are three primary groups of diffusion from each of the three manufacturers: Frost, Spun, and Gridcloth.

Frost diffusion is the most common, and the industry vernacular generally follows the Lee numbering system.

Lee	Rosco	Gam
216 (White Diffusion)	3026 (Tough White Diffusion)	10-80 (Ten-Eighty)
250 (Half White Diffusion)	3027 (½ White Diffusion)	10-70 (Ten-Seventy)
251 (Quarter White Diffusion)	3028 (¼ White Diffusion)	10-60 (Ten-Sixty)

This chart is provided merely as an example of the similar offerings from each of the three manufacturers of diffusion. Practically speaking, all of these types of diffusion are interchangeable; Rosco 3026 can easily be substituted with Lee 216 or Gam 10-80. The individual manufacturers—when it comes to the typical diffusions—are nearly identical. Each manufacturer, however, does offer its own additional diffusion choices that are unique to that brand.



Various forms of common diffusion placed against a black piece of paper to illustrate density differences.

Spun diffusion is a more textile-like material that has a natural amorphous fiber pattern to it. It creates a very soft source, without reducing the intensity too much. Both Lee and Rosco make spun diffusion (Rosco 3006, 3007, and 3022; Lee 214, 215, 229, 261–265).

Gridcloth is a textile material, almost a rough silk. It can be sewn and used in large sections. It comes in Full (R: 3030, L:430), Light (R: 3032, L:432), and ¼ (R: 3034, L:434) strengths.

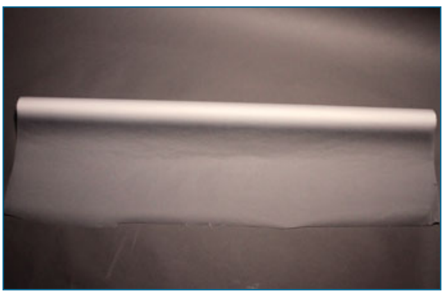
Finally, not offered by any of the gel companies, *muslin* (which is a thick, canvas-like woven cotton fabric) is often used as a diffusion and/or bounce material. Bleached (white) or un-bleached (off-white, which adds a touch a warmth to the color of the bounced light) can create wonderful soft light.

All of these are exceptional tools for creating diffusion, but they are expensive. There are, however, many alternatives to these materials that can be just as effective.

Caution

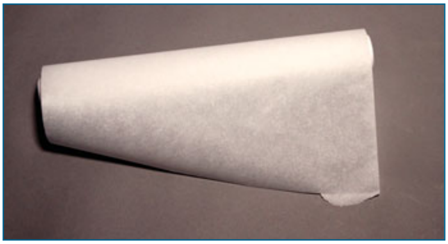
A major difference between commercial, professional diffusion materials and those inexpensive alternatives is that the professional variety are all flame retardant. They are meant to withstand high temperatures, close to lights, without melting or bursting into flames. All of the alternative materials I'll talk about here are exceptional diffusers, but they are *not* flame retardant. If you use them too close to the lighting fixtures, it is very likely they could start a fire. Be cautious, especially when making softboxes (discussed in Chapter 7), as trapping in the heat with non-retardant materials can be dangerous.

Cheaper Alternatives to Diffusion



Tracing paper, also referred to as 1000H.

Tracing paper is one of the most common diffusion alternatives, and one that is actually used quite often in the professional industry along with the real stuff. Offered in different strengths at any art supply store, and in large rolls, tracing paper is translucent enough to allow light to pass, yet opaque enough to act as an excellent diffuser. Tracing paper is *extremely* flammable and should never be used in direct contact with any hot lighting fixtures.


Standard household parchment paper.

Parchment paper is excellent diffusion that is heat resistant (though *not* flame proof) and can be used closer to hot fixtures with caution. It is only commonly available in 12-inch to 16-inch widths, so it's not great for larger diffusion needs.


A standard white bed sheet for diffusion or bounce.

Bed sheets are also wonderful alternatives to heavier diffusion. A simple white sheet can make a fantastic large diffusion frame. Sheets are available in a variety of thicknesses, thread counts, and variations of white, each providing different levels of diffusion. A little experimentation is necessary to find the type that works best for your taste.


A few yards of white lining silk.

Lining fabric is an inexpensive silk-like material intended for the lining of clothes. You can get it at any fabric supply store in white, or off-white to add a little warmth to your fixtures. Stretch it around a frame, and you have an instant "silk" to match the expensive silks used in the professional motion picture industry. It usually sells for anywhere from $2 to $4 per yard.


A piece of white plastic picnic table liner.

Plastic picnic table liner can also be a good diffuser. These are sold in large cuts or rolls and are incredibly cheap. It's a fairly opaque, but thin, material and makes for great heavy diffuser or bounce (see more on bouncing in the next section of this chapter). Again, keep these well away from any hot lights. This stuff will melt *very* quickly. It also tears easily and is, generally, not very robust.

Clear or white Visqueen (Polyethylene) is most commonly used as disposable drop cloth. It's sold in large rolls and available in any paint department of the hardware store. Again, use caution too close to light sources, or you'll have a stinky, gooey, melted mess on your hands.

A roll of translucent Visqueen drop cloth.

Vinyl shower curtain liners are very white and opaque, so they don't transmit a lot of light, but they can create wonderful soft sources. As with bed sheets, the naturally large size allows for an inexpensive large source if stretched out and filled with light.

In its natural environment, the vinyl shower curtain liner makes great bounce material.

The Art of the Bounce

Another way of creating soft light is to *bounce* the light off a reflective surface. Generally, anything white or light colored can be an excellent bounce (remember that a white object reflects the majority of light striking it), but there are some materials that are better than others, and each material is going to have a different quality of light reflection.

Recall that Chapter 2, "The Fundamentals," discussed the different properties of light reflection: specular, spread, mixed, and diffuse. The best bounce materials will have mixed or diffuse qualities.

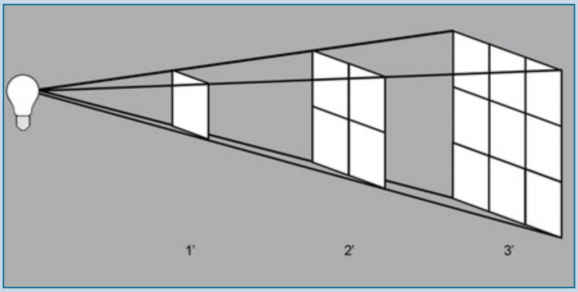
To get the best results out of a bounce, you'll generally want to fill the full bounce with the light source. The less area of the bounce that is filled with light, the less intensity of light will be reflected off it. For some, this seems counterintuitive because people think if they spot a light into a bounce card, they'll get more intensity out of it, but the reality is the more you can fill that card, the more reflective area is bouncing light and the brighter the reflective light will be.

Fall-Off and the Inverse Square Law

Light loses its intensity over distance. The intensity of the light will diminish, and the amount of light available to reflect off any given surface will drop rapidly over a distance. This is called the *fall-off,* and the physics of this phenomenon are defined by the *inverse square law,* which states that light intensity will diminish by the inverse of the square of the distance.

$$\text{Intensity} = \frac{1}{\text{Distance}^2}$$

If you have a point source light that provides 1,000fc of illumination at 2 feet, moving that fixture 2 feet farther away, to double the distance, would produce light output of 250fc (the square of 2 is 4, so one-fourth the light). If you moved that light an additional 2 feet, the light output would be 62.5fc.



A visual depiction of the inverse square law in action. As the distance increases, so does the spread of the light. Thus, the intensity is reduced over the greater area.

This law holds true only for point sources, as light that has been focused through a lens can travel farther with less loss. In addition, softer light, which is scattered more, will fall off much faster than the inverse of the square of the distance.

Fall-off is very important to understand, as you will quickly lose intensity of light the farther you move it from a subject. In addition, when bouncing light off a material, you're not only adding distance (distance from the light to the bounce added to the distance from the bounce to the subject), but also adding a material that will absorb a certain portion of the light. Therefore, generally speaking, you need larger sources for bounce lights than you would if the light were directly aimed at your subject.

Two of the most common portable, and relatively inexpensive, bounce materials are *foamcore* and *beadboard* (Styrofoam), both discussed next.

Foamcore

Foamcore is made up of two rigid pieces of paper with polystyrene foam "sandwiched" between them. It is available at any art supply store and comes in a variety of thicknesses and sizes, up to 4×8-feet large. 3/16-inch thick is a pretty commonly used size. Foamcore can be cut into all sorts of sizes and shapes, but typically 4×4-feet and 2×3-feet are common sizes that work for a lot of situations.

The semi-gloss surface of the foamcore makes its bounce property fall into the mixed reflectance category.

Foamcore is also available in black to be used as flags (see Chapter 11) or in dual-color options so you can have white on one side and black on the other. This is good for double-duty use where you can use one piece of foamcore as a flag or a bounce.

You'll be using foamcore in the next chapter; having a good supply on hand is never a bad idea.

Beadboard

Styrofoam is the trade name (EPS or Expanded Polystyrene is the generic name) for large flat sheets of beaded foam. The benefit to beadboard over foamcore is that the textured surface scatters light more indirectly and, therefore, creates a much softer bounce. The textured surface makes beadboard fall into the diffuse reflectance category.

One-inch thick EPS is generally the preferred thickness as it's less prone to breaking and bending than thinner varieties. You can find 4×8-foot sheets, but it's much more common to find 2×4-foot sheets in hardware and art supply stores.

Beadboard and foamcore are often taped together to make one bounce card with two different textured sides. The two pieces are cut to the same size, one placed on top of the other and taped together around the edges. It's a convenient way of keeping the beadboard more protected (with the more rigid backing of the foamcore) and to have one piece of bounce material with two different qualities; you have the harder bounce on the foamcore side and then can flip it over for a softer bounce source on the beadboard side.

Both foamcore and beadboard will clamp easily into the gobo head of a C-Stand, or you can use spring clips to clamp them to some other object or stand. Both are, typically, a little too heavy (especially combined) to be effectively taped into place, but if you're crafty with your adhesive, you can make it work.

A Note About Tape

There's a plethora of adhesive tapes out there, and I recommend that you carry several varieties at any given time.

Duct tape is the most ubiquitous and universal tape. Duct (not duck) tape is a woven fabric, generally with a silver metallic plastic (polyethylene) finish, with a heavy adhesive backing. It can be torn by hand, is very strong, and bonds to many different surfaces. The biggest trouble with duct tape is its super-strong adhesive that tends to bond too well to things like wall finishes, finished wood, flooring, furniture, equipment, and more. You're often left with a sticky residue, or, worse, you remove a portion of the surface of whatever you taped to. Duct tape is good for use on materials it doesn't have to be removed from.

Gaffer's or Gaff tape is an industry staple. It is very similar to duct tape in that it is a woven cloth tape with a strong adhesive, but it does not have the plastic coating and has a matte finish to it. Although most commonly used in black or white, gaff tape is available in many colors. Typically, gaff tape is sold in 1-inch (often called "camera tape") and 2-inch widths. Gaff tape's adhesive is not quite as offensive and aggressive to surfaces as duct, but it is often too much for a delicate surface. It should never be used on delicate surfaces: finished wood, painted surfaces, and the like. I've seen gaff tape rip plaster off walls before—never a pleasant thing whether you own the location or not (typically not). Gaff tape, like duct, is very strong, easily torn by hand, and is excellent for use in building basic tools and for use in taping things together that do not have to be removed.

Paper or masking tape is one of the most delicate tapes available. Paper tape has a low-adhesive backing and is intended to be removed from the surface it is adhered to without damaging the surface. One of the best varieties for this, in my opinion, is blue "painter's tape," which has a very low-tack backing. This is the best tape for attaching posterboard or diffusion to walls, or for attaching light objects to delicate surfaces. It's not infallible, by any means, and you should always use caution with any tape on any delicate surface, but it's often your safest bet. It is *not* strong like duct or gaff, but it is sufficient for light-duty jobs.

Showcard or Posterboard

Posterboard is available in any art supply store and is generally thin with a semi-gloss finish to it. It's an inexpensive and lightweight bounce material that can be taped up to nearly any surface, but is not rigid enough to stand alone.

Showcard is a slightly more rigid (and expensive) version of posterboard. It's a little harder to find in general art stores, but generally has a more matte finish than posterboard.

Additional Materials

Many of the materials I mentioned for diffusion also work for bounces. The more opaque a material is, the better a bounce it will be. Bed sheets, vinyl shower curtain liners, and muslin are all excellent bounce materials that provide different qualities of bounced light.

Light can also be bounced off any white wall or ceiling. Once upon a time, on a low-budget independent feature, I used the side of a white grip truck as a large bounce for a quick night-time exterior shoot, and the result was impressively effective. Don't be embarrassed if you make use of your surroundings and improvise—especially in a time crunch.

Techniques for Bouncing

Remember that the larger the size of the light source, relative to the subject, the softer the light quality. This is why bounce cards are generally 2×4-feet at their smallest and are often 4×4-feet or larger. Professionally, cinematographers often erect 12×12-foot or 20×20-foot frames of bounce materials, as these create incredibly soft sources. The larger your bounce, the softer the light will be.

Space, however, is generally a consideration. You don't always have the room for large bounce sources and have to resort to smaller sources or more elaborate techniques.

The thing to keep in mind, even with diffuse materials, is that the angle of incidence is still equal to the angle of reflectance. Try to position your lighting fixtures and direct your bounce so that the angle of the light falling onto the bounce is equal to the angle of light you want reflecting off it. When you set your fixture and bounce card, be sure to move the card around and watch the subject you're lighting. You'll be able to see when the bounce is "focused" or optimized for its best effect and intensity on the subject and what position works best for your needs.

In addition to flat bounce surfaces, there are a few techniques for maximizing bounce in a tight area. Taping a piece of posterboard in the corner between two walls or between the ceiling and the wall creates a curved bounce source in a tight space.

Another great technique for saving space and creating a soft source is actually combining bouncing and diffusion. This is often called a "book light." You can create your own by connecting one edge of two bounce cards together (like an open book), placing a light between them and then covering the open end with a sheet of diffusion. This also works great in a white corner of a room where you stick the light in the corner and stretch diffusion across the back of the light between the two walls.

Taping a piece of board into a corner to create a smoother, softer bounce.

A "book light" created by shining a light directly into a white corner and then placing diffusion *behind* the light to further soften the bounced source.

Making the Best of Cheap Sources

Softening of light is one of the main techniques you can employ to "save" cheap lighting sources. Halogen work lights or shop lights, clip-on lights, or cheap industrial sources often have unappealing light quality. They're not designed for pleasant lighting of people, and softening these sources is the key technique to make them useable.

It is also softer light that often helps to create the "film-like" look that many narrative digital video cinematographers strive for.

Now that you have a more solid understanding of light quality and know how to control your quality of light, you're ready for the next chapter, which really dives into the good stuff and starts to discuss lighting techniques.

6

Lighting Techniques

Lighting is *not* a paint-by-numbers art. Contrary to popular teachings, there is no secret formula for how to light. Although the three-point lighting concept (key, fill, backlight) that is covered in many other texts has merit, in my professional career, I have rarely employed the classic three-point lighting scenario. In reality my lighting might be only a key or only two backlights or lighting with what others would consider only fill. Perhaps I light with two fill sources, a key, and three backlights. It depends on myriad variables that cannot be considered in the classic three-point configuration.

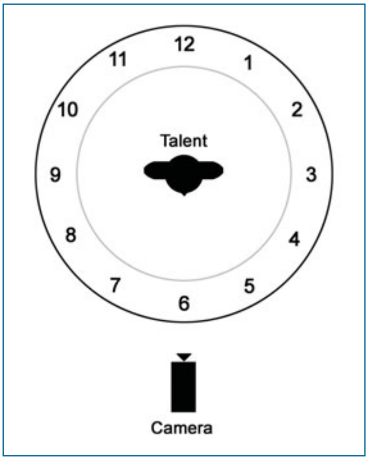
The top image, from the film *Mothman*, features actor Douglas Langdale, a mysterious man in black in a forest in West Virginia. Lit only with two backlights positioned deep in the trees (unit photography by Christopher Probst). In the image on the left, actor Stirling Gardner is an imposing force in *Mindgame*. This shot was lit only by a practical lamp low and off to Stirling's left side and an ambient "room tone" fixture.

In addition, one of the aspects of the three-point lighting concept that has always frustrated me is the question of what happens when the subject *moves.* As soon as your subject gets up and moves (which, strangely, happens from time to time when shooting *motion* pictures), the three-point concept goes right out the window.

In this chapter, you'll take a look at lighting from a different perspective than other books. Let's break it down to its simplest form: a single source. Let's take a peek at what a single source of light looks like from any given position on a single subject.

Position of Light

If you are pointing a camera at talent, you can define positions on a horizontal plane around the talent like numbers on a clock face, with the talent sitting in the center of the clock and the camera at the 6:00 position.



Using a clock face to identify lighting positions around a subject: the camera is at the 6:00 position with the talent in the center of the clock face.

I'll demonstrate the look of lighting positions around the clock face with the help of actress and model Lisa Jay and using a single Fresnel light. For the sake of this demonstration, I'm going to use a hard light source to help accentuate the differences in the various positions of the light. Starting at 12:00, the effect of this light position is a complete silhouette, showing no detail on Lisa's face, but equal highlights on the back of the head and both shoulders. This is a full backlight position.

Backlight position, the light at 12:00.

As you make your way around the clock face from 12:00 to 1:00 to 2:00, you start to see the light begin creeping around Lisa's face. These are still backlight positions. Between these two positions, the 1:30 position can also be called a ¾ backlight.

Moving farther around the clock face, the look of the light source at the 1:00 (left photo) and 2:00 (right) positions.

When you hit the 3:00 position, the light has now become a side-light. You can see in the image that I am now lighting half of Lisa's face. The high contrast of only half of the face lit, with the deep shadows, creates a very dramatic look.

The light at the 3:00 position creating a half-light or side-light look on Lisa's face.

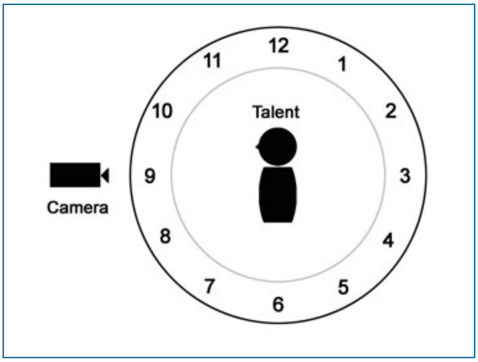
Bringing the light farther around to the 4:00 and 5:00 positions, you start to see a more natural and common look. The 4:30 position is considered a ¾ front light and is a common "key" position.

Moving farther around the clock face, the light begins to become standard key lighting positions at 4:00 (left) and 5:00 (right).

The front-lit, 6:00 position.

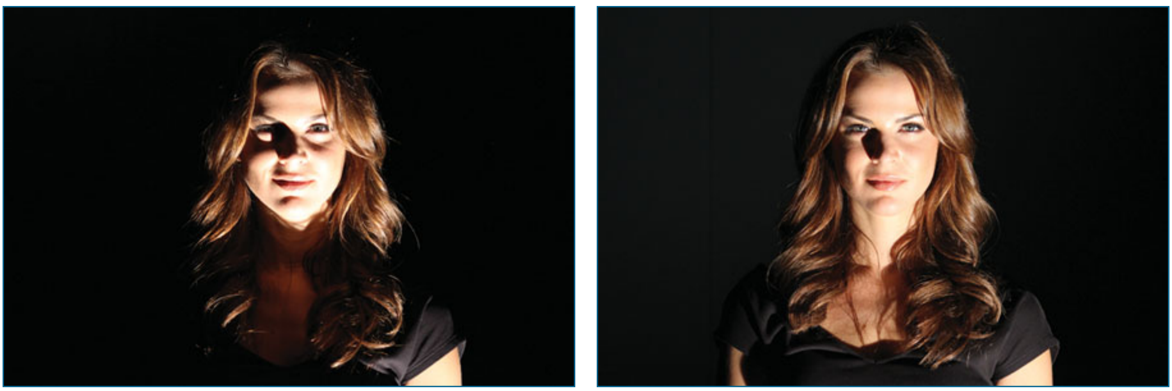
Finally, with the light at the 6:00 position, you have a full front-light. The features of the talent are "washed" away without shadows to define the texture of her face. This is a very common lighting position for fashion and beauty.

If you add a clock face, this one perpendicular to the existing imaginary clock so that it defines the vertical positioning of a light, you can see some very dramatic results from the height of a source relative to the talent, with 6:00 being directly below the talent and 12:00 being directly above.



A secondary clock face to describe vertical lighting positions around a subject with 6:00 directly below and 12:00 directly above the talent and the camera at the 9:00 position.

With the fixture at the 4:30 horizontal position, I'll start at the 7:00 vertical position (as 6:00 would be directly below Lisa's chair and the chair would block all of the light).



Moving around the vertical clock face, these images show the light at the 7:00 (left) low and 8:00 (right) low positions.

From these very low positions at 7:00 and even 8:00, you get what is often called "monster" lighting because it creates a rather horrifying and monstrous look. The reason this looks so grotesque is that it goes against nature. Our natural source of light, the sun, is always above us or directly level with us; natural light is never below us. Most all lighting of living and traveling spaces in homes and businesses is overhead or above eye-level, so seeing light below eye level is often perceived as uncomfortable and strange. As with all rules, however, this one doesn't always apply. Many times a hot (overexposed), soft bounce from a low position can have a very natural and flattering look; resembling light bouncing off the floor, perhaps (see the shots from *Tranquility, Inc.* in the "Motivating Light" section later in this chapter).

An uncomfortable moment for Lisa as the 9:00 position is shined directly into her eyes.

The 9:00 vertical position is directly at eye level. This is, obviously, uncomfortable for the talent as the light is shining directly in her eyes, and, for the viewer, it still doesn't feel quite natural. It feels wrong because you would almost never see this out in the real world. Why? Because it would be very uncomfortable to have lights shining in your eyes; there's a reason the cheap cop movies always use the table lamp directly in the eyes as an intimidation factor.

The 10:00 (top) and 11:00 (bottom) vertical positions on Lisa.

Light in the 12:00 position becomes what you would also call "toplight." It is a very dramatic position.

With light at the 10:00 and 11:00 position (previous page), you start to get into familiar territory. This is where light looks most natural, most flattering to most individuals. With the light above the person's eyeline, you see a very comfortable and natural play of light on Lisa's features.

The Key Light

No, I'm not contradicting my ranting diatribe on three-point lighting; its components are all relevant as separate pieces. The principal one is the "key" light. Now, this actually has two meanings, and they're often, but not always, describing the same light.

Chapter 3, "Understanding Exposure," discussed the idea of the "key" light being the brightness value within a composition that is at the proper exposure (Zone V) value for the particular *f*-stop. If you are shooting at an *f/2.8*, whatever lights on the set that give you the footcandles necessary to achieve an *f/2.8* in Zone V can be said to be *at key.*

The second definition of a "key" light is the primary source of illumination on the talent. In many cases, these are one and the same. The primary source of illumination on the talent may also be where the Zone V exposure is set. However, this is not always the case. As explained in Chapter 3, my artistic preference is to often put Caucasian faces at about a stop *below* key—that is my artistic choice. I don't *always* do that; each situation requires a different approach, but it is something that I typically do—in which case the "key" light (primary source), for me, is in Zone IV, not at the "key" (exposure) Zone V.

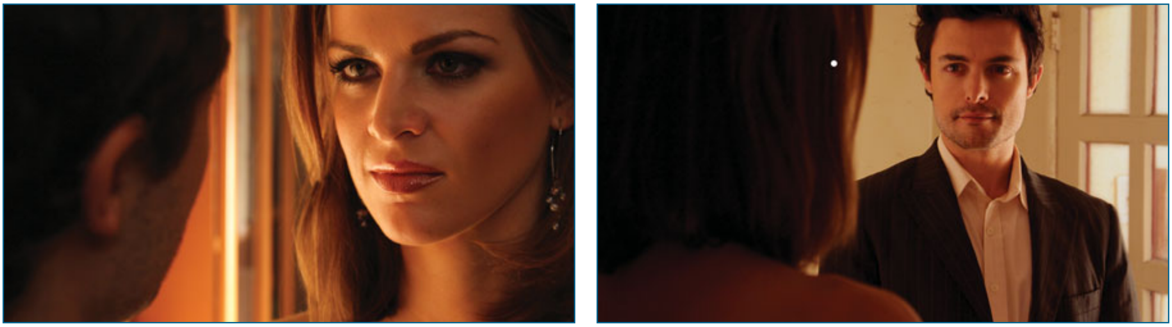
Here, though, I'm going to discuss "key" light as the primary position of illumination for your talent. The paint-by-numbers approach would tell you that this "key" position has to be between the 3:30 and 5:30 horizontal positions. I say that's *bullpucky*.

I've shot scenes where my "key" was at 1:00 or 2:00, just barely edging the talent with backlight. I've shot scenes where my "key" was at the 12:00 vertical position, with no other sources.

The "key" (and, yes, I'm going to keep using those quotes around that term) is your *primary* source of light for any given scenario. Which leads me to the next topic: motivating light.

Motivating Light

The principal factor for me, as a cinematographer, determining where I put my lights is often dictated by where the natural light is motivated from. Where would the light be coming from, naturally, in this situation? Is it daytime? Is it nighttime? Is there a window in the room? Every time I walked into a location, the first thing I would do is find the natural sources of light in that location. Do those positions and types of lights work for me for what I need to shoot here? Is the light motivated by a table lamp? By overhead fluorescents? By the glow of a candle?

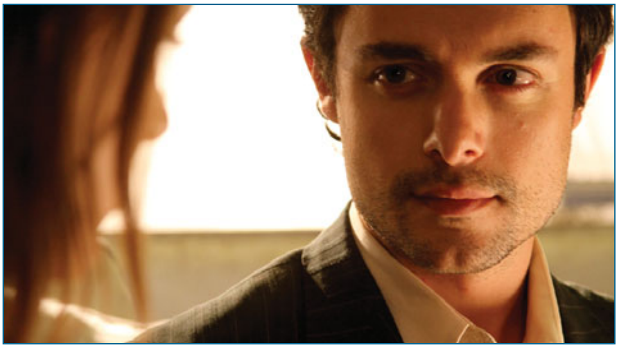


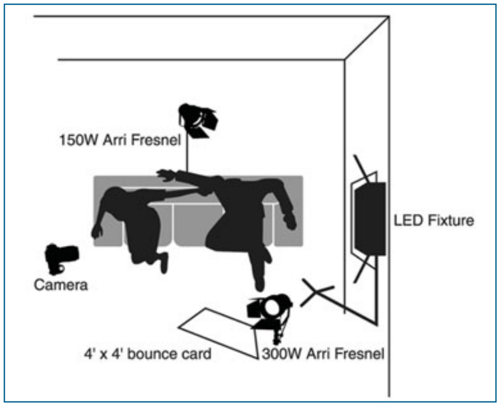
Two shots from the short film *Tranquility, Inc.* Actress Lisa Jay opens the door to a mysterious stranger. Lisa is lit by an Arri 650W Fresnel into a bounce card on the floor on her right side *motivated* by unseen late afternoon sunlight bouncing off the floor. In the reverse shot, actor Mark Gerson is the mysterious man with strong sidelight, provided from a 650W Fresnel "booklight" off to Mark's left side, *motivated* from the French glass door.

Very often, especially in situations where I had limited lighting tools to work with, I would start with the existing lighting at a location and adjust that to my liking: turning this light on, that one off, opening this window, closing that one, and so forth. And then I would bring in my own lighting to augment or accentuate the light that was naturally at that location.

If you're shooting on a set on a sound stage, you don't have the luxury of "natural" light because everything is fabricated. Then you start with: what kind of location is this? Is it a home (practical lamps, floor lamps, table lamps, chandelier, and so on)? Is it an office (overhead fluorescents, windows, individual desk lamps, computer screens, and so on)? Is it a forest at night (moonlight through trees, campfire)? You need to imagine how a real location like this would look and start from there.

On a practical location, the natural, existing light is often not enough for your needs. Many times augmenting that existing light is the best course of action (see Chapter 3 for more on this). Although natural daylight may be coming through the window, it may not reach far enough into the room, at a sufficient intensity to light your talent. In this case, you'll use additional lighting inside the room *motivated* from the direction of the window so that it still appears as though it is natural light.





A practical example of augmenting natural light. Although you see bright daylight outside the window behind actor Mark Gerson, the day was actually overcast and the light was dim. I overexposed the daylight and then added an LED fixture above the window to mimic the feel of daylight and put a hot edge on Mark's left shoulder. The edge on his right shoulder was provided by a 150W Fresnel, and his "key" was a 300W Fresnel into a low bounce card on his left side.

To this end, your "key" light can come from anywhere. Pay attention to what you see and experience every day in the real world. Learn to *see* lighting in any given situation and ask yourself these questions:

- How would I re-create this lighting?
- What would I have to do to augment this lighting if I were shooting here?
- Where is/are my primary source(s) of light coming from right now?
- How might I change this lighting to create a particular mood?

These questions will help to strengthen and refine your mental lighting arsenal.

The Art of the Fill

Fill light, by definition, is light added to the shadow areas of a composition to bring them up into the latitude range of your medium. Fill light is intended to reduce the contrast range in the scene to whatever level you desire.

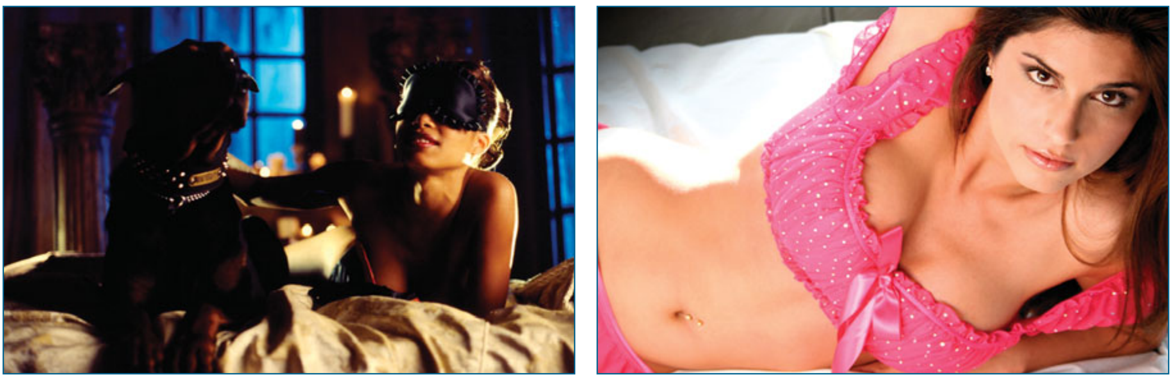
Contrast ratios are defined as the difference between the "key" and fill sides of a subject.

If your key and fill are of identical intensities (key at *f/5.6* and fill at *f/5.6*), your contrast ratio is 1:1. If the key is twice as bright as the fill (key at *f/5.6* and fill, one stop under, at *f/4*), then your contrast ratio is 2:1, and so forth. Anything more than a 4:1 contrast ratio means your shadow side is pure black, and the contrast range is beyond what the camera can resolve.

Fill light is, most often, softer than the "key" light, as the intention is to eliminate the shadows, not create additional ones. Commonly, fill light is not even an additional light, but just a bounce brought in to capture some spill from the "key" light and reflect it back at the talent.

Many times throughout my lighting career, I didn't use a designated fill light. As demonstrated in the second photo in this chapter, instead of a specific fill light, I used a technique called "room tone" (a term adopted from the late, great Conrad Hall, ASC), which was to bounce a small source—generally in the ceiling—at a very low intensity to raise the overall ambient light in the room to just above the latitude range of the camera. The bounce in the ceiling makes this "room tone" very soft, and so it feels "sourceless," meaning that it doesn't feel like it was really there at all. Then I would place my "key" lights, motivated by whatever natural lighting was at the location, and I was off to the races!

This is not to say that fill light should always fill all your shadows. It depends on what you're shooting and what the mood should be. Sometimes you want deep, dark shadows. Sometimes you want everything in the range of the sensor's latitude.



A mysterious and high-contrast image (left) with a beautiful model and her best friend. Deep shadows help create a very mysterious mood. On the right, model Shannon Setty in a different kind of sensual image with very low contrast and very few shadows.

Far too many digital video shooters feel that everything needs to fall within the acceptable latitude of their camera; that the signal range must conform to the values available on a waveform monitor. That is not true. There is no technical right or wrong as long as the image conveys the emotion and message you're trying to convey.

Modeling Faces

For most digital cinematographers, shooting faces is the majority of their workload. Because of that fact, it's time to put all the knowledge you've learned thus far into creating, sculpting, and modeling the light on the human face.

Model Jennine Dwyer is lit very simply with a 650W Fresnel into a Chimera softbox from her 6:30H and 10:30V position. The softbox has a diffusion face 24×32 inches large and it is, approximately, 3½ feet away from her.

Learning from Rembrandt

I'm going to dip back into the "classics" a bit, again, because it's an oldie, but a goodie. The "Rembrandt" style of lighting pleasantly shows off the shape of the face while making sure that both eyes are lit. Named for the famous 17th century Dutch painter, Rembrandt Harmenszoon van Rijn, this technique is best seen in many of the Dutch master's self-portraits.

This look is typically achieved from a "key" light in the 4:30 (or 7:30) horizontal (about 45 degrees) and 10:30 vertical (about 45-degree) position. The telltale of the Rembrandt-style is the small triangle of light under the eye on the shadow side of the face, formed by the cheek and shadow of the nose.

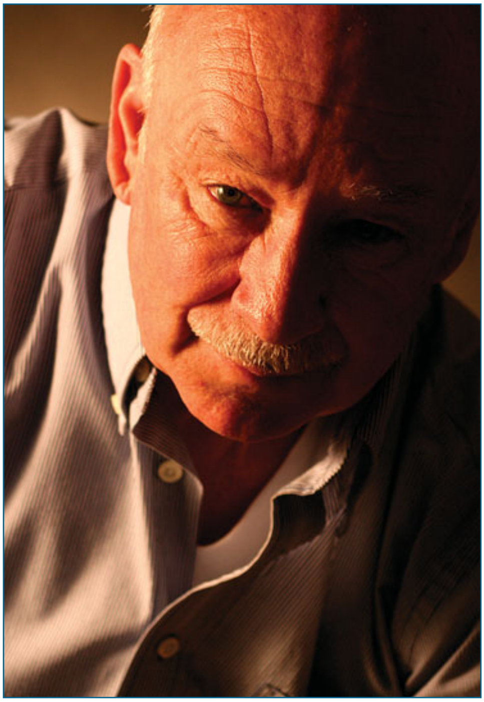
Rembrandt, titled Self Portrait, 1630. In many of his self-portraits, the Dutch painter was known for using a key light position that pleasantly defined the contours of the face and created the tell-tale triangle of light on the shadow side of the face.

Actor Dean West poses for a headshot, lit with the classic Rembrandt style with the telltale triangle on the shadow side of the face.

This isn't always the best technique, depending on the talent. Sometimes the shape of the talent's face is not compatible with this style. Large features can be accentuated by the shadows and direction of the light in this style. However, it is often considered one of the most natural "key" light positions and is a pretty good starting point for many situations.

Contrast Values: Men vs. Women

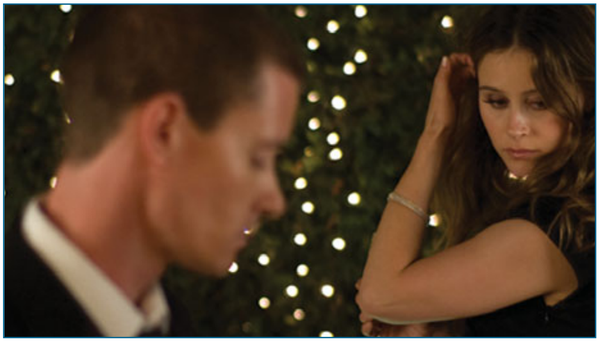
Generally speaking, men are lit with more contrast than women. This is *not* a steadfast rule, by any means, just a generally accepted technique. More contrast typically creates a more masculine feel. A softer contrast typically creates a more feminine feel. The following images are meant to illustrate these ideas.




My father, Douglas Holben, a former photographer, posing for a portrait. High contrast adds mood and accentuates the masculine feeling of the shot. Model and actress Michelle Berthelot West in a very soft, natural light to delicately accentuate her beautiful feminine features.

Remembering, of course, that the direction and position of the light can accentuate or reduce the surface texture of the object you're lighting, a more oblique angle of light (hard or soft) on the face will tend to accentuate the features and texture of the skin. If your talent has a large nose, for instance, you'll generally want to keep the light more in the 5:00 to 7:00 horizontal range to help minimize the shadow cast by the nose and reduce the size. Conversely, for someone with a large forehead, you may want to raise the height of the keylight to put more hair shadow on the forehead and minimize the size.

The contrast values between men and women are never more extreme than in "beauty" lighting for fashion, or what is sometimes called the "Revlon" look. In fashion and beauty magazines women are often lit from the 5:45 to 6:15 horizontal position and 9:30 to 10:30 vertical. This is nearly direct front light, or very "flat" light, which tends to smooth out the features.



Model and actress Amanda Bolten in a very soft and intimate moment beneath the sheets. In *Tom and Sophie* actress Lauren Waisbren is lit with very large soft sources in a romantic and beautiful setting.

The Super Secret Off-Camera Key

Here it is, folks; I'm giving away the farm. Here's the big secret—the one that helps a cinematographer's lighting go from "good" to "great."

Whenever possible, "key" from the off-camera side.

That's it. That simple.

This means if you're shooting your talent, and your camera is more to the talent's left side, you should "key" the talent from the talent's right side.

This is also referred to as "shadow-side to camera." It's the same idea. This puts definition and texture on the camera-side of the talent's face and adds depth and polish to the image.

Finally using myself as a guinea pig, I'm demonstrating the effect of off-camera key lighting, which puts the shadow side toward camera and helps to add more shape and definition to the face, adding interest to the image.

With the on-camera key, the face is lit more flatly, with less interest, and it doesn't have as much depth to the image as the off-camera key.

If you light from the *on*-camera side, you tend to have faces that can look flat and lifeless. You flatten the dimensions in the talent's face, making it less appealing.

This rule doesn't always apply, of course, but it is an excellent rule of thumb to keep in your back pocket. Sometimes, even if it isn't necessarily logical to light from the off-camera side, it still looks better and, therefore, feels better.

Look Behind You: Background Lighting

Or, rather, look behind your talent. Don't neglect the environment around the talent. Is there too much light back there? Is there not enough? Have you set your room tone?

Background lighting should define the environment around the talent, but never distract from them (unless, of course, there is narrative reason for distraction).

Many times, when I entered a location, the background lighting would be the *first* thing I considered. Where are the practical lights? How should this space look? Where can I accentuate or *remove* light? I'd start lighting the space around the talent first, and then find out where the talent was going to be and where they were going to move and then I would decide how to augment, supplement, or replace the room lighting for the talent themselves.

Whenever you walk into a practical location for the first time, it's a good idea to turn on every light you can to see what you're working with. In a perfect scenario, you can do this one at a time, turning each light on and off as you go to see what each individual lighted area looks like alone. Then you can make a solid decision about what lighting from that location you want to use, what lighting you want to keep off, and how you're going to need to augment from there.

Many times background lighting is just about the details and textures. As a general rule, you never want to flat light your background. You're not just turning on a light and shining it into the area behind the talent. You want to highlight certain areas; a glow here, a highlight there. Sometimes this means you've got to think like an architectural lighting designer, but that's a good thing! If you can learn to think like that, you can improve the dimension of your location.

Think outside the box. Try bouncing your backlight off the floor or raking it just along the edges of the furniture. Keep an eye out how natural light (especially sunlight) plays around actual locations.

There's very little worse than just blank white walls behind your talent. The best scenario is a darker colored or more textured background. Sometimes the best lighting plan is to find a better location, or even a better space within a specific location—although, granted, that's not always a viable option.

There are a lot of smaller lighting tools, as discussed in Chapter 10, "A Light by Any Other Name: LEDs and More," that are inexpensive and perfect for background lighting. Little accent fixtures you can find at a home décor store or in the lighting aisles of your hardware store.

When you're dealing with background lighting, think about *separation* of your talent from the background. Sometimes the best separation is to not light the background at all, but to have a deep shadow that helps the talent stand out. Sometimes a little glow or accent light behind the talent helps to add dimension and depth to make them stand out. You don't always have to backlight your talent to separate them; sometimes a glow on the wall behind them will do the same trick more elegantly. If your talent has light-colored hair (or light-colored skin and no hair), you'll probably want your background behind that actor to be darker, more shadowed to separate them. If your talent has dark hair (or dark skin and no hair), a glow behind them is better to separate them.

A Different Approach

Years ago, for a short film called *Mindgame*, I shot in a practical apartment location in Hollywood. The apartment was one long room with the bed near a floor-to-ceiling window. For a long, dramatic scene, the director, my good friend Jamie Neese, wanted to play the scene with both characters sitting on the bed, with the camera looking into the length of the room. Ordinarily, having a long room in the background of the shot is preferable because it adds depth and texture. In this case, however, this was a morning sequence, and I knew the main source of light would be the window and natural daylight. If I shot into the room, with the window directly behind the camera, the actors would be totally flat lit—with no dimension or modeling on their faces at all. I convinced Jamie to flip the shot—to shoot against the window, which backlit the talent, put the shadow-side to camera, and accentuated the drama of the scene. We decided to start the scene with the window at the camera's back and then quickly block the actors to move to the other side of the bed, to keep them backlit for the remainder of the scene.

Two screen captures from *Mindgame*. The first was the opening of the dramatic scene with the window at the 6:00 position, behind the camera, flat lighting the actors. The second shot is with the camera on the opposite side of the actors, putting the window in the 12:00 position to backlight the actors and create more drama in the scene.

In this case, the best lighting solution was simply to shoot a different direction in the same location.

Swimming in the Pools of Light

Few things boggle young cinematographers more than when the talent moves. When you suddenly have to follow your talent from one area of a location to another—even just one side of a room to another—it can be a complex issue. How do you keep them lit as they move?

The answer is—you rarely have to.

If you're shooting a walk-and-talk, with the camera moving with the actors as they exchange dialogue, that's different—depending, of course, on the genre and mood of the walk-and-talk. If it's an interview or a corporate presentation, keeping the talent well lit the entire time is a must. One of the best techniques for this is to actually move the "key" light along with the talent. With a small, soft, fixture handheld or on a boom pole, you can move it along with the subject, keeping the angle of the light and distance between the talent and the source even as you go. A China ball (see Chapter 7, "Soft Lights") or a small fluorescent fixture is great for this; they are soft, diffuse, and portable. Keeping the fixture moving also eliminates the need for aggressive rigging of lights throughout the walk-and-talk. The trick to the moving light is to keep it soft and keep off the walls/background behind the talent so that the viewers don't notice the light moving.

Aside from the moving source, the best technique for lighting movement is to think in "pools" of light—or areas of light and shadow that the talent will move through. Are they just walking from point A to point B? Then think about how they will look at point A and when they stop at point B and don't worry so much about the transition area.

Perhaps they're moving from point A to point D with minor pauses at B and C along the way. Then consider what you want/need to see at points B and C. Maybe at point B the talent stops, briefly, to pick up a folder from a desk. Instead of working to make sure the talent is perfectly lit at this moment, perhaps consider only lighting the desk and folder with a practical lamp on the desk and let whatever spill light illuminate the talent's face.

If you keep your eyes open and keep *seeing* real life around you, you'll notice that light isn't always perfect. People are often backlit in silhouette, or in shadow, or moving close to a bright light.… Keep an eye on life, and it will help inspire your lighting work.

Working from Wide to Close

A technique to keep in mind when working is to consider how you'll approach your wide shots first, and then refine for your close-up work. If you work the other way around, lighting for your close-ups first, you can often find it isn't possible to re-create your mood in a wide shot. Compromises often have to be made for the wide shots at any given location. After you've completed the wide shots and established the look, it's easier to refine your lighting when you get into shooting the close-ups.

In a perfect scenario, you always follow the adage: block, light, rehearse, shoot—in that order. Even if you're shooting reality or documentary, if you have to light, you have to know where your subjects are going to be—or you're just rough lighting an environment and shooting whatever you can.

In a narrative situation, block, light, rehearse, shoot is the strongest approach.

You block the scene first. You—along with the talent (or stand-ins for the talent) and the director—decide where the talent will be, where they will move, and how they will interact in the scene to be photographed.

From there, you send the talent away and start lighting based on what you saw in the blocking. This is where you light the environment and set the areas for the talent. When you've completed your lighting, the talent is called back to the set.

This is the rehearsal period where the talent refines their performances and you get a chance to see your lighting in action. You refine (tweak) the lighting, and then you shoot.

It's All About the Story

This brings me to an all-important note about lighting and storytelling. Lighting is the cinematographer's primary tool to convey story and emotion. Lighting directs the viewer's eye to the important parts of the frame. "Bad" lighting can direct the viewer's eye to the wrong place or to nowhere specific at all. "Good" lighting takes the viewer's eye and directs it exactly where the cinematographer wants it to go. What is most important in this frame right now: Is it the talent's face? Is it their hands? Is it the detail in the background?

Lighting should be used to convey mood that either complements the mood of a given scene or plays counter to it, depending on the requirements and artistic decisions of the creative team. There's really no right or wrong in lighting, as long as there's motivation and thought behind what you do.

Are you shooting an interview with a CEO? Maybe a little bit of contrast on the face in the "Rembrandt" style will give the CEO a classic, yet strong appearance. Are you shooting a violent fight? Maybe stage it under harsh glare of fluorescents to play counter to the dramatic action and accentuate a kind of harsh realism.

Are you shooting a romantic encounter? Try the classic warm candle-lit feel with soft "keys." Are you shooting product shots (often called "table top")? Better make sure you're working those specular highlights to define the shape and texture of the products.

Don't be afraid to be bold. Don't be afraid to take risks. Don't be afraid to push the envelope of your technology. Don't be afraid to think outside the box. Always think about whatever story and mood you want to convey and make your lighting work *for you*.

And, on that note, let's dive in and start making some tools to light with!

7

Soft Lights

Okay! Enough of the academic stuff… in this chapter, you get your hands dirty!

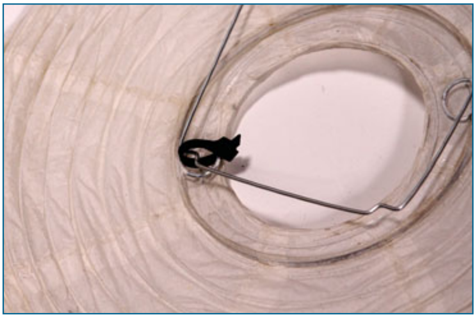
As discussed in Chapter 5, "Light Quality," soft light is a key toward getting a refined, more film-like look to your digital video. Soft light is also often much more pleasing on faces, and diffusion materials can help make inexpensive sources act like the big boys.

Using Paper Lanterns (Japanese Lanterns or China Balls)

Paper lanterns are kind of a no-brainer because they are already built for you. They're portable, lightweight, inexpensive, and really make some beautiful light. Paper lanterns are commonly available in 8-inch, 12-inch, 16-inch, 20-inch, 24-inch, and 30-inch diameters. You can find them at most home décor stores and party supply stores, or online at a number of vendors. I've seen 8-inch lanterns for as low as $1.50 a piece and the large, 30-inch lanterns for as low as $5.00 a piece.

A photo of a paper lantern, otherwise known as Japanese lantern or China ball.

Paper lanterns are delicate and take some care in handling to make them last, but if cared for, they are well worth it. I try to keep them in one box, without anything else in the box that might puncture the paper.



A wire zip-tie secures the paper lantern spreader to the lantern for safekeeping.

The small wire spreader that comes with the lanterns is easily lost, which renders the lantern useless. To keep these in place, I use a small *zip-tie* (or cable tie) to attach the top wire of the spreader to the top frame of the lantern. This keeps them always together.

CAUTION

It's important to use caution with the wattage of bulbs that you use in paper lanterns. The paper is incredibly thin and flammable. Always make sure that the bulb you use does not make contact with the paper. This means the ball should always be positioned so that the lamp is hanging down and perfectly centered. With larger diameter lanterns, you can safely use higher wattage globes.

One of the best tools I've seen for paper lanterns is the Lanternlock (www.lanternlock.com), which is a rigid aluminum frame with built-in medium (standard) or mogul (larger) base and cable. If you have a Lanternlock or two, you can toss out those weak spreaders and just use this tool. It doesn't pack up neat and tidy, but it is definitely robust and safer because the lamp is always assured to be away from the paper, no matter what configuration you put the lantern in.

You can also purchase a "liberty bell" at most hardware stores; this is a standard medium-base socket attached to an extension and plug. Pre-built, this makes rigging of the lanterns easy.

If you don't have a pre-made liberty bell, you can make your own, which I'll explain next.

A Word About Costs

Each project in these step-by-step chapters includes the item costs involved with that project. For general tools, such as screwdrivers, drills, and wire strippers, I don't include a price; these are things you should already have if you're going to embark on any of the projects in the book. All prices are average and rounded to the nearest dollar. Also note that many items I include in any particular project can be used for multiple projects. So, although a roll of duct tape may be $8, it will last you quite awhile and should work for several projects. You should have to buy only one small box of wire nuts for all of the projects in the book, but I include the cost of those wire nuts for each project. In effect, you will find that if you build multiple projects from this book, the quoted prices will exceed the cost of the actual project.

Making a Liberty Bell

The liberty bell is really just a medium-base socket with a plug. You can buy them already made from your local hardware store or wherever paper lanterns are sold, or you can quickly make your own by following these steps.

A completed liberty bell with a PH 212 Photoflood bulb ready for use with a paper lantern.

The components necessary to create your own liberty bell.

You'll need the following supplies:

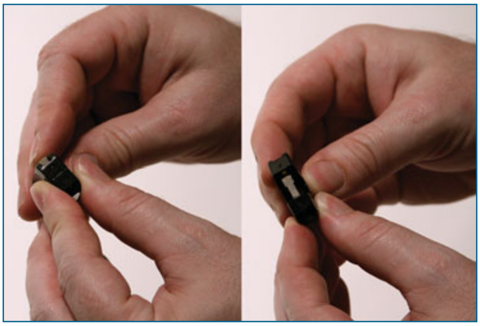
- 6-foot length of 18/2 zip cord: $1
- Add-a-Tap: $2
- Quick-On: $2
- Medium base socket adapter with Edison plug: $4
- Roll of PVC electrical tape: $4

Total cost: $13

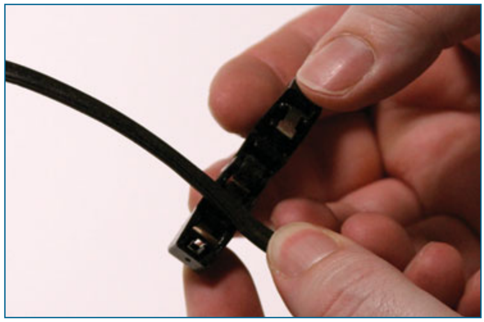
Step 1

Start by attaching the Add-a-Tap to the 18/2 length of zip cord about 6 inches from one end. To attach the Add-a-Tap, follow these steps:

1. Find the silver lever on the side of the tap.
2. Gently pull the silver lever away from the plastic. The tap will open on a hinge on the opposite side of the tap.
3. Gently place the 18/2 zip cord in the grove in the center of the opened tap so that it lies flat against the plastic with the two wires side-by-side.

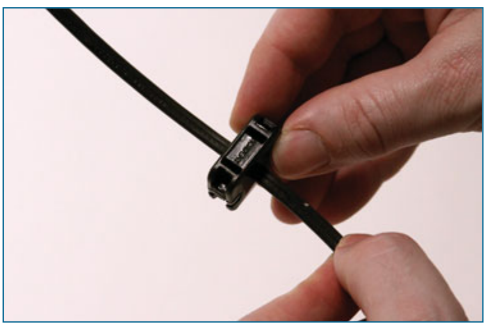


The small silver lever on the side of the tap that allows the tap to open.



Placing a piece of zip cord into the mouth of an Add-a-Tap.

4. Gently squeeze the tap closed. The built-in metal teeth will pierce the insulation of the cord and make contact with the wires inside.
5. Keep pressing on the tap until it “clicks” shut.
6. Give the tap a good tug to make sure it’s secured and not going to pop open.



A fully secured Add-a-Tap on a piece of zip cord.

Step 2

Take the 6-inch tail that is sticking out of the tap and fold it back on the longer length. Hold it in place while you take the PVC electrical tape and secure it safely.

Be sure to overlap the exposed end of the wire under the tape. You are taping to create a loop in the end of the wire, but also to securely seal the exposed end of the zip cord to prevent contact with live wires when it's plugged in.


Bending a loop in the zip cord.

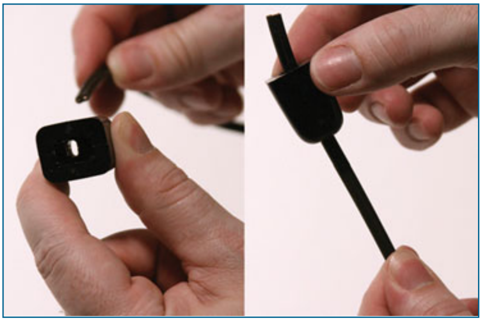

The loop needs to be secured and the exposed end taped to protect the exposed wire end from any unwanted contact.

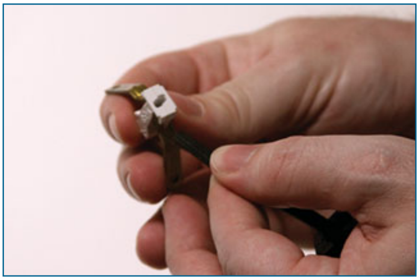
Step 3

At the opposite end of the zip cord, attach the Quick-On plug. To attach the Quick-On, follow these steps:

1. Gently squeeze the two pins together and pull the center away from the outer plastic.
2. Feed the end of the zip cord through the small hole in the base of the outer plastic.


Open a Quick-On plug by squeezing the terminals together and gently pulling the center away from the housing.


Threading the zip cord into the Quick-On base.



How the zip cord end slips into the base of the Quick-On center.

3. Gently spread the two pins on the centerpiece as far as they will go.
4. Slip the end of the 18/2 zip cord into the small hole in the bottom of the centerpiece. Push it in until it stops.
5. Gently squeeze the two pins together. The metal teeth on the pins will pierce the plastic insulation of the cord to connect with the wires inside.
6. Gently feed the center portion back into the plastic outer portion, carefully feeding excess zip cord back through the hole in the base of the plug.
7. Once the center portion is firmly back in place, the plug is now attached. Give one of the pins a gentle tug to make sure the center portion is correctly seated.

Squeeze the terminals together to puncture the zip cord.

Once connected, the center portion slides back into the housing and the plug is complete.

Step 4

Simply plug the medium-base socket to plug adapter into the Add-a-Tap at the end of the zip cord. You now have a completed liberty bell!

Masking Off Your China Ball

One of the most significant problems with paper lanterns is the fact that it's 360 degrees of light! You have a bulb in the center of a white ball, so it radiates light in every direction at once. This is a very sledgehammer kind of tool when sometimes all you want is a ball-peen hammer.

Because paper lanterns are round, it can be a challenge to mask them off with any kind of precision. Consider the following materials for doing so:

- **Duvetyn** is one of the best masking materials; it is a woven textile in flat black that is easily torn. Using *C-47*s (the industry term for a wooden clothespin), you can gently clip the *duvetyn* to the top of the ball, but this can be tricky. The lanterns are so easily torn that the additional weight of the duvetyn can be too much. You're better off clipping the duvetyn to the C-Stand supporting the ball, but it's difficult to get the right finesse from just clipping the masking to the stand.
- **Black Wrap** (also Black Foil or Cinefoil) is a great tool for this, but it isn't cheap. Available from the major gel manufacturers (Rosco, Lee, and Gam), Black Wrap is, essentially, black aluminum foil. It's easily moldable, lightweight, and extremely heat resistant (although being black itself, it does *absorb* a lot of heat and can heat up quickly). Black Wrap is good to have around, but it can get very costly. About $30 for a 2-foot wide by 25-foot long roll. Conversely, good ole standard aluminum foil is only about $2 for a 2-foot wide by 25-foot long roll. The difference, of course, is that aluminum foil is reflective and will bounce light off it in all sorts of directions. If you're careful with your placement and how tightly you hug the lantern with the foil, you can effectively mask off portions of your lanterns with traditional aluminum foil, but it takes a little care.
- **Black plastic garbage bags,** although not quite as elegant, can be sliced open to lie flay and make masking for your lanterns. Garbage bags are light, easily clipped to the fixture and—if you get the "stretch" variety, even though it has a sheen to it—the textures are so diffuse that it won't bounce light everywhere. As with many alternate materials, plastic bags are far from fire retardant, so keep them away from the hot lamp socket, or you're going to get some stinky melted plastic.
- **Black picnic table liner** is another alternative. Available at any party store, this stuff is cheap and lightweight. It isn't completely opaque, so if you're in a really light sensitive situation, you may need to double up on it.

The Croney Cone

Named after the late, great cinematographer Jordan Chronenweth, ASC, whose work brought films like *Blade Runner* to life, the Croney Cone is a simple softbox that attaches to the front of various lighting instruments.

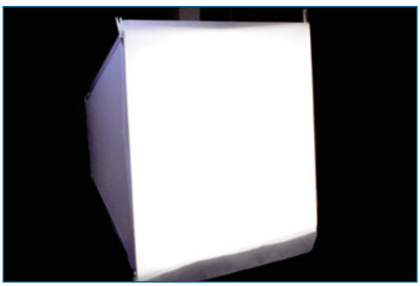
The Real Stuff

There are a number of manufacturers that make high-end "Croney Cone" softboxes, Chimera and Lowel being two of them.

An Arri 650 Fresnel attached to a small Chimera Quartz Lightbank softbox.

They're made of heavy-duty soft material that is black outside and reflective inside with removable and interchangeable diffusers. They collapse down like tents and are easily transported. These are *not* inexpensive, however. They're a significant investment and you need specific adapter rings for specific fixtures, so if you have a number of types of fixtures, you'll have to purchase different adapters. They do not easily work with do-it-yourself fixtures, but integrate with the real stuff (discussed in Chapter 1, "What You Need") very well. Like all lighting equipment, they are an investment, but they will last you a long time if properly taken care of.

Making Your Own Croney Cone Softbox



The Croney Cone softbox.

The components necessary to make your own Croney Cone softbox. Not pictured, two pieces of $\frac{3}{16}$-inch thick 60"×40" foamcore, roll of 36-inch wide tracing paper and three #2 spring clamps.

Use the following steps to make your own Croney Cone. I'll demonstrate the cone for a set of halogen work lights, but you can make cones for any variety of fixtures.

You will need the following supplies:

- Two sheets of 40"× 60"×3⁄16-inch foamcore (not pictured): $16
- 2-foot roll of white gaff or duct tape: $8
- 36"×36" piece of diffusion (tracing paper, not pictured): $3
- Four clothespins: $3
- Three #2 spring clamps (not pictured): $6
- Tape measure
- Razor knife
- Yard stick and/or square
- Marker

Total cost: $36

Using a favorite of no-budget shooters, I purchased a two-light halogen work light from the hardware store. It comes with its own stand, which is handy, but the light coming from these fixtures is pretty ugly, so adding a Croney Cone softbox to the fixture helps considerably.

The completed work light fixture, assembled according to the manufacturer's instructions.

Step 1

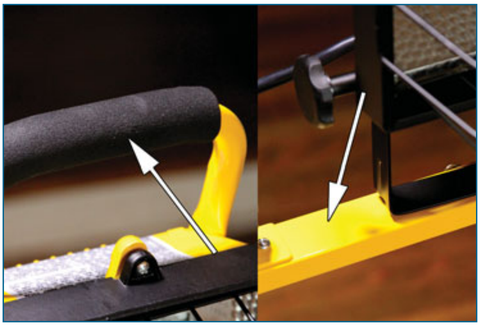
Construct the work lights according to the manufacturer's instructions. This is going to include putting the lamps in the fixtures. Remember that these are tungsten-halogen lamps; do not let your fingers come in contact with the glass envelope of the lamp. If this does happen, use a little isopropyl alcohol to clean it off before turning the lamp on (more on this in Chapter 8, "Tungsten Fixtures").

Step 2

You now need to determine how deep this box will be. A deeper (longer) box will allow for a larger face and, of course, the larger the face of the box, the softer the quality of light. In this case, the box will cover both lights of the fixture, but you also don't want it to be too big or unwieldy. I think a 24-inch deep box would work. There's really no specific reason for that except a gut reaction. You *could* go as deep as 40 inches because that's how wide the foam-core is, but I think that will create a box that is too big and heavy for most applications.

Step 3

Figuring out how to mount the box to the light isn't an easy task. For this specific fixture I decided to use the two strongest points on the fixture to connect to—the top foam handle on each of the work lights and the T-bar base of the stand.



The points on the fixture I decided to mount the softbox to.

The next step is to measure the vertical distance between these mounting points (13 inches in this case) and then the distance side-to-side of the two fixtures (20 inches). This becomes the size of my rear opening of the softbox (13"×20").

Measuring the fixture to determine the rear opening of the softbox.

Step 4

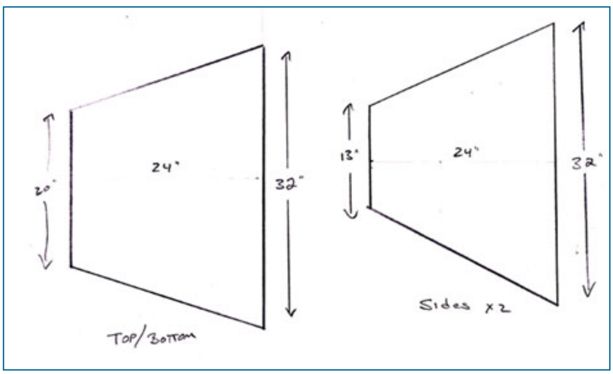
To determine how wide the face of the box will be, you start with knowing how deep you want it. In this example, I've already decided on a depth of 24 inches for the box, and you want to maximize the efficiency of the softbox—making sure that the light output from the work lights completely fills the front diffusion of the soft box. Dark spots would mean that you have too large of a face. So to determine how wide of a face you can make, you need to set the lights 24 inches away from a wall and turn them on.

Then you measure the hotspot of light on the wall and find that you can easily go 32"×32" for the face of the box. That's definitely large enough for many needs. This gives the box dimensions as follows: a rear opening of 20"×13", a depth of 24 inches, and a front opening of 32"×32".

Measuring the light beam on a wall at the distance of the softbox depth to determine the size of the box face.

Step 5

To make sure you have this right, you might want to sketch it out on paper. This falls under the category of the adage that my father taught me, "measure twice; cut once." By sketching it out, you get a better picture of what you need: two isosceles trapezoids that are 24 inches deep with a short side of 20 inches and a long side of 32 inches for the top and bottom of the softbox and two isosceles trapezoids that are 24 inches deep with a short side of 13 inches and a long side of 32 inches for the two sides.



Measure twice, cut once: drawing the intended forms before cutting the foamcore helps to eliminate mistakes.

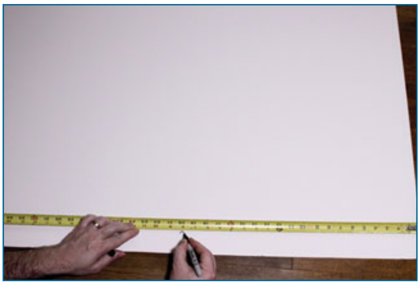
Step 6

Once you have a solid idea of the pieces you need, the next step is to trace it out onto the foamcore. Let's draw out the top and bottom (larger pieces) first.

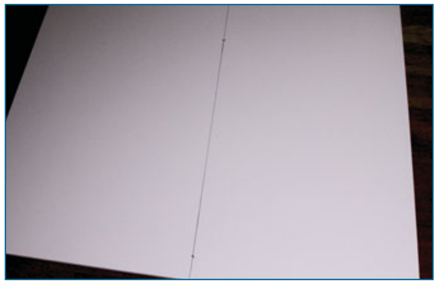
It's best to mark the centerline of the foamcore to ensure a uniform shape to your pieces. The foamcore is 40 inches wide, so the center will be 20 inches from the edge.

Using a tape measure, place a mark on the edge at 20 inches and then move the tape measure down the foamcore to the middle and place another 20-inch mark and then a third at the opposite end.

Using the second piece of foamcore as a straight edge, align the long edge with the three marks you just made and draw a line right down the center of the foamcore.



Marking out the point to determine the centerline of the foamcore. All measurements will be based on the centerline to ensure uniformity of the pieces.



The centerline marked on the foamcore.

Step 7

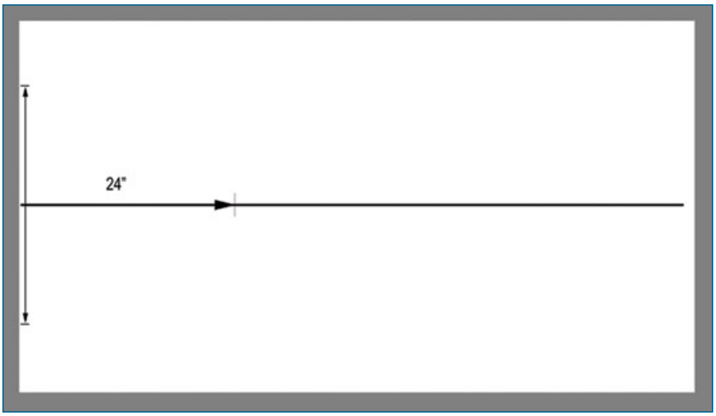
Once you have your centerline, you can draw out the individual sides on the foamcore. Use the factory edge to start with as one outside edge of the cone. You know that the sides are 32 inches wide at their opening and 20 inches wide at the back.

32 inches divided by 2 is 16 inches, so starting at the centerline, you measure out 16 inches to one side and make a mark and then go back to center and measure out 16 inches to the other side. This gives you two marks 32 inches apart from each other and centered on the foamcore.

Marking out the 32-inch side by measuring off 16 inches from each side of the centerline.

Step 8

Next, start at the edge and measure 24 inches down the centerline. Make a mark there; this is the depth of the box.



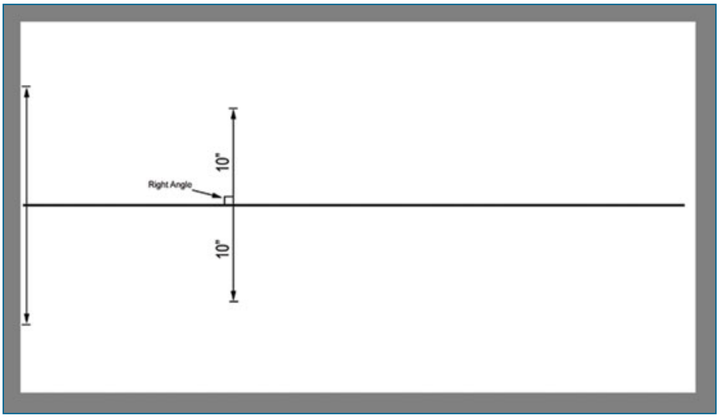
Marking out the depth of the box by marking out 24 inches down the centerline from the factory edge.

Step 9

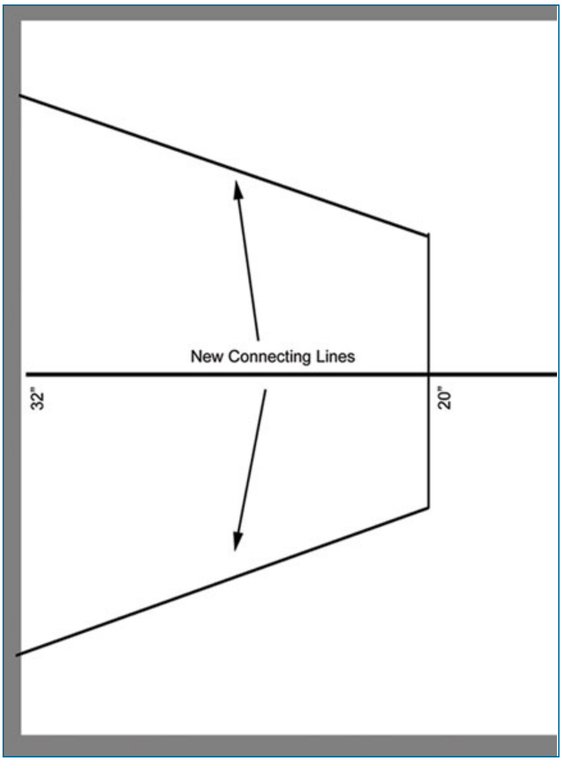
From that new mark, you need to mark out the short side of the piece. You know the short side is 20 inches, so measure out 10 inches from the center to one side and make a mark; do the same for the other side. These two marks will be 20 inches apart.

Use the square (or corner of the other piece of foamcore) to align one side to the centerline so that you know your new marks will be at a perfect right angle to the centerline and perfectly parallel with the 32-inch line that you marked off on the factory cut edge. Keeping these lines perfectly parallel is important to making a box that fits together later!

Marking out the short side of the top/bottom by measuring out 10 inches from the centerline on both sides to create a 20-inch side.



The final shape of the top of the Croney Cone box.



Step 11

The top (right) and newly created bottom (left) shapes traced out on the foamcore.

You already have the 20-inch side drawn for the top piece, and this same line will become the 20-inch side for the bottom pieces. From that center line where the 20-inch line is drawn, you want to measure out the depth 24 inches for the bottom piece and make a mark. From that new mark, you need to make another 32-inch line. Measure out 16 inches to one side and make a mark and then 16 inches from center to the other side and make a mark. Using the corner of the other piece of foamcore to ensure you're making a perfect right angle (this line should be exactly parallel to the other 32-inch side made from the factor edge), connect the two 16-inch marks to create your second 32-inch side.

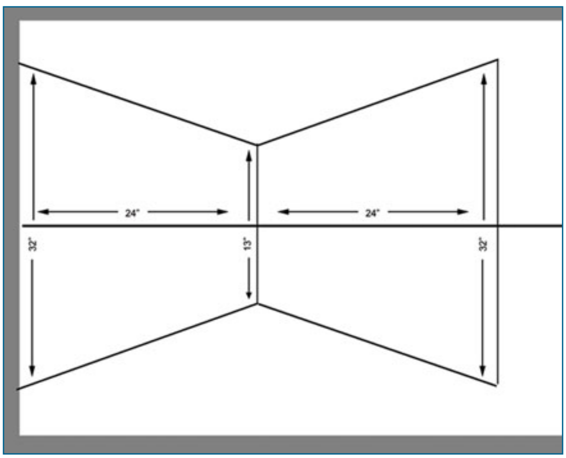
Finally, connect the 32-inch side to the 20-inch side by completing the trapezoid shape and drawing in the sides of the bottom piece.

Step 12

Now comes the fun part! Taking your razor knife, and using the square as a straight-edge guide, simply cut the foamcore down the lines you've drawn. This will create two pieces that are 32 inches on one side, 20 inches on the other, and 24 inches deep.

Step 13

Using your second sheet of foamcore, repeat the same process (Steps 5–12); except this time you'll create two isosceles trapezoids with long sides of 32 inches, and short side of 13 inches instead of 20.



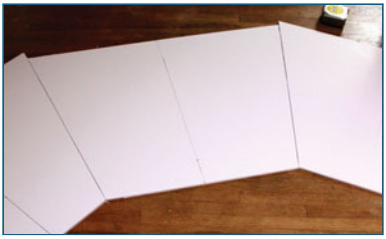
The sides of the Croney Cone softbox traced out.

Step 14

Cut out the sides from the foamcore.

Step 15

Carefully align the backs of the pieces on the floor, top to side to bottom to side.

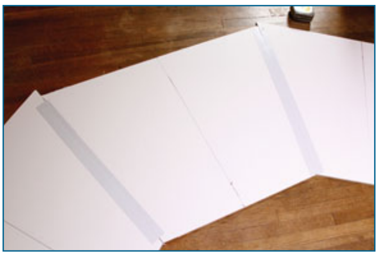


Now lay the pieces out on the floor. You want to place a top/bottom piece first, and then a side piece next to that so that the 32-inch sides are facing the same way and the shorter sides are facing the same way. Be sure to align the short edges, as shown in the photo.

Then lay down another top/bottom and finally the second side. Two of the sides will be slightly longer than the other two; don't bother to trim, this will come in handy later. Just be sure the backs are carefully aligned.

Step 16

Using the duct or gaff tape, tape over the seams between the pieces to connect them.

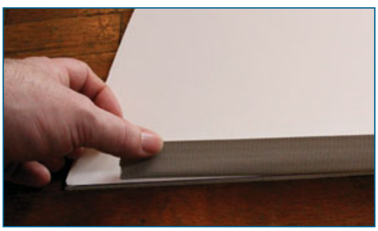


Keeping the edges tightly together, use the 2-inch gaff or duct tape right over the seams to connect the pieces.

Do this for all three connecting seams: top to side to bottom to side.

Step 17

On the final seam, fold a piece of tape in half (non-adhesive side to non-adhesive side) and tape half of it to one edge of the foamcore.



With the final edge, rip off a piece of tape and fold it in half non-adhesive side to non-adhesive side. Place it along the open edge of the bottom side.

Step 18

Folding the pieces along the taped seams so that the tape is on the *inside* of the box, you'll form your trapezoid and then connect the two open edges and gently unfold the open half of the tape to secure the final seam.

This creates your full box.

Folding the pieces together with the tape seams inside and using the final folded piece of tape to secure to the final edge of the foamcore.

Step 19

Tape over all of the seams on the outside of the box.

Taping over the outside seams to secure the box.

Step 20

Now you've got your box! It's time to attach it to the work lights. Clamp two #2 spring clamps to the top (one on each of the work light's top handles) and one on the base T-bar.

The finished form of the Croney Cone.

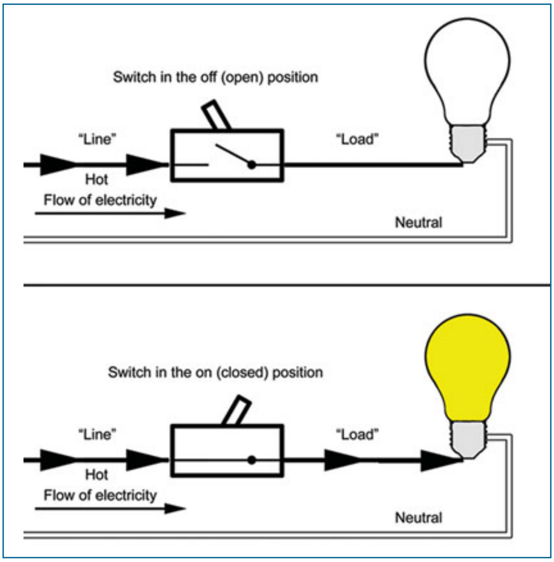
The mounting points. Attach the softbox to the work light fixture.

Attach the diffusion using the clothespins.

Understanding the Switch

Before you jump into the next project, it's important to understand the function of a switch, as you will be incorporating them—in addition to dimmers—in several of the upcoming projects. Later, some of the wiring starts to get more advanced and will require a fundamental understanding of what is really going on.

A switch, for all intents and purposes, is an interruption device that stops or allows the flow of electricity to a component downstream of the switch (as discussed in Chapter 4, "Understanding Electricity," a breaker is really just an automated switch). When the switch is off (also called "open"), it breaks the connection inside the switch to stop the flow of electricity downstream. When the switch is turned on (also called "closed"), it makes the connection inside that allows the flow of electricity.



The function of a common switch.

Switches interrupt only the hot leg of a circuit; they do not connect to the neutral. Both the neutral and ground remain in constant connection with whatever is being powered and only the hot leg is interrupted.

So, every switch must have a hot leg powering it, called the *line*, which comes from the power source, and then connects to the black or hot line going to whatever device is being powered, called the *load*.

When you have two switches, both powering a different device or aspect of a device, both switches need to receive a connection to the power (line) and to the hot lines of the device being powered (load). You'll do this by branching off the powered line to connect to both devices; this is often done with a "pigtail," which is an additional short piece of wire that is meant to branch off to form a new connection. For now, just keep this in mind, and I'll explain more as you go along.

Making the Connections

Although I have to assume that you, dear reader, have a firm fundamental do-it-yourself spirit and a basic understanding of how to tackle the projects in this book, there are a few basics that I feel compelled to explain here to make sure that the work you do is safe. Making sure you have good, safe wire connections is paramount to creating projects that last and, um, don't go up in smoke and flames.

Chapter 4 discussed how electricity works: electrons traveling through conductors. A conductor doesn't have to be one solid wire. In fact, anything touching that bare wire, if it is capable of conducting electricity (such as the human body), will become a part of that circuit and conduct electricity. This means that you can extend and branch electrical circuits by simply connecting two wires. However, the better connection you have between those wires, the less resistance, the better transfer of electrons, and less heat generated. Additionally, electricity *wants* to flow and, depending on the voltage (pressure) of the electricity, it can "jump" or arc across dry air to make a connection. If you have a small gap between wires, the electricity can arc between them, creating dangerous sparks and, potentially, fire.

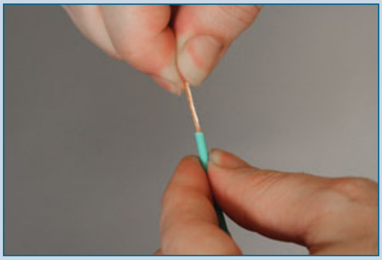
When you're connecting two (or more) wires together, you want to make sure you have a good, tight, snug, firm (can I use any more synonyms here?) connection. As you're working with inexpensive and small gauge wires with all of the projects in this book, you'll mostly be working with *stranded* wire.

A close-up of a piece of stranded wire.

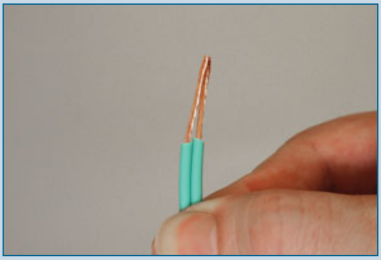
This means the wire inside the insulation isn't one solid piece; rather it's hundreds of tiny hairline strands wrapped in insulation to make one larger piece.

To connect two wires, it's best to first twist each wire so that the individual strands neatly align together and get tightened up. Giving the wire a right-hand (clockwise) twist is best, as the action of screwing on a wire nut will serve to tighten that twist even further.

Next, take the two individually twisted wires and place them side-by-side, tip to tip.



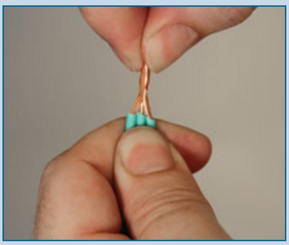
Always pre-twist your wires before combining them with other wires or devices.



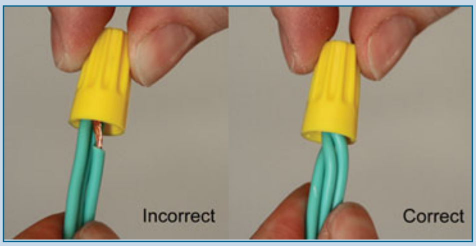
Carefully align the wires and make sure they're the same length. Trim them, if necessary. Keeping them the same length helps ensure a better connection.

Repeat the twisting process (clockwise, again) to twist the two wires together. If one is longer than the other, trim it so they're both the same size. If you're incorporating more than two wires, line them all up next to each other and twist them all together at once (don't twist two and then try and add on a third or fourth later; twist them all together at once).

Once you have a good twist to the wires, slip them up inside the wire nut and give that a good twist. It should tighten down on the wires firmly. Then give the nut a tug and make sure that no wires pull loose. Also make sure that no exposed wire is visible below the wire nut that can come in contact with any other metal components or wires inside the fixture.



When connecting multiple wires, be sure to pre-twist the wires together before attaching a wire nut.



The image on the left shows an improperly connected nut and wires with exposed wire below the nut; the image on the right shows a correctly applied wire nut.

Making a Box Light

This is an inexpensive fixture with surprisingly excellent light quality. To create this fixture, I used an empty box from a case of printer paper (12"×17"×10"), but you could use any kind of medium-sized box—preferably with a detachable lid, like a file box. This project creates a soft light fixture that works with or without diffusion.

The completed box light off (left) and on (right).

The components necessary to build the box light.

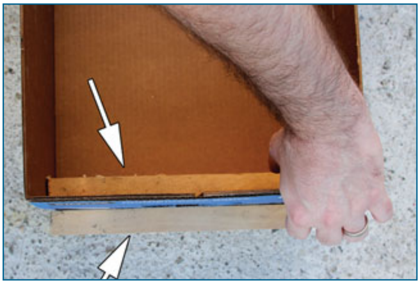
You will need the following supplies:

- A box with a detachable lid
- 10 feet of 16/3 extension cord: $9
- Two medium-base porcelain sockets: $6
- Two 8-inch cuts of 1"×3" lumber: $2
- Box of 1⅝-inch drywall screws: $2
- Can of black high-heat (BBQ) paint: $5
- Can of white high-heat (BBQ) paint: $5
- Box of ⅝-inch self-tapper screws: $2
- Single-gang ½-inch outdoor gang box: $4
- Double single-gang switch: $4
- Nail on plate: $12
- Four medium wire nuts: $1
- Bag of wire mounts: $5
- Bag of small zip ties: $5
- ½-inch paddle bit
- Drill
- Phillips head bit for drill
- Pair of wire strippers
- Razor knife
- Switch plate (not pictured): $1
- ⅝-inch self-tapper screws (not pictured): $2
- Tube of silicon glue (not pictured): $2
- Standard tape measure (not pictured)
- Standard screwdriver (not pictured)

Total cost: $67

Step 1

Taking the base of the box, you'll attach the two 8-inch pieces of 1"×3" to one of the short sides of the box, one inside and one out. The two pieces should align. If you were only screwing the wood into the cardboard, it would rip through. Matching up the pieces of wood and screwing them together (one inside and one outside the box) will reinforce the connection. From the outside, screw them together using the drill and the $1\frac{5}{8}$-inch drywall screws, one in each corner.



Positioning the lumber on the inside and outside of the box to reinforce the mounting points.

Secure the wood to the box using the drywall screws.

Step 2

Drill a $\frac{1}{2}$-inch hole in the 1"×3" wood to allow the wires to pass through to the gang box, which you'll attach later. You want your hole to be $2\frac{1}{2}$ inches from the end of the wood and centered between the sides of the wood.

Using the paddle bit to drill a $\frac{1}{2}$-inch hole through both pieces of lumber.

Attach the $\frac{1}{2}$-inch paddle bit to the drill and drill a hole in the wood $2\frac{1}{2}$ inches from the end.

When you get through the first board and into the cardboard, the bit will likely get clogged. You may need to pull it out and clean off the cardboard from the bit before cutting through the second board inside.

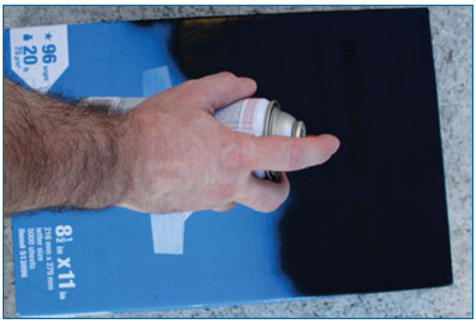
Step 3

Using the white high heat paint, coat the entire inside of the box, including the wood. Coat the inside of the lid as well. Get a good, thick, even coat. High heat or “BBQ” paint is intended to be used on barbeque grills and won’t crack or peel under high heat situations. It will also help to raise the combustion point of the cardboard to flame treat the fixture a bit. High heat paint is found in the spray paint section of nearly every hardware store.

Using the white BBQ paint to coat the inside of the box and lid.

Step 4

Using the black high heat (BBQ) paint, coat the outside of the box evenly.



Using the black high heat paint to coat the outside of the box and lid.

Step 5

Wait for both paints to thoroughly dry. Yup. I actually made that a step in and of itself. Have a cool beverage and admire your work while it dries.

Step 6

Attach the first porcelain socket to the inside onto the 1"×3" wood, about 3 inches from the edge of the box and centered on the wood. Use the 1⅝-inch drywall screws to secure the porcelain socket to the wood.

Be careful not to overtighten the screw, as it can easily crack the side of the socket.

Attach the second socket about 3 inches from the opposite side of the box. Both sockets will be side-by-side on the wood (note that you want to make sure the ½-inch hole in the wood is not covered by a socket).

Mounting the porcelain socket to the 1"×3" lumber inside the box.

Mounting the second socket to the inside lumber.

Step 7

Take the 10-foot extension cord and cut off the female (socket) end and discard it.

Step 8

Measure an 8-inch length of the cord from the cut end and cut off a piece. Repeat this to create two 8-inch pieces of cord cut at both ends.

Cutting off the socket end of the extension cord.

The cutting of two 8-inch lengths of extension cord.

Step 9

Strip off the orange outer insulation completely from the two 8-inch pieces. Be very careful not to cut the black, white, or green insulation of the wires inside. You only want to remove the orange and not cut the wires inside.

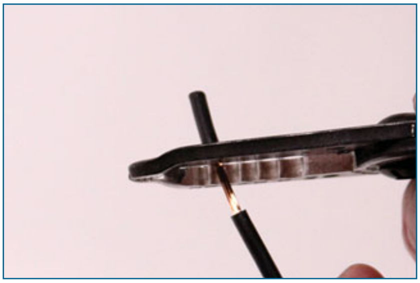
Step 10

Once the insulation is stripped, separate the individual wires so you have two 8-inch lengths of black wire, two 8-inch lengths of white wire, and two 8-inch lengths of green wire.

Stripping off the orange insulation from the 8-inch piece of extension cord. Be very careful not to cut the wires inside the insulation.

Step 11

Strip off 1 inch of insulation from both ends of the both black wires and both white wires.



Stripping insulation off individual wires.

Step 12

Attach one end of one of the black wires to the gold (gold is hot/black, silver is neutral/white) screw on one of the porcelain sockets. Make sure to bend the wire into a hook and make sure the open end of the hook faces to the right so that when the screw tightens down it forces the hook more closed as opposed to more open. It's helpful to twist the end of the wire first to collect all the smaller wires tightly together before bending.

The proper way to attach the hot line to the socket, making a loop with the open end facing right to tighten the loop as the screw tightens down.

Step 13

Repeat this step with the other loose black wire attaching to the other gold connector on the second socket. Each socket should now have a black wire attached to its gold connector.

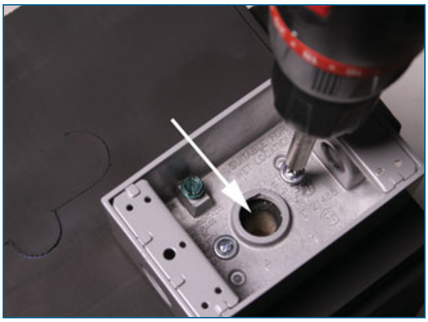
Step 14

Connecting the neutral line to the socket.

Attach one end of one of the white wires to the silver screw of the same porcelain socket. Again, make sure that the screw closes the loop as it tightens.

Repeat this action with the second socket, using the remaining loose white wire. At this point, each socket should have one black wire and one white wire connected to it.

Step 15



Line up the back hole of the gang box with the ½-inch hole in the 1"×3" wood. Use the self-tappers to secure the box to the wood.

Since you're using an outdoor gang box here, there are no screw holes in the back of the box to attach it, as it is intended to be waterproof. Instead, use the ⅝-inch self-tapper screws to attach the gang box to the wood outside the cardboard box. You need to make sure that the center hole in the back of the gang box aligns with the ½-inch hole you drilled with the paddle bit in the 1"×3". You don't need to pre-drill any holes in the box; that's the benefit of self-tappers—they will drill their own holes in the metal as you screw them down.

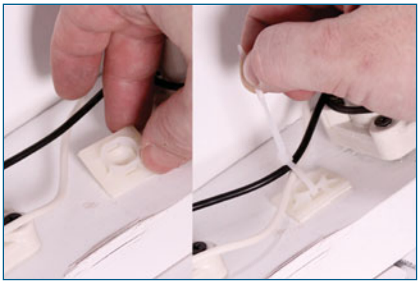
Step 16

Passing the wires through the hole into the gang box.

From the inside of the cardboard box, pass all four wires that you connected to the sockets, two black and two white, through the ½-inch hole in the wood and into the gang box.

Step 17

Inside the cardboard box, attach a plastic wire mount to the wood in the position indicated in the photo (between the two sockets). Use a small zip tie to secure the wires in place. You're neatening up the wires here, and keeping them safe away from touching hot bulbs. Neatness counts.



Using the wire mount and zip tie to secure the wires inside the box.

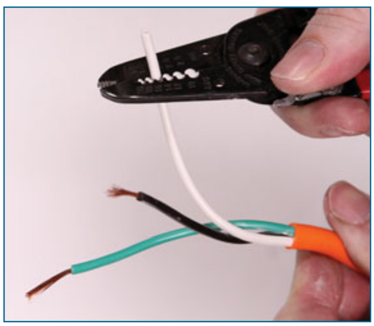
Step 18

Using the silicon glue, place a dollop of glue on each of the exposed wire connections on the porcelain sockets. Be sure to thoroughly cover the screw and any exposed components. This will serve as electrical insulation to avoid any contact with exposed wires (my sincere thanks to cinematographer Graham Futerfas for this suggestion).

Using the silicon glue to seal the electrical connections on each porcelain socket.

Step 19

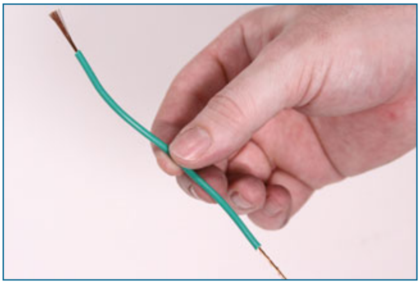
Taking the remainder of the extension cord, strip off 4 inches of orange insulation from the cut end. Expose the three wires inside and strip off 1 inch of insulation from each black, white, and green wire.

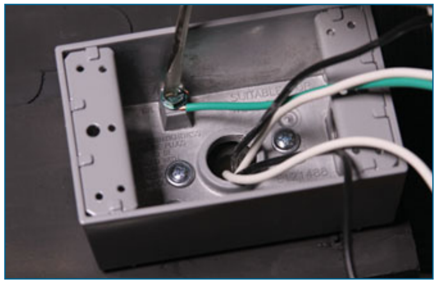


Stripping the individual wires.

Step 20

Returning to the two 8-inch loose green wires (created in Step 10), you can discard one of them (it won't be needed) and cut the other in half to make two 4-inch green wires. Set one of them aside for now. With one 4-inch green wire, strip 1 inch of insulation off both ends of the wire. Make a loop in the exposed wire at one end and attach that end to the green grounding screw inside the gang box.





Connecting the stripped 4-inch grounding wire to the grounding screw inside the gang box.

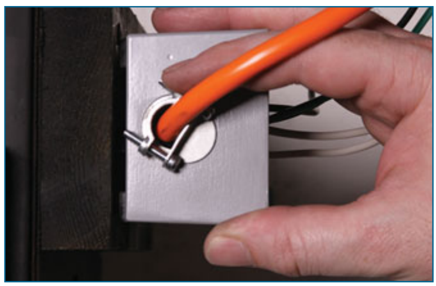
Step 21

Attach the ½-inch wire retainer to the outer end of the single gang box. Screw it into one of the open holes in the gang box. You can discard the retaining (threaded) ring that came with the wire retainer as the box has its own threaded holes.

Step 22

Feed the stripped end of the remaining extension cord through the wire retainer into the box. Tighten down the screws on the retainer to squeeze and hold the orange wire securely in place. Make sure you have about 4 inches of black, white, and green wire inside the box.

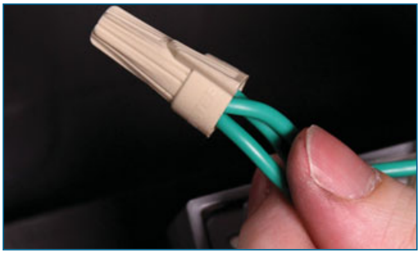
Step 21: Connecting the wire retainer to the gang box.



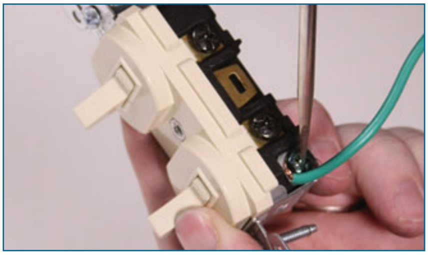
Step 22: Passing the extension cord end through the wire retainer in the gang box.

Step 23

Using the second half of the loose 4-inch green wire that you created in Step 20, strip off 1 inch from each end. Using a wire nut, attach the green wire that you connected to the gang box, the green wire from the end of the extension cord that you just secured in the gang box, and one end of the final 4-inch green ground wire you just stripped all together under one wire nut. Make sure the wire nut is secure by giving it a little tug.



Connect the three ground lines, including the additional 4-inch length, together under one wire nut.



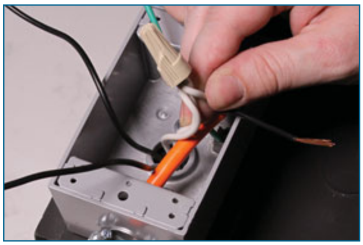
Step 24: Attach the loose ground wire to the grounding screw of the dual switch.

Step 24

With the remaining loose end of the 4-inch ground (green) wire, attach it to the ground screw on the double switch. Again, form a loop, keeping the open end of the loop to the right when you're screwing down so that the screw tightens the loop in the wire.

Step 25

Attach all three neutral (white) lines together with one wire nut—one from each of the sockets and one from the end of the extension cord.

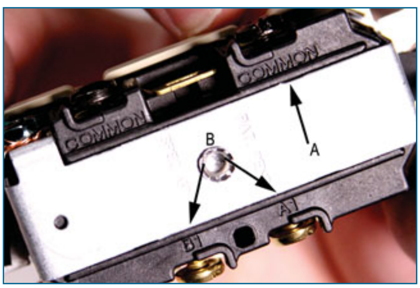


Attach all of the neutral (white) wires together under one wire nut.

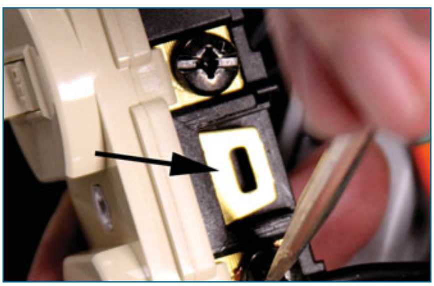
Step 26

One side of the double switch should be marked A1/B1 ("B" in the photo); this is the "load" side. The other side should be marked "common" ("A" in the photo), which is the "line" (power) side.

The common side will also have a small golden bracket.

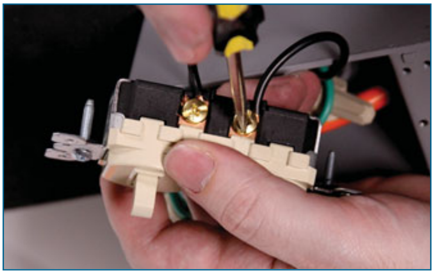


The sides of the dual switch, marked common (A), which is the "line" or powered side, and A1/B1 (B), which is the "load" or device side.



The gold connector between the terminals on the common side.

This connects the two screws on the "line" (power) side. If, for some reason, you wanted two separate power sources to this switch, you would break the little bracket to separate the connections. For this project, leave this intact.

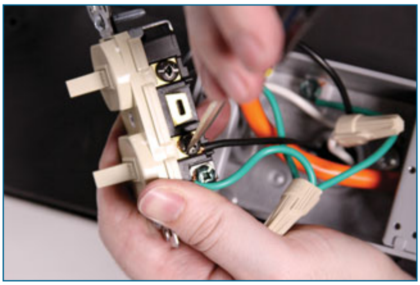


Step 27: Connecting the hot wires to the sockets to the "load" (A1/B1) side.

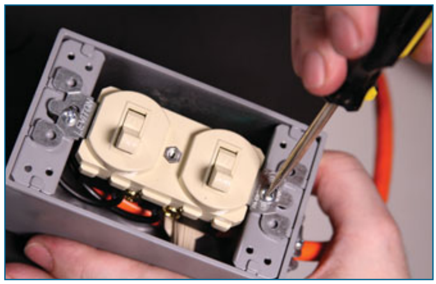
On the A1/B1 ("load") side, attach one black wire from one of the sockets inside the box to one of the screws on this side. Do the same with the second wire on the second screw. One black wire from one socket should be attached to the A1 screw and one black wire from the second socket should be attached to B1. It doesn't matter which is connected to which.

Step 27

On the opposite, "line," side of the switch (marked common), attach the black wire from the extension cord to one of the two screws. It doesn't matter which.



Attaching the hot line from the extension cord to the common (line) terminal on the dual switch.



Securing the switch into the gang box.

Step 28

Carefully stuff all of the wires inside the gang box and secure the switch to the box with the screws provided with the switch. They're often secured to the switch already; you just need to screw them down.

Step 29

Attach the faceplate to the switch.


Attaching the faceplate to the box to close the gang box.


Attaching the nail-on plate to the outside of the box.

Step 30

On the bottom of the box, you'll mount the nail-on plate so that you can attach this fixture to a C-Stand. Screw the baby nail-on plate to the 1"×3" wood on the outside of the cardboard next to the gang box. Use the same 1⅝-inch drywall screws to screw this plate to the wood.

Step 31

Screw your choice of standard bulbs into the sockets inside the box.

CAUTION

Always remember to count your amperage. Keep in mind that the lowest ampacity component of any device determines the maximum capacity for the device. Chapter 4 discussed amperages and wire gauges. A 16-gauge wire (the gauge of the extension cord used in this project) has a capacity of 10 amps. In this case, you have one 16-gauge wire per socket, which would mean that each of those wires is capable of handling 10 amps—or a 1,000W bulb! However, look at the sockets themselves, each will list its total capacity (most often expressed in wattage). In this case, you have two 660W sockets. So, even though the wire for each socket can handle a 1,000W bulb, the socket itself can handle only 660 watts. Next down the line: although both sockets have one 16-gauge wire, they are both powered by only one 16-gauge wire inside the extension cord that connects to the wall. Although the sockets themselves can handle 660 watts (1,320 watts or 13.2 amps), that single 16-gauge wire connecting the switch to the power can handle only 10 amps. The switch itself is rated for 15 amps, so you're safe there. In this case, the weakest link in the chain is the final cord plugging the fixture into the wall—it has a capacity of 10 amps—so the entire device (even though individual components can handle

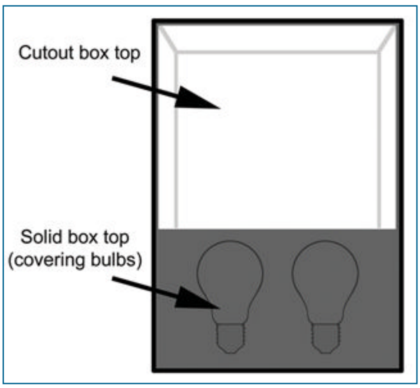
Caution (continued)

more) cannot exceed 10 amps. This means the maximum wattage bulb you can use is a 500W bulb in each socket. Note, however, that two 500W bulbs will generate a considerable amount of heat and may cause the cardboard (even treated with the BBQ paint) to combust. I tested this fixture with 150W bulbs. If you use anything of a higher wattage, be sure to safety test it first. Put the fixture in a safe place (preferably outdoors, away from anything combustible) and turn it on for at least an hour (two would be best). Be sure to have a fire extinguisher nearby in case it does get too hot and start to burn. My recommendation is not to exceed 150W bulbs.

Step 32


Measuring the box opening by determining the height of the bulbs inside the box.

Next, you're going to cut out a hole in the box top that will allow the light bouncing around inside to escape, but to not expose any of the light bulbs themselves. This creates a naturally soft source fixture because there is no direct light from the point-source bulbs, but rather only indirect (bounced) light emitting from the fixture's opening. Use a tape measure to measure the distance from the bottom of the box to the top of the light bulbs and add 2 inches to that measurement.



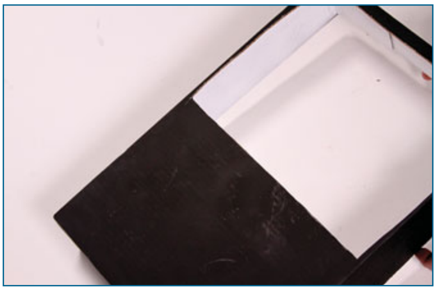
The lid on the box light is concealing the bulbs, but allowing the indirect light to escape.

Taking the top of the box, measure the same distance you just measured from one edge of the box top and make a mark. This will become the bottom edge of your opening in the box top.

Marking and cutting the lid opening in the box.

Step 33

Trace out a rectangle in the box top from the mark you just made to ¼-inch from the sides and top and cut this section out of the top.



The cut box top on the final fixture.

Step 34

Place the top back on the box. Your fixture is done!

Making an (Almost) Instant Diffusion Frame

This one was a discovery that I got pretty excited about. While perusing the isles of the hardware store, I came across a window screen frame kit that was perfect for creating an inexpensive diffusion frame. The kit is intended for you to create your own window screen, and they come in different sizes that are meant for you to cut down to your desired shape. I simply used the kit without cutting the sides to make a square frame. I followed the manufacturer's simple instructions and then used liner's silk instead of screen material. It would have been really handy to have a spline roller (tool specially designed for making screens, like a small, unsharpened pizza cutter), but I didn't have one so I just used the handle of a kitchen butter knife.

The almost instant diffusion frame clamped into the gobo head of a C-Stand. With a flat item like this frame, it's best to clamp in the *back* of the gobo head instead of in the normal clamp section. This will avoid locking up the head.

This took me all of 10 minutes to assemble. It creates a wonderful diffusion frame that easily clamps into the head of a C-Stand.

I bought the 36-inch kit and created a 3'×3' frame. Unfortunately this isn't something that comes apart and back together easily, so it has to stay intact.

The screen kit was $10 and the liner's silk to fill it was $3. Total cost, $13.

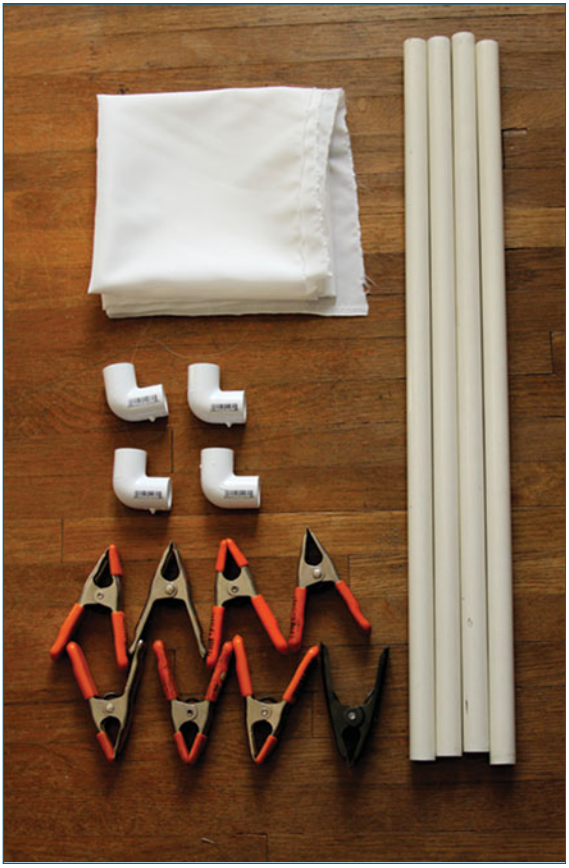
The components of the screen replacement kit and the final finished diffusion frame.

These are *not* rugged enough to handle rough conditions and, if not delicately cared for, they won't last long. However, they are incredibly inexpensive and fairly quick to make. I wouldn't recommend using any kind of paper diffusion in these frames, as it will tear easily when working in the spline. Liner's silk is probably the best bet, unless you want to invest in a roll of the real stuff, like Grid Cloth (see Chapter 5 for more info). You could use a bed sheet, as well, but I would stay away from any paper or vinyl and avoid the aggravation.

Making a PVC Diffusion Frame

If you can't find a window screen kit, using PVC pipe is just as easy and you can create frames of any size. For the sake of demonstration, this example creates a frame that is 24 inches square. You can easily use these same steps to create a 3-foot square or a 4-foot square or even a 10-foot square or larger. However, if you're going larger than 4 feet, I recommend using a larger diameter PVC pipe for better rigidness.

The final PVC diffusion frame attached to a C-Stand.



The components of the PVC diffusion frame.

You will need the following supplies:

- Four lengths of ½-inch PVC pipe cut to your desired size: $2
- Four 90-degree elbow connectors: $1
- Appropriate size of diffusion material of your choice (this example uses a 2-foot, 8-inch square of liner's silk; you'll want the size of your final frame plus 4 inches on all sides): $3
- Eight #1 spring clips: $7
- Piece of medium grit sandpaper (not pictured)

Total cost: $13

It doesn't get much easier than this, really.

Step 1

The individual lengths of ½-inch PVC cut to size.

Pre-cut your straight lengths of PVC to the desired size. Sometimes cutting PVC can create rough edges. If so, use a piece of sandpaper to smooth out the burrs. You can use a specific pipe-cutting tool or saw (generally a hack-saw is best) or have the hardware store cut them for you.

Step 2

Connect the 90-degree elbows to the PVC pieces to form a full square. I don't like to glue the pieces because this allows me to easily break the frame down and travel with it, as opposed to trying to carry around a large, pre-built PVC square.

The connection of the 90-degree elbows to the individual PVC pieces.

The final completed PVC frame.

Step 3

Wrap one edge of your diffusion around the PVC and line it up carefully so that it's even. You want the diffusion to wrap around the ¾ portion of the pipe in a "U" shape.

The diffusion is wrapped around the PVC in order to clamp it into place.

You need the diffusion to be 4 inches larger than the straight PVC pieces because the elbows will add 1 inch to each side and you need enough material to wrap around the PVC edges.

Using the #1 clamps, clamp the diffusion in place. For the frame in this example, you need only two clamps per side. If you have a larger frame, you may need more. Clamp at about every 24 inches or so.

You're done! You now have a good frame of diffusion! ½-inch PVC is pretty thick, but still a reasonable size to clamp directly into the head of a C-Stand. It's not the prettiest thing in the world, but it is workable, easily portable, and inexpensive; and it works.

With the tools covered in this chapter, you're well on your way to creating softer sources for your inexpensive lighting fixtures. Don't be afraid to color outside the lines and apply the concepts of these projects to different fixtures or different materials. Keep an eye out every time you visit the hardware store—you'll be amazed by what you can find!

Now onward to making some actual lights!

8

Tungsten Fixtures

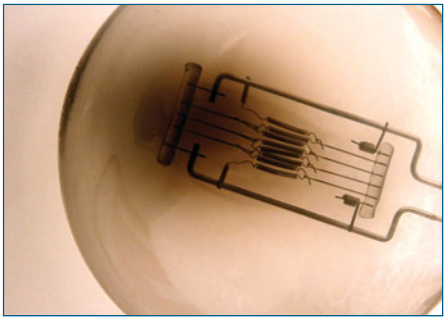
The term "tungsten" actually covers a lot of ground. There are a number of lamps that fall into the tungsten family, and this chapter covers several of them.

Bulbs 101: The Science Behind Tungsten Light

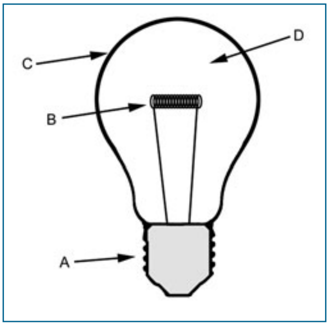
Tungsten is a natural element (atomic number 74 on the periodic table); a very brittle metal with the highest melting point of all metals (3,422°C). It is the fundamental element of incandescent fixtures, being the primary component of the *filament* inside the bulb.

A tungsten lamp consists of the following parts:

- Base
- Filament
- Envelope (bulb)
- Inert gas



The filament of an incandescent light bulb.



The various components of the standard light bulb. Base (A), Filament (B), Envelope (glass bulb) (C), and inert gas (D).

When electricity is supplied to the bulb, the electrons passing through the filament create heat (as a by-product of electromotive force) and the heat, in turn, begins to *incandesce*—or create light. Recall from Chapter 2, "The Fundamentals," that 0° Kelvin is absolute zero or –273°C. So a tungsten filament with a color temperature of 2,700°K is actually burning at a physical temperature of near 2,427°C or 4,400°F—in other words *freakin hot* (it's important to understand that Kelvin temperatures are based on a *theoretical* black body radiator, so the physical temperature matches are not exact, but are close).

The light that you get from tungsten bulbs is pure incandescence: light from heat. This is also the downfall of tungsten bulbs; they lose about 90% of their energy to heat. That means for every 100W of electricity, roughly 90W is lost in heat and the bulb is only using 10W to actually generate the light. This not only creates a lot of heat from the bulb, but also is not the most efficient use of electrical energy.

The tungsten filament is encased inside an airtight borosilicate or silica *envelope* (the glass portion of the bulb) filled with an inert gas, most often argon or nitrogen. If oxygen were allowed to reach the filament, the oxygen would cause the hot tungsten to oxidize and nearly instantly evaporate.

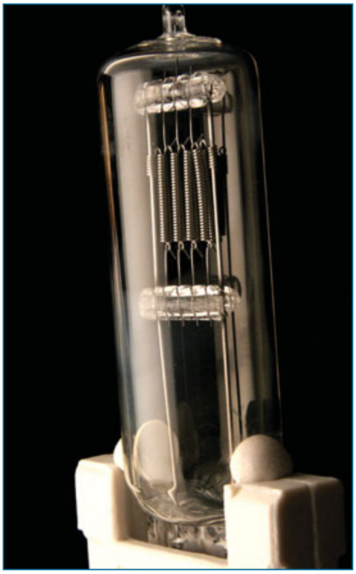
The darkening of the envelope of a light bulb from the gathering of evaporated tungsten particles.

Over time, the tungsten filament, even without the presence of oxygen, will start to evaporate and the particles will collect on the coolest part of the inside of the envelope. This causes the envelope to blacken and the filament to weaken as it loses mass. The filament will, eventually, become weak enough to break, and this is a "blown," or dead, bulb.

Tungsten-Halogen Bulbs

This phrase might be more misused and misunderstood than "HD" (high-definition). Correctly used, *tungsten-halogen* lamps (also called *quartz-halogen* or, more correctly, *quartz-iodine* or just *halogen*) describe a specific variety of incandescent bulbs that feature several distinct differences from regular tungsten bulbs.

The first difference between halogen and regular bulbs is that the nitrogen or argon gas inside is combined with a halogen element, most often iodine, but sometimes bromine, chlorine, fluorine, or astatine. The additional gas serves the primary purpose of helping to redeposit evaporated tungsten particles onto the filament. When the gas is heated, it helps to collect and trap the evaporated tungsten and keep it from collecting on the envelope. When this floating particle of tungsten comes back in contact with the hot tungsten filament, the halogen is burned off and the tungsten re-adheres to the filament. This keeps the envelope from darkening and also prolongs the life of the filament. Unfortunately this re-depositing is not uniform, so although it does prolong the life of the filament, eventually some portion of the filament will become thin enough to fail.

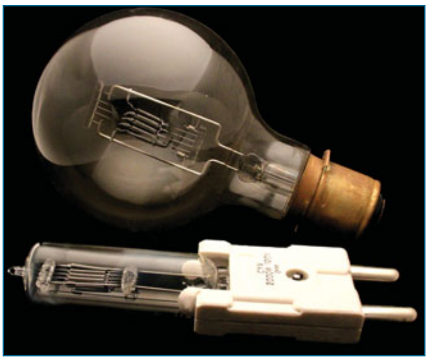


The tungsten-halogen bulb has a thicker, more heat-resistant envelope, allowing for a more compact bulb.

In order for this re-depositing to happen, however, the lamp must burn at a much higher temperature than the standard tungsten bulb. This higher temperature requires a thicker, more robust envelope than standard glass: quartz.

Quartz glass has a much higher melting point than standard borosilicate glass. It is thicker and, due to its higher melting point, can be used to create much smaller bulbs. This means you can get higher wattage bulbs in a smaller size.

As they burn hotter, tungsten-halogen bulbs are much closer to the classic "tungsten" color temperature of 3,200°K than standard household bulbs.



Comparing an older, standard 2,000W incandescent bulb and a modern 2,000W tungsten-halogen bulb. The halogen is much smaller, with a thicker envelope.

Caution

Because of the intense heat of the halogen bulb, one of the serious dangers is fingerprint oils. When replacing or handling halogen bulbs, always use gloves or avoid touching the glass of the bulb. If you do, the oils left behind by your fingers, when heated, will actually weaken the glass and cause the lamp to distort, and even burst. If you happen to touch the glass, use an alcohol wipe to clean off the oils before turning the lamp on. It's always a good idea to have isopropyl alcohol wipes on hand for just this occasion.

Tungsten-halogen bulbs require specialized housings, fixtures, and sockets. Their increased heat makes them more difficult and more dangerous to work with. As a result, you'll mostly be dealing with standard incandescent tungsten (not tungsten-halogen) bulbs when you're making your own fixtures.

A standard medium-base socket light bulb.

What you'll primarily be using are standard *medium-base* bulbs available at any hardware store.

Caution

The "green" movement has rendered standard incandescent bulbs the black-hat wearing, handlebar-mustache twirling bad guy, with the "PC" replacement being CFL (Compact Fluorescent Lamp) bulbs. Be very conscious, should you choose to use CFLs in place of incandescent bulbs, that they do *not* have the same properties in terms of color spectrum, color temperature, light quality, and light output (see Chapter 9, "Fluorescent Fixtures," for more information). Although incandescent lamps are nowhere near as energy efficient as fluorescent fixtures, they are *not* bad guys who tie poor helpless maidens to the railroad tracks.... Do not fear the incandescent bulb. Be aware, however, that the current political movement—fair or unfair—may render finding incandescent bulbs an arduous chore in the near future.

A Note on Dimming

One of the great aspects of incandescent bulbs is their ability to be dimmed. You can put an incandescent fixture on a dimmer to reduce the voltage or hertz being delivered to the lamp. This reduces the heat of the filament and, in turn, reduces the light output. Be careful, however, because as you dim an incandescent source and reduce its physical temperature, you are also reducing the color temperature, making it much redder. As you dim down, the color temperature will lower.

Photofloods

Photoflood lamps are specially made to be color balanced for photography. Officially called "enlarger bulbs" and used for photographic enlargers, PH/211, PH/212, and PH/213 bulbs are much closer in color temperature to the 3,200°K range than typical household tungsten bulbs without incorporating halogen gas or a thicker envelope.

Photofloods are more expensive than standard household bulbs—about $7 to $10 per bulb as opposed to $1–$2 per bulb—and they don't last as long, generally about 100 hours (with PH/213 bulbs having a ridiculously short lifespan in the 3–5 hour range), but their color precision makes them much more friendly for incorporating with professional lighting fixtures. The PH/211 is a 75W bulb with a color temperature of 3,000°K; the PH/212 is a 150W bulb with a temperature of 3,050°K; and the PH/213 is a 250W bulb with a temp of 3,400°K.

You can also find BCA lamps, which are blue-coated photoflood lamps that have a much higher color temperature (due to the blue coating) at around 4,800°K for integration with daylight color temperatures. They are, more or less, tungsten bulbs with CTB built into them.

PH/212 photoflood bulb.

A BCA incandescent lamp with a color temperature around 4,800°K.

Watch Out for "True Color" Bulbs

A "true color" neodymium coated bulb.

As I've discussed, standard incandescent bulbs, especially non-halogen, tend to burn at a lower than premium color temperature, typically in the 2,500°K to 2,900°K range. This can often look orange or reddish when combined with more precise color temp fixtures. Since the early 2000s, some manufacturers have been making "true color" bulbs, which purport to give "more vivid" colors. The bulbs are made with *neodymium* in the glass, which is a natural element often used in photographic filters to cut the longer wavelengths of light (orange, yellow, and red). Although these bulbs might create a more pleasing, more "white" home environment, they are *not* calibrated for photography. The neodymium is not a substitute for CTB color correction. They do have a higher color temp than standard incandescent bulbs, but they are not a true daylight color temperature. The neodymium itself is a bit of a wild card and can create some odd colorcasts. Although it may be tempting to use these bulbs in place of photofloods, I don't recommend combining them with any other fixture without heavy testing beforehand, as the results can be unexpected.

In a Pinch: The Clip-On

When building do-it-yourself lighting kits, clip-ons are generally the first tools in the basket. They're extremely inexpensive (nearly disposable), lightweight, and fairly effective at what they do. You can generally find them for anywhere from $5 to $8, depending on the size.

The ubiquitous clip-on fixture.

Really no more than a stand-alone reflector with a spring clamp, these clip-on lights usually come with their own medium-base socket and cord. They even have a built-in switch! Look at all the work you *don't* have to do!

You're going to need to soften these babies. You can bounce them into walls, ceilings, or bounce boards, or diffuse them. Parchment paper is good for softening them right at the face of the reflector, or you can easily use two, three, or more of these clip-ons to fill the back of a large frame of diffusion (see Chapter 7, "Soft Lights") for a very soft source.

They do tend to spill light all over the place, so to control them, it's nice to create a kind of snoot.

Making a Clip-On Snoot

I stumbled upon this particular snoot while scouring the isles of the hardware store. Looking through the roofing and ductwork aisle, I found pieces of aluminum venting that were perfect for a snoot. This is a reducer intended to take down the size of ventilation tubing from one diameter to another. In this case, it fits perfectly onto the front of a small clip-on fixture with a diameter of 6 inches.

The components necessary for a metallic snoot for a clip-on light.

The roofing vent reducer slipped onto a 6-inch clip-on light.

To connect this to the fixture, you simply screw in a couple of self-tapping screws.

Using self-tapping metal screws to secure the duct reducer to the clip-on light.

This creates a great little snoot to control the light spill from this simple clip-on. The step-down reducer costs $8, and the clip-on itself was $6.

The light from the clip-on light without snoot (left) and with snoot (right).

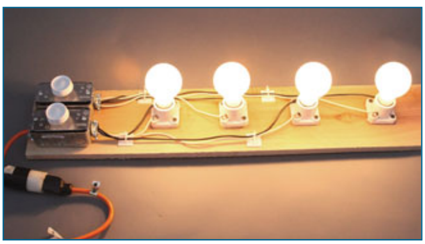
If you cannot find such a duct reducer, you can quickly make a snoot out of aluminum foil, but be aware that the foil is likely to bounce a great deal of light around in addition to helping control it. If you have Black Wrap or Cinefoil, you can also craft quick snoots out of that.

Halogen Work Light

Halogen work lamps can be found, inexpensively, at any hardware store.

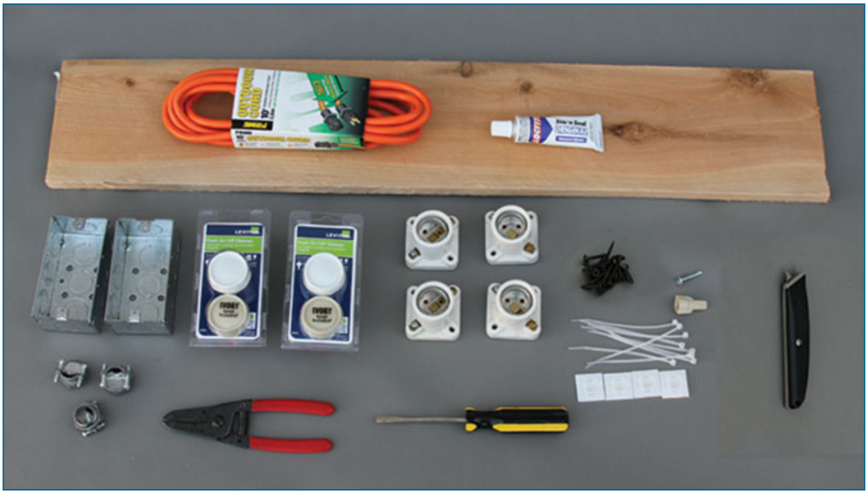
These little ubiquitous fixtures are very appealing to the budget-conscious digital shooter. They're high powered, often 500W, portable, and often have their own stands. The problem is that the light they create is ugly. It's uneven, creates hot spots galore, and is harsh and glaring. These fixtures definitely need to be softened. My number one recommendation is building a Croney Cone for them (covered in Chapter 7), but you can also put them behind a diffusion frame or bounce them into a large wall or diffusion. Be careful; these fixtures definitely get hot!

The Batten Strip



The completed batten strip.

The batten strip is a simple, yet effective tool that is often used in the professional arena. Yes, even on big-budget Hollywood movies, the electrical department will get down and dirty with a piece of lumber and some porcelain sockets—that's all it is. These are easily tucked into corners, behind furniture, attached overhead, and more.



The components necessary to build a batten strip fixture.

Here's what you need:

- 3-foot length of 1"×4" lumber: $2
- Four medium-base porcelain sockets: $12
- 10-foot long 16/3 extension cord: $9
- Box of $\frac{1}{4}$-inch drywall wood screws: $2
- Tube of silicone glue: $2
- Two $\frac{1}{2}$-inch deep single-gang receptacle boxes: $4
- $3\frac{1}{2}$-inch wire retainer: $2
- Package of wire mounts: $5
- Package of wire zip-ties: $5
- Two single-pole 15A rheostat dimmers: $10
- Package of medium wire nuts: $2
- Roll of PVC electrical tape (black, red, or blue) (not pictured): $2
- Seven wire nuts: $1
- Pair of wire strippers
- Flat-head screw driver
- Drill
- Razor knife

Total cost: $58

Step 1

You need a length of lumber. Batten strips can be any particular length. In this example, you'll make a 36-inch long strip. You can make 6-foot or 8-foot strips; just be sure that you're carefully counting your amps so that you're not overloading any element of the fixture. The more sockets you add, the more light bulbs you need and the more amps you'll draw (see Chapter 4, Understanding Electricity," for more info).

For lumber, you can use any cut of 1"×4"; generally construction grade is the least expensive kind. In this case, I found a picket fence board at the local hardware store that was 6 feet long and 5½ inches wide and only $1.49! That was my winner. I used a skill saw to cut it down to a 3-foot length.

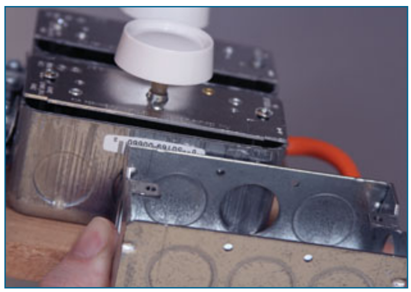
Step 2

Mounting the gang box to the wood.

You'll be mounting the two deep single-gang device boxes to the lumber. Use your shortest drywall screws to screw the box directly to the wood. In this case, I'm mounting them longways to make the wiring easier.

Note

Truth be told, I messed up. When I initially purchased the components for this project, I did *not* buy deep gang boxes. I bought regular gang boxes. Unfortunately, modern rheostat dimmers are incredibly thick and they simply won't fit into a standard gang box with wires and wire nuts! Most of the photos in this chapter actually depict the normal boxes, but be aware that—if you're using rheostat dimmers for this project—you will absolutely need a deep gang box. Also, I was unable to find a deep two-gang receptacle box at my hardware store, so I chose to use two single gang boxes side-by-side. If you can find a two-gang box, that would be even easier.

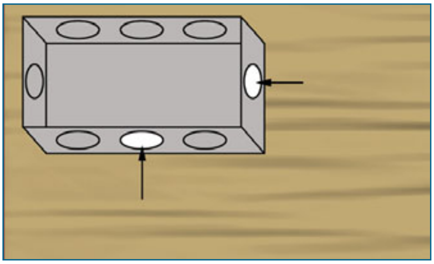


The differences between the standard single gang box and the deep gang box. Yes, that tiny bit of extra height in the deep boxes makes a difference.

Step 3

Once you've mounted one box close to the end of the board, you're going to pop out some of the hole covers. You want to use a screwdriver to poke these holes in. You might have to be a little aggressive and tap hard on the circle to punch it in. Then bend it back and forth to break it off the single weld at the bottom of the hole. It should break clean off. You'll punch two of the holes in this first gang box: one in the end of the box facing the length of the board, and one in the side of the box on the inside of the board.

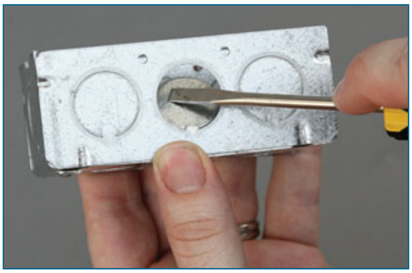
You may have to use some brute force to detach these hole covers, but rest assured they're designed to be removed. A pair of pliers can help when you wiggle the cover loose from its weld.



An illustration showing which punch-outs to break out of the gang box.

Step 4

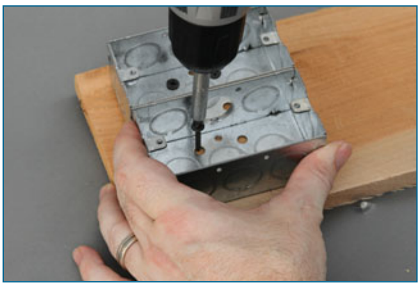
Next you'll break out one of the center side holes on the second gang box.

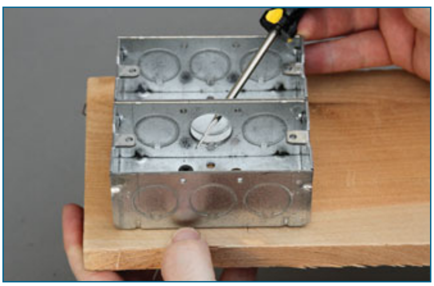


Break out the punch-outs.

Step 5

Now you'll mount the second gang box to the board right next to the first so that the open holes in the sides line up.

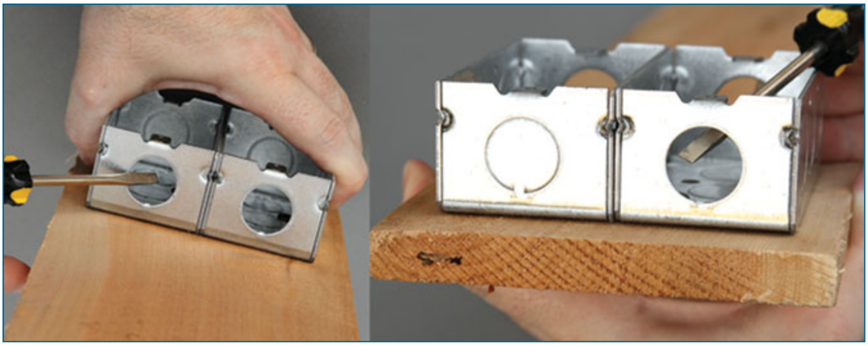




Mounting the second gang box and making sure the center holes line up.

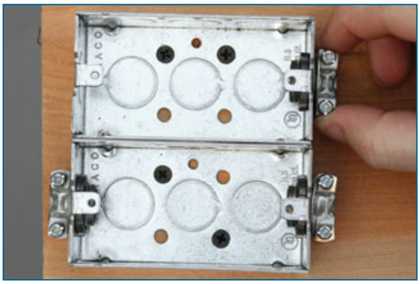
Step 6

Next, you'll punch out two more holes in the second gang box, one on either end.



Breaking out more punch-out holes.

Step 7



Attach the wire retainers to the open holes in the gang boxes.

Moving on, you need to mount the wire retainers in the three open holes on the outsides of the two gang boxes. You'll unscrew the lock-down ring from each retainer, slip the threaded end of the retainer through the hole, and secure it with the retaining ring. Make sure it's in tight. It's easiest to make sure that the screw heads are always positioned up for easier access when tightening down on the wires. To really tighten down the retaining ring, use your screwdriver against the side flanges on the ring to tap it tighter.

Step 8

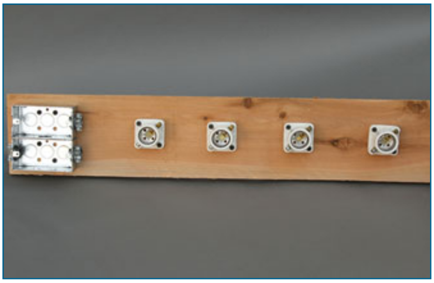
Mounting the sockets to the wood.

Next, you will mount the four porcelain sockets on the wood. You want to space them equally down the board. The first should be about 4 to 6 inches away from the gang boxes and the next three should be about 4 to 6 inches apart from each other.

Use the drywall screws to secure the sockets to the wood. Make sure that the gold screws for each socket are on the same side of the wood—this will simplify wiring later. Also, use caution when screwing the sockets to the wood; if you overtighten the screws, it can easily crack the porcelain.

After this step, your strip should look like the following image.

When mounting the sockets, make sure that the gold connector screws are all on the same side to make wiring easier later.



The project thus far; the gang boxes and sockets are mounted to the lumber.

Step 9

Take the 10-foot extension cord out of its package and cut off the socket (female) end and discard it.

Cut the socket off the end of the extension cord.

Cut off the length of extension cord to make wires to wire up the individual sockets.

Step 10

Measure the distance from the gold connector on the farthest socket on the board to the center of the gang box and add 3 inches. Cut this length off the cut end of the extension cord.

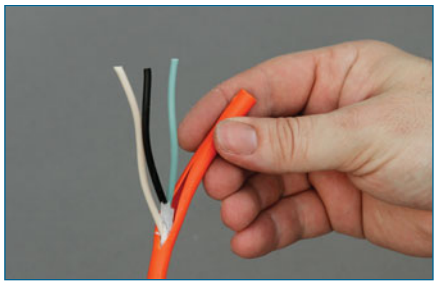
Step 11

Repeat this process for each of the remaining sockets: measure the distance between the socket connections and the center of the gang box and add 3 inches. Then cut that length off the extension cord. Obviously, these lengths will be increasingly shorter as you get closer to the gang boxes and your final socket.

For my board, I have four sockets and I ended up with four cuts of extension cord: one at 20 inches long, one at 16 inches long, one at 12 inches long, and one at 8 inches long.

Step 12

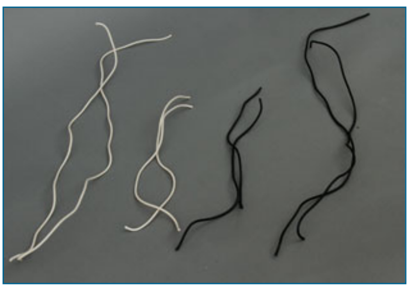
Strip the orange insulation off all of the pieces of extension cord you just made. Carefully cut the orange insulation off without cutting the three wires inside.



Stripping off the insulation from the pieces of orange extension cord to separate the wires.

Step 13

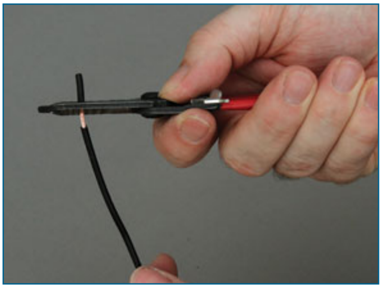
After cutting and stripping the orange insulation, you should now have eight individual pieces of wire, four black and four white.



Separate the individual wires; you should have four lengths of black wire, four lengths of white wire, and four lengths of green wire. Set aside the greens; you're going to be working only with the black and whites for now. Save the green wires; you'll use them in Step 22.

Step 14

From all four of the black wires and all four of the white wires, strip off 1 inch of insulation from each end.



Stripping off the insulation from the ends of the individual wires.

Step 15

Now it's time to attach all of the wires to the sockets. You're going to connect one black wire to each of the gold screws on the sockets and one white wire to each of the silver screws on the sockets.

Starting with the longest black wire, give the end a good tight twist with your fingers to get the individual strands together and then bend it into a hook shape so that the opening of the hook faces the right. On the farthest socket from the gang boxes, slip the black wire under the gold connector and screw it down. Make sure that the open end of the hook in the wire faces the right so that when you screw down the gold connector, it tightens the loop rather than opens it.

Connecting the first black wire to the first gold connector.

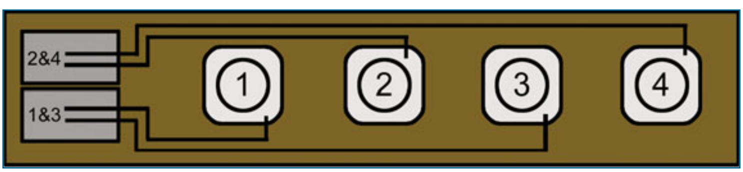
Repeat this process all the way down the sockets, connecting the next longest black wire to the next gold screw and so forth, until each socket has one black wire attached to its gold screw.

Repeat this process for attaching the white wires to the silver screws on the sockets.

When you're done, each socket should have one black wire attached to the gold screw and one white wire attached to the silver screw. All of the wires should be long enough to reach back to the gang boxes.

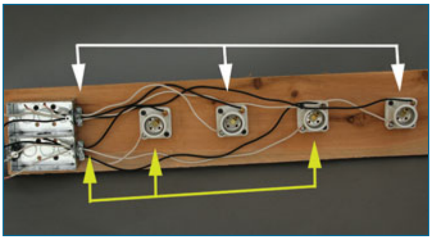
Step 16

To make this fixture as versatile as possible, it's best to separate it into two individual circuits. My personal preference is to alternate the bulbs, making the odd-numbered bulbs on one circuit and the even-numbered bulbs on another.



The board wiring concept for separating the sockets into individual dimmers.

With that in mind, each of the gang boxes is for one dimmer that will represent one circuit of the fixture. If you number the sockets 1 through 4, with 1 being closest to the gang boxes, you're going to take the white *and* black wires from sockets 2 and 4 and feed them through the wire retainer in the left gang box. You'll then feed both black and white wires from sockets 1 and 3 into the wire retainer on the right-side gang box. Right or left doesn't really matter here. What matters is that you're feeding the wires from two sockets into one box and the wires from the *other* two sockets into the other gang box.



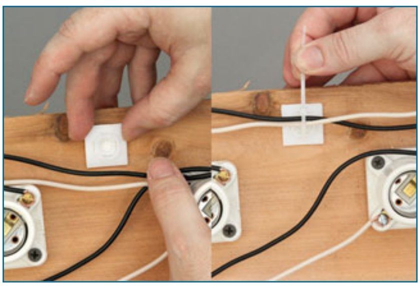
The project thus far. Note the wires leading into the individual gang boxes.

When you're done, it should look like the image on the left.

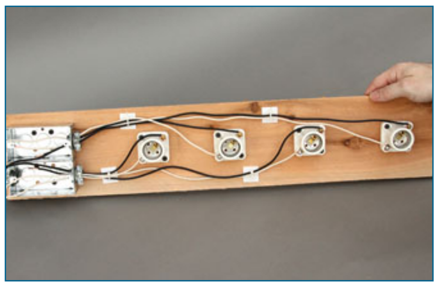
Step 17

Now you'll neaten up your work a bit and secure the wires to the board. Using the self-adhesive wire mount bases, you'll attach two of them to each side of the board so that they neaten up the wires. Once the mount base is attached, use a small zip-tie to secure the wires in place. Trim off excess zip-tie to make it even neater.

When you're done, it should look something like the final image below on the right.



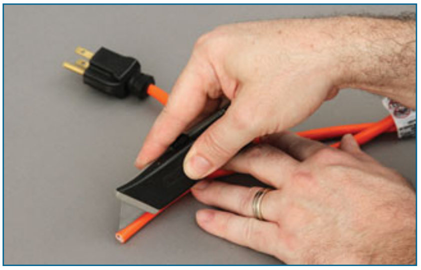
Carefully secure the wires to the wood to keep them neat and safe.



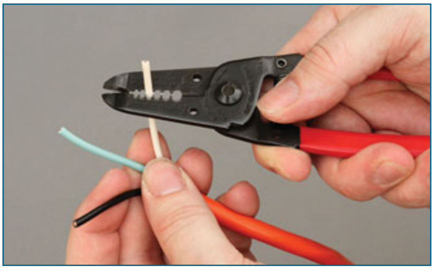
All wires should be secured and kept away from hot bulbs and sockets.

Step 18

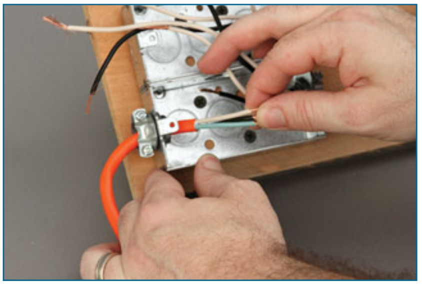
Using the remaining portion of the extension cord, with the plug still attached, you're going to strip off 4 inches of orange insulation from the cut end. Be very careful to cut only the orange insulation off and not the black, white, or green wires inside.



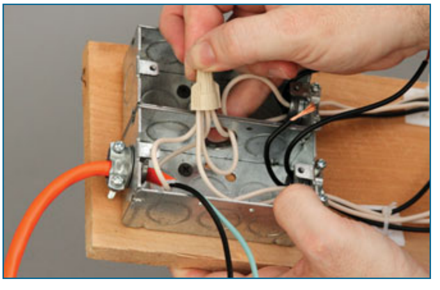
Strip off the orange insulation from the end of the extension cord.



Strip off the individual black, white, and green wires.



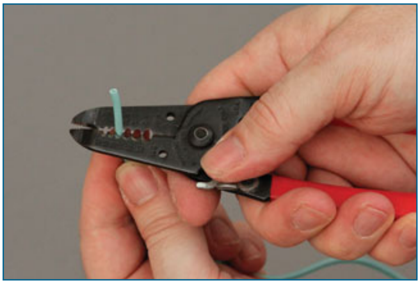
Pass the stripped end of the extension cord through the wire retainer into the gang box.



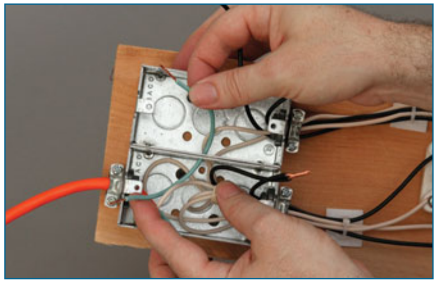
Connect all of the neutrals (white) under one wire nut.

Step 22

Find the four lengths of green wire you set aside from Step 13. Take one of the shorter lengths of green wire and cut it down to a 5-inch length. Then strip off 1 inch of insulation from each end of the wire.



Stripping insulation off the green wire.



Pass the green wire between the two gang boxes.

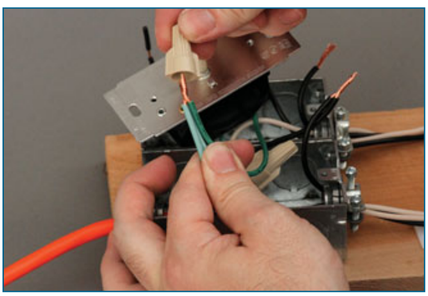
Step 23

Pass this green wire through the center punch-out holes in the center of the boxes so that one end of the wire is in one gang box and the opposite end is in the second box. This will be the connection between the grounds in the first box and the ground of the second dimmer in the second box. This is called "pigtailing."

Step 24

Open the package for one of the single-pole dimmers, being careful to not lose the screws that are also inside the package. There will already be two black wires and a green wire attached to each dimmer. Each wire should have the insulation pre-cut, but they often have the cut insulation still attached to protect the end of the wires. Simply pull this off and discard it.

Take the green (ground) wire from the dimmer and connect it to the green wire from the extension cord and one end of the loose green wire that you just passed into both boxes. All three green wires should be twisted together and secured with a wire nut.

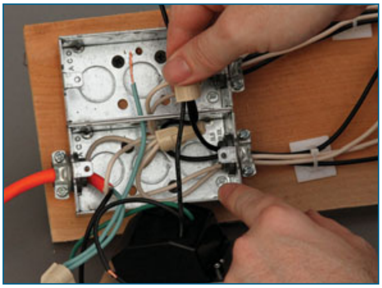


Connect the ground (green) wires.

After attaching the wire nut, give it a little tug to make sure they're all firmly connected.

Step 25

Gather the two black wires from two of the sockets together with one of the black wires coming out of the dimmer (it doesn't matter which black wire from the dimmer). Connect these three black wires together under one wire nut. Give the nut a test tug to make sure it's connected. These are your "load" ends of the dimmer circuit.



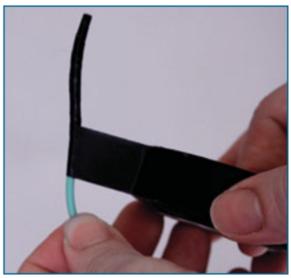
Connect the hot lines on the load side.

Step 26

You're in need of a hot pigtail now. Just as you made a grounding pigtail to connect the grounds from one box to the other, the second dimmer needs a connection to the hot line coming from the extension cord. Unfortunately, you have no spare black wires left; everything's been used. As I really hate waste and there's no reason to cut more wire since you have some loose wires now, you can instead use one of the remaining pieces of green wire for your hot pigtail. All the wire in this extension cord is made identical, just with different color insulation. The coloring is purely for identification of the wires and serves no other purpose. There is nothing necessarily wrong with simply using a 4-inch cut of green wire as a hot, except if anyone else needs to ever open up this fixture, the green-colored wire may confuse him and cause injury. So you're going to re-identify the green wire as a hot wire by wrapping it in a roll of colored PVC electrical tape. In a perfect world, you'd do this with black electrical tape to match the color of all the rest of your hot wires in this fixture, but blue and red are also acceptable colors for hot wires, so use what you have.

Simply take the PVC tape and wrap a single layer around a 4-inch cut of remaining green wire. As much as possible, you only want a single layer as you don't want to potentially overheat this wire by wrapping it in more insulation than you need. You could also use a black permanent marker, instead of tape. The whole point is to make sure that this wire is clearly identified as a "black" hot wire and *not* a green, ground wire.

Once you've wrapped the complete wire in PVC tape, strip off 1 inch of insulation (and tape) from each end of the wire.



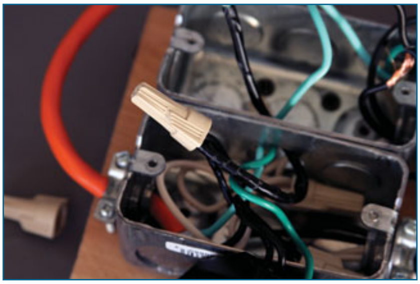
To create a hot pigtail, you wrap a leftover piece of green wire in black tape.

Step 27

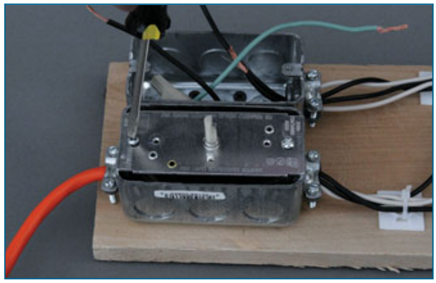
Now pass this new "black" pigtail wire through the connection between the two gang boxes so that one end is in each box.

Step 28

Now gather the “black” pigtail along with the black wire from the extension cord end and the remaining black wire from the dimmer and connect these three wires under one wire nut. These are your “line” hots in the first box; the black lines connected directly to the power source (the extension cord end that plugs into the wall).



Securing the hots on the line side under one wire nut.



Carefully tuck the wires and wire nuts into the box and secure the dimmer to the gang box.

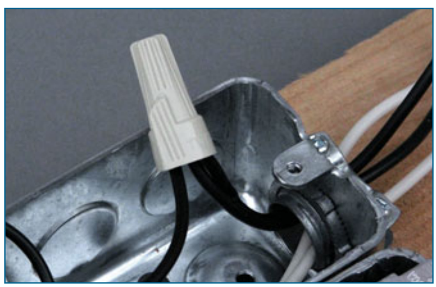
Step 29

Carefully tuck all of your wires and wire nuts into the gang box and press the dimmer into place. Use the two screws that came with the dimmer to secure it to the gang box.

Step 30

Open the second dimmer package and remove its contents. Again, be careful not to lose the two screws. In the remaining gang box, connect the ground pigtail to the ground wire of the second dimmer using a wire nut.

Connect the remaining ground wires under one wire nut.



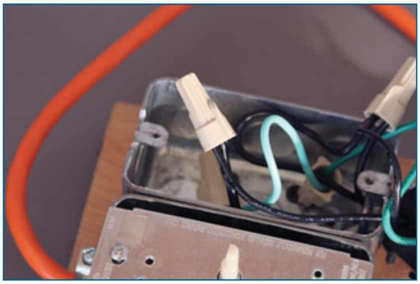
Connect the hot wires on the load side of the second dimmer.

Step 31

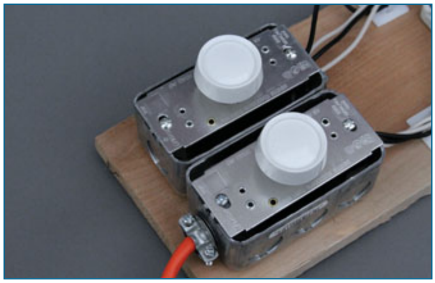
Connect the two black wires from the remaining two sockets on the board to one of the black wires on the dimmer using a wire nut. Again, it doesn't matter which black wire on the dimmer you use. This is your "load" connection for the second dimmer.

Step 32

Connect the remaining black wire of the dimmer to the black pigtail that you made with a wire nut. This is your "line" connection for this circuit. Remember that this pigtail is connected directly to the hot wire coming from the extension cord. This is the wire that provides the electricity for the second circuit on the board.



Connect the hot wires on the line side of the second dimmer.



Both dimmers secured in their gang boxes.

Step 33

Now carefully tuck the remaining wires into the gang box and secure the second dimmer in place.

Since this example uses two gang boxes, you don't have a faceplate to connect to cover the devices, so leave them open.

Step 34

Now simply take the two push buttons and connect them to the dimmers.

Step 35

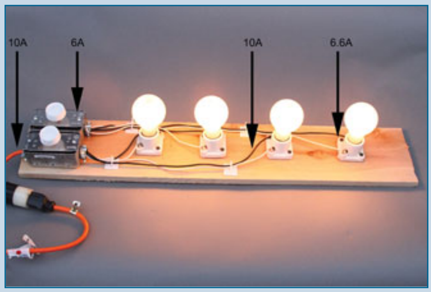
Use the silicon glue to insulate the connections from accidental contact.

Using the silicon glue, place a dollop of glue on every one of the silver and gold connections on the batten strip sockets. This is to electrically insulate the connections to avoid accidental contact with them.

Add bulbs of your preference. You've completed your fixture! One of the dimmers controls two lamps on the strip and the other dimmer controls the other two. Remember to carefully calculate your loads so that you never over-current the weakest element of the fixture.

Calculating Safe Loads for the Batten Strip

A quick inventory of the components of this fixture reveals the following:



The various ampacities of the batten strip fixture.

Each socket is rated for 6.6A—that means up to 660W bulbs in each socket. Each hot line connected to each socket has a rating of 10A (16 gauge wire), so that can handle the 660 watts as well. However, each dimmer connects to two sockets. The dimmers are only rated for 6A, so they can handle only 600 watts total. This now reduces the maximum wattage for each bulb to 300W (even though the sockets and wires can handle more). However, keep in mind that the entire fixture is powered by *one* 16-gauge extension cord. That 16-gauge cord is rated for 10 amps. If you had four 300W bulbs (1,200 watts total), that would be 12 amps, which would exceed the rating for the extension. So, for this fixture, the power cable is the weakest link in the ampacity chain and the entire fixture cannot exceed 1,000 watts, which means 250W bulbs, maximum, for each socket.

If you chose to create this fixture with a larger 14-gauge extension cord, you have a maximum of 15 amps for that cord, which would mean your next weakest link would be the dimmers, which can handle 600 watts each, so you can step up to 300W bulbs.

If you've constructed a batten strip with more than four sockets, calculate your wattages and amperages very, very carefully. Never exceed the maximum rating of whatever component has the lowest ampacity. Using these same components, if you made a 6-foot fixture with eight sockets, you could not exceed 125 watts per bulb.

The Covered Wagon

Round 'em up, cowboys and cowgirls, we're ridin' the wagon trail!

No, not really. What you're going to do is take the batten strip and turn it into a softer, more indirect fixture by creating a wrap of diffusion for it.

Just wrapping diffusion around the fixture would be a bad idea. Even the professional diffusion material, if it comes in direct contact with a hot bulb, will melt and possibly burn. Inexpensive alternatives will *definitely* melt and *probably* burn. So you need to create a structure that will support diffusion around this fixture while keeping the material away from the bulbs themselves.

The completed covered wagon project.

The components necessary for the covered wagon project.

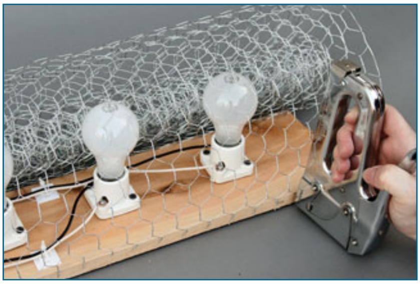
What you'll need:

- Roll of "poultry netting" (aka chicken wire): $12
- Roll of 2-inch duct or gaff tape: $8
- Roll of tracing paper or other diffusion material: $3
- Staple gun
- Pair of wire cutters, diagonal cutters, or tin snips

Total cost: $23 (plus batten strip)

Step 1

Starting with the pre-made batten strip, unroll the chicken wire and, using the staple gun, staple it to one side of the batten strip.



Using the staple gun, secure the chicken wire to the lumber.

Trim off the wire from the roll.

Step 2

Unroll the chicken wire over the top of the bulbs to the other side. You want, at least, a 3- to 4-inch gap between the top of the bulbs and the chicken wire. The higher you make this gap, the larger the diffusion face will be and the softer the fixture will be. When you've measured what you need, use your cutters to trim off the excess wire.

Step 3

Staple the second side of the chicken wire. You now have a canopy of wire over the top of the bulbs.

Staple the second side of the wire to the second side of the board.

Trim off excess wire from over the dimmer area.

Step 4

Trim off the excess wire over the dimmer switch area.

Step 5

Starting at one side of the strip, using the duct or gaff tape, tape down the edge of your diffusion to the base of the strip.

Secure the diffusion to the board with gaff or duct tape.

Step 6

Wrap the outside of the wire with your diffusion and measure enough to reach the bottom on the second side. Then cut it off the roll.

Step 7

Tape the second side of the diffusion to the bottom of the strip.

Finish taping the diffusion to the base of the lumber.

Trim off the excess diffusion over the dimmer area.

Step 8

Trim off the excess diffusion from over the dimmer area.

Now you've completed your covered wagon—Wagon HO!

You can mount a nail-on plate to the back of this strip to mount it to a C-Stand or just place it on the floor or even temporarily screw it into a wall. These are very versatile fixtures that can fit into a number of places easily.

TIP

If you decide to use CFL lamps in this fixture, keep in mind that most CFLs *cannot* be dimmed. If you use CFLs, keep the dimmers at 100% and just use them as an on-off switch. Attempting to dim most CFLs will either burn out the lamp's ballast or the dimmer itself.

Keeping the Fire Department at Bay

All electrical components carry a danger of fire as the second biggest hazard, next to electrocution. Knowing the capacities of your devices, keeping them in good condition, and never overloading them will keep you safe and avoid dangerous situations. As a precaution, it is always a good idea to have a fire extinguisher handy. I have one mounted to the top of a first-aid kit that I carry with me. There are four classifications of fire extinguishers: A, B, C, and D. A class A extinguisher is, basically, compressed water. They are generally silver (not red) and are intended only for basic combustible materials (paper, wood, and so on). A class B extinguisher is intended for flammable liquids—gas, oil, and so on. These are most often white. Class C extinguisher is intended for electrical fires. This will be a non-conductive foam or CO_2. A class D extinguisher is for flammable metals—magnesium, potassium, and so on. The most common type of extinguisher is a combination ABC extinguisher, which is good for all types of fires except burning metals (which you're unlikely to encounter). If you do not have a class ABC extinguisher, a class C is a must around electricity. Never reach for a silver extinguisher if there is a fire involving electricity; you'll be spraying water on the area and, potentially, making the situation worse.

From here, let's journey onward and take a look at non-incandescent sources and tools you can build.

9

Fluorescent Fixtures

Once upon a time, fluorescent light was the bane of the cinematographer's existence. The light produced by the ubiquitous lamps was greenish, ugly, and unflattering. However, modern advances in multi-phosphor mixes in fluorescent tubes have made them feasible and efficient tools to light with.

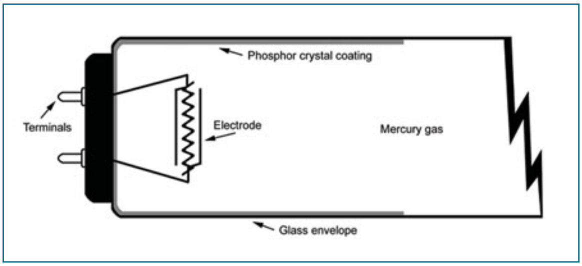
The benefits of fluorescent lighting are that it is naturally soft, it consumes very little electricity, and it puts off nearly no heat—these are all strong pros in the digital video world.

The cons of fluorescent lighting are the inconsistent mixture of different types of tubes you're likely to encounter in any given location, the high green content, the non-continuous and false color spectrum, and the flicker associated with shooting at very fast shutter speeds or frame rates.

Bulbs 101: The Science Behind Fluorescent Light

A fluorescent tube is made up of five primary parts:

- Electrode
- Mercury gas
- Phosphor crystals
- Glass envelope (bulb itself)
- Metal terminals



The components of a fluorescent light.

Fluorescent light is derived from electrons that are emitted by an electrode at one end of the tube which collide with a free electron of an atom of mercury (a metal/conductor in gas form) inside the tube. This collision, which happens at high speed, produces ultraviolet radiation. The radiation, in turn, excites the phosphors coating the glass tube, which then emit light. *Fluorescence* is unlike incandescent light and doesn't produce a full spectrum of color. Although fluorescent lighting is energy efficient and doesn't create the heat that standard incandescent lighting does, the lack of color spectrum causes digital videographers a number of headaches. Instead of providing a smooth, even distribution of color from the full spectrum, fluorescent light provides spikes of specific color wavelengths. Although fluorescent bulbs may simulate a specific color temperature (called *CCT* or *Correlated Color Temperature*) equivalent to incandescence, it is never perfect. That being said, with careful selection of your lamps, you can use them very efficiently to light your scenes.

There are many types of fluorescent lamps, from the popular CFL or Compact Fluorescent Lamps to the Slimline to the ubiquitous T-12 tubes. The most important aspect of the different shapes and styles is that you find the right lamps for whatever fixture you're working with.

Advancements in phosphor coatings have made fluorescent lights viable for use in photography.

By nature of their operation, fluorescent lamps require very precise control over the electrical current delivered to the lamp. Without this control, the lamp would nearly immediately die, possibly in a very destructive manner. Regulation of electricity, then, is provided by a ballast. Every fluorescent fixture requires a ballast to control the electrical flow.

NOTE

The *ballast* provides an initial high burst of current to cause the electrode to spark and then carefully regulates the flow. A fluorescent lamp, by its nature, is a negative differential resistance device, which means that, unlike metal conductors, as more current flows through the tube, the electrical resistance within the tube actually drops. If the lamp were connected to a constant supply of electricity, it would most likely explode, or at least quickly burn out the electrode. After the initial spike, the ballast needs to carefully regulate the electricity to keep the lamp lit, but not allow it to overheat the electrode or allow too much flow of electricity. Ballasts are specifically designed to work with a particular size and wattage of fluorescent lamp. If you ever need to replace a ballast, make sure it's designed for the specific types of lamps in your fixture.

Most important to digital cinematographers are the CCT and CRI ratings of the lamps you work with. *CRI* is *Color Rendering Index,* and it is a scale from 1 to 100 by which non-continuous spectrum light sources are measured to denote how accurately they simulate a full spectrum of color and, in turn, allow objects to be seen in their "real" colors.

The technical information on the box of fluorescent lamps including correlated color temperature, CRI, wattage, and lumen output.

A CRI of 100 would be natural daylight, which renders objects true colors. A CRI of 50 might mean that reds viewed under that light will appear more maroon or greens will appear more gray. You can white-balance under low CRI lamps, but you're still not going to get true colors in your scene because the wavelengths of light are not there, regardless of how neutral your camera makes the whites.

Low CRI lamps are often seen where inexpensive, long-lasting illumination is needed, but where true color is not a priority. The worst-case real-world example is the low-pressure sodium vapor street lamps that permeate many cities. These fixtures emit a very specific wavelength of yellow/orange light and, effectively, have a CRI of 0.

Commercial and residential fluorescent lighting normally has a moderate CRI in the 70–85 range to make the light more comfortable for people to work and live in. They are moderate at representing natural colors, but can have a high concentration of green/blue in them.

However, advancements in phosphor combinations and in fluorescent lamps have led to some really great tools available pretty much anywhere. Look for lamps with high CRI ratings—in the 85–95 range. Look for lamps with a CCT that most closely matches the lighting you'll be mixing the fluorescent source with.

The Real Stuff

In the late 1980s, gaffer Frieder Hochhiem created a custom-made high-output fluorescent fixture for cinematographer Robby Müller while shooting the film *Barfly.* This creation eventually evolved into a whole new career for Hochhiem as he founded Kino Flo, Inc., a company dedicated to the art and science of fluorescent lighting.

These fixtures set the standard in the industry and brought fluorescent technology out of taboo and into vogue. Research and development into specific recipes of phosphor blends, first with third-party vendors and then through Kino's own creation, resulted in color correct tubes with very high CRIs of 95.

In addition to getting the phosphor mixes perfected to work seamlessly alongside tungsten and daylight color temperatures, Hochhiem also incorporated several aspects into the Kino Flo fixtures to solve the other problems of fluorescent lighting in motion pictures. One of the primary differences is Kino Flo's high-frequency ballast that cycles the lamp 25,000 times a second (as opposed to a standard ballast, which cycles the lamps 60 times a second). This makes the Kino Flo virtually "flicker free" at any shutter speed or frame rate.

Today, there are many other manufacturers who are making fluorescent fixtures, including Arri, Lowel, and Mole-Richardson, to name a few.

These fixtures can be very, very expensive, however and there are times when budget, location, or overall resources don't allow the luxury of working with a refined system like Kino Flo—and that's when you have to improvise.

There are alternatives for the do-it-yourselfer that may not be as refined and flexible, but are workable in many situations. Fluorescent tubes are now available at your local hardware store with high CRIs in various correlated color temperatures. As long as you're careful about what lamps you purchase and when you use them, fluorescent light is naturally very soft; with small fixtures, it's easy to tuck in to tight spaces.

Caution

Although you can buy Kino Flo lamps separately and they will fit into standard household and industrial fixtures, those lamps are specifically designed to work with Kino's overdriven ballasts and will not perform to the same precision and output in a "normal" fixture. If you're making your own fixture, your best bet is to get standard bulbs with high CRIs.

A Look at Fluoros in Action

After one of my lighting lectures at the Digital Video Expo, where I received a lot of questions about fluorescent lighting, I decided to do a little testing and demonstrate the differences in fluorescent bulbs with regard to CRI and color temperatures.

With some help from actress/model Amanda Bolten, I set up a small set and brought out a number of inexpensive and readily available fluorescent tubes that I found at my local hardware store. Table 9-1 shows the variety of bulbs I tested.

Table 9-1 The Bulbs

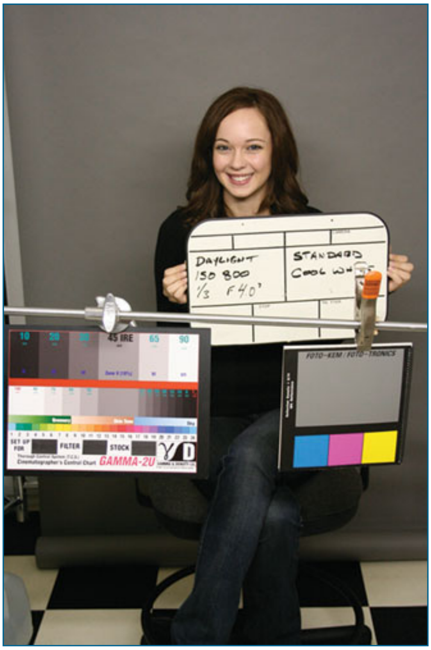
Type	Wattage	Color Temp	CRI	Output	Cost
Cool White	34	4,100K	62	2650 lumens	$2.00
Cool White Plus	40	4,100K	70	3200 lumens	$2.00
Soft White	40	3,000K	85	3300 lumens	$3.25
Daylight Deluxe	40	6,500K	84	2325 lumens	$3.50
Natural Sunshine	40	5,000K	92	2200 lumens	$12.00

Fluorescent manufacturers use the lumen measurement of light, which is, in essence, a metric version of footcandles (see Chapter 3, "Understanding Exposure," for more info). For all intents and purposes, one footcandle is equal to 10 lux/lumens. So the fixtures in Table 9-1 will provide an intensity of roughly 220–330 footcandles at a distance of one foot. Notice that the higher the CRI, the higher the cost of the tube.

In the following images of model Amanda Bolten, pay special attention to the color of Amanda's skin tone, and to the color of the gray behind her, in addition to how the light affects the yellow, magenta, and cyan patches on the chart to the right. One of the biggest problems with fluorescent light is the inherent green tint, so watch for the greenish hue in the gray and in Amanda's skin tone.

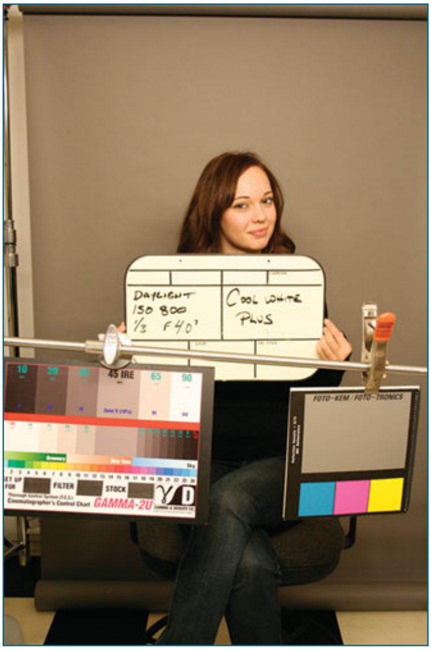
In each photo, Amanda is holding up a board identifying the parameters of that particular shot. The only stuff that's really important to note: on the left side of the board, the camera's color balance setting (daylight or tungsten), the camera's ISO setting and *f*-stop. The right side of the board details the specific fluorescent lamp used for that shot.

Simply because they were the specific lamps in stock at my local hardware store, all of the lamps I used were manufactured by Phillips.



This first image shows the effects of a Standard Cool White globe with a daylight color balance on the camera. Model Amanda Bolten.

The effects of the Soft White globes with a tungsten color balance on the camera.



The effects of a Cool White Plus globe with a daylight color balance on the camera.

The effects of a Daylight Deluxe globe with a daylight color balance on the camera.

The effects of a Natural Daylight/Sunshine globe with a daylight color balance on the camera.

Tube	R, G, B	Patch
Standard White	138, 130, 119	
Soft White	182, 157, 137	
Cool White Plus	142, 139, 132	
Daylight Deluxe	145, 149, 148	
Natural Daylight	136, 137, 132	

The gray measurements of each of the different fluorescent tubes.

Surprisingly, two of the tubes rendered a near perfect neutral gray: Daylight Deluxe and Natural Daylight. Although, personally, I like the skin tone rendered by the Cool White Plus tubes, which is slightly warmer: R142, G139, and B132.

It's important to keep in mind that these are merely the results of one test. If you were to conduct your own test, with your own fixtures, the results may vary. The idea here is to simply demonstrate, as objectively as I can, the differences in CRI and CCT in commonly available fluorescent lamps.

CFLs (Compact Fluorescent Lamps)

In the last few years, especially with the heavy environmental movement, Compact Fluorescent Lamps have become very popular. Their efficiency is twice to four times that of incandescent bulbs, which lose 90% of their energy to heat. Since fluorescent fixtures get their brightness primarily from the surface area of the glass, manufacturers designed a way to twist the glass into a tight spiral to compact it down and get a lot more surface area in a smaller space. CFLs generally incorporate their ballast directly into the base of the bulb to create a single device that can be screwed into any standard light bulb socket. The smaller size and all-in-one construction meant that people could replace their tungsten bulbs with fluorescent bulbs and not have to change out their fixtures. These are very efficient sources and are fairly inexpensive (although much more expensive than the equivalent wattage

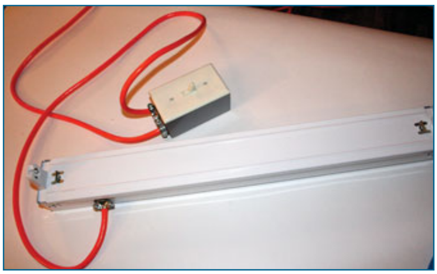
One of many designs and shapes of CFLs.

in tungsten bulbs; about 5–10 times as expensive). They are not, however, manufactured for use in photography. Most CFL globes do not have published CRI ratings, and there are considerable differences between manufacturers and even individual product lines and shapes within a single manufacturer.

You can certainly use CFLs to light with, no doubt, but it's best if you're going to use them to use them exclusively—and stick to one manufacturer and specific model of CFL. In that case, you can white-balance away any green cast and achieve some good results. If you're combining with any other sources, however, I'd recommend staying away from CFLs altogether.

Making a Fluorescent Fixture

This is a fairly simple project that takes a standard, inexpensive, household fluorescent fixture and turns it into a portable, switchable fixture. In essence, all you're really doing is adding a switch and a plug to an existing fixture as opposed to hard-wiring it into a building. These same principles apply to a fixture of any size. In my kit I have a 2-foot single fixture, a 4-foot single fixture, and a 4-foot double fixture, all modified by connecting a switch and a plug to make them portable.



The final fluorescent fixture.

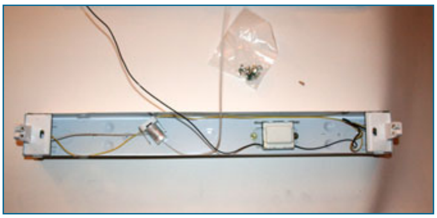
The necessary components for this project.

The necessary components are listed here and shown in the preceeding image:

- 2-foot fluorescent fixture: $15
- Single-gang ½-inch outdoor box: $2
- Single-pole standard light switch: $1
- Single-gang nylon switch plate cover: $1
- Two ½-inch wire retainers: $1
- 25-foot 16/3 grounded extension cord: $5
- Four wire nuts (not pictured): $1
- Roll of 2-inch white gaff tape (not pictured): $8
- Pair of wire strippers
- Razor knife (not pictured)
- Screwdriver

Total cost: $34

Step 1



The basic fixture, assembled according to the manufacturer's instructions, without applying the fixture's cover.

Open the fluorescent fixture's box and follow the manufacturer's instructions to put the sides together and secure the ballast to the fixture. Don't put the final cover on the fixture—leave it off for now.

TIP

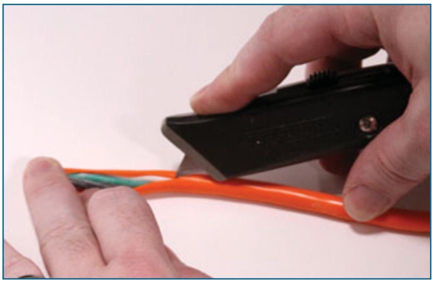
I will also, often, use white gaff tape on all of the sharp edges of the fluorescent fixture's metal frame. Because the fixture isn't meant to be portable or handheld, the edges can be very sharp and can easily cut you, so it's safer to put a little protection in place.

Step 2

Take the extension cord out of its packaging. Cut the female/socket end off the extension cord and discard it.

Then measure out about 4 inches of cord and cut that off. Carefully cut off the orange insulation, being very careful not to cut the three wires inside, only the orange coating.

Cut off the female (socket) end of the extension cord and discard.



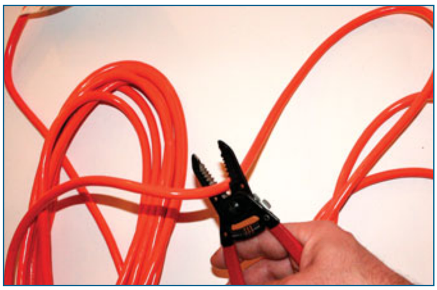
Stripping off the orange insulation from the 4-inch extension cord.

When you remove all of the insulation, you'll have three wires, a black, white, and green, each about 4 inches long. You can discard the black and white wires. Keep the 4 inches of green wire to use as a ground pigtail later; you can set it aside for now.

Step 3

Next, from the cut end of the long extension cord, measure about 5 feet of cord and cut that off.

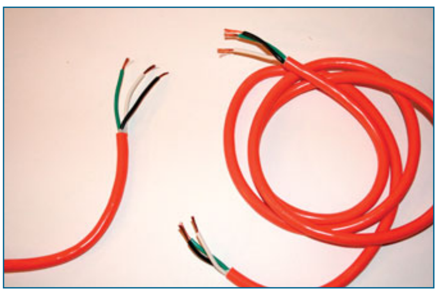
You should now have two pieces of the extension cord, one 20-foot piece of cord with the male (plug) end still attached (this will be your line cord, plugging into the wall and supplying power to the switch) and 5-foot piece of cord that is cut at both ends (this will be your load end connecting the switch to the fixture).



Cutting off 5 feet of cord.

Step 4

Strip about 4 inches of the outer (orange) insulation off each cut end of both lengths of cord. Be very careful not to cut the three wires (black, white, and green) inside the cord.



The two lengths of cable, one 5 feet in length with both ends stripped (load), and one 20 feet in length with one end stripped and the other still attached to the male (plug) (line).

Step 5

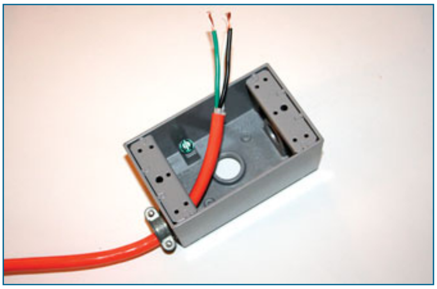
After that, strip off about 1 inch of the black, white, and green wires individually.

Step 6

Open the package for the ½-inch outdoor single-gang box.

Step 7

Take one of the ½-inch wire retainers and remove the retaining nut on it. You can discard the retaining ring; you won't need it.

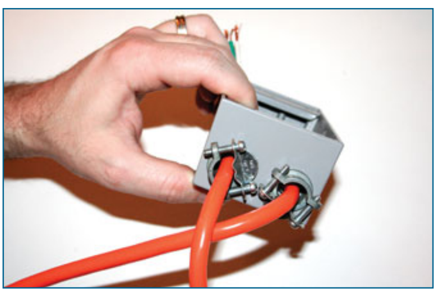


The ½-inch outdoor single-gang box with the (line) stripped plug cable inserted into the wire retainer at the base of the box.

Thread the stripped wire from the end of the 20-foot piece of cord (with the plug still attached) through the clamp section of the ½-inch wire retainer. Then screw the threaded end of the retainer into the bottom of the gang box. Do this so that the stripped end of the wire is inside the gang box and the clamp locks the wire firmly in place. You'll want to have about 6 inches of cord inside the box.

Step 8

Repeat this same action with one end of the shorter 5-foot (load) cable, but put the wire retainer into the threaded hole next to the one you just installed, in the bottom of the box (if your gang box does not have two holes at one end, just put the 5-foot cable into the hole at the opposite end of the gang box). You want to have about 6 inches of cable from the end of the 5-foot cord inside the box.



The two lengths of extension cord in the wire retainers in the bottom of the gang box. If your gang box does not have side-by-side ½-inch holes, put the second retainer on the opposite of the gang box.

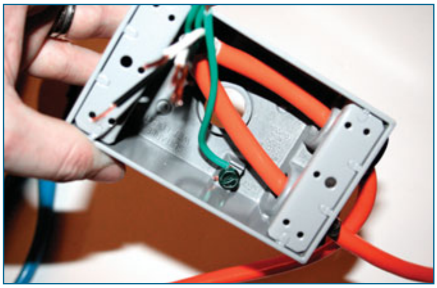
The stripped end of the 20-foot plug cable and one end of the double-stripped 5-foot cable should now be fed into the gang box.

Step 9

Now, return to the 4-inch piece of green wire you set aside in Step 2 and strip off the green insulation about 1 inch on both ends of the wire.

Inside the gang box you'll find a green grounding screw. Loosen that screw as far as you can before it comes out. Bend one end of the stripped green wire into a hook shape and hook it around the threads of that green screw. Make sure that the open end of your hook faces to the right so that when you tighten the green screw (clockwise), it will force the hook shape to become smaller instead of opening it up.

When the screw is tightened down, the green wire should be firmly attached and the bare wire in firm contact with the box and the green screw.



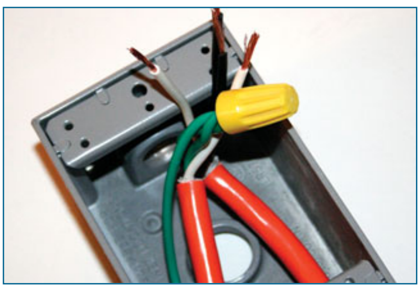
The attached grounding (green) wire.

Step 10

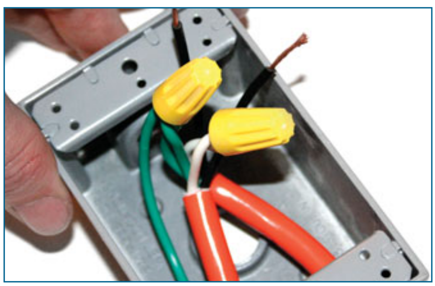
Next, take the other end of the short 4-inch green ground wire you just connected to the ground screw and twist it together with the other two green ground wires from each of the other cord ends inside the box.

Twist a wire nut onto these three wires to bind them tightly together. Give the wire nut a little tug to make sure it's got a secure hold of the wires.

What you've done is connected the ground wires from the 5-foot (load) cut end of the cord and the 20-foot (line) length of the cord to a ground wire attached to the grounding screw inside the gang box.



The connected ground wires.



Connected neutrals.

Step 11

Take the two white (neutral) wires from the wires inside the gang box and twist them together. Then twist on a wire nut firmly and give the wire nut a little tug to make sure it is firmly connected.

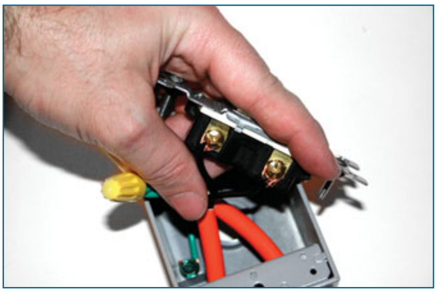
Step 12

You now have your connected greens (grounds) and whites (neutrals) and you have two bare black (hot) wires left inside the box.

Bend a hook into the bare ends of each of the black wires, just like you did with the green (ground) wire.

Take your single-pole light switch and unscrew the two gold screws on the side of the switch. They won't come all the way out; you just want to unscrew them enough to get a wire under them.

Hook one of the black wires around the threads of one of the golden screws—it doesn't matter which—making sure the open end of the hook shape is to the right so that when you screw down the gold screw (clockwise), it forces the hook to tighten.

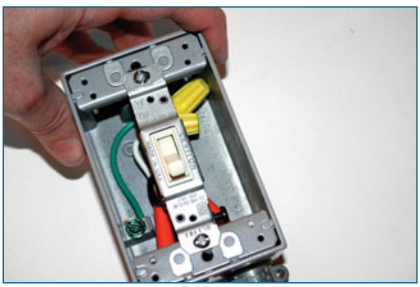


Each of the hot (black) wires is now connected to each of the gold screws on the light switch.

Screw down the screw. Now attach the other black wire to the other gold screw and screw it down. It doesn't matter which wire is connected to which screw.

Step 13

Using the two silver screws at the top and bottom of the switch (more than likely they're connected to the switch with a paper washer), secure the switch into the gang box.



The switch is secured into the gang box.

The faceplate is secured, closing the gang box.

Step 14

Open the switch faceplate and, with the enclosed small screws, secure it into place on the face of the light switch.

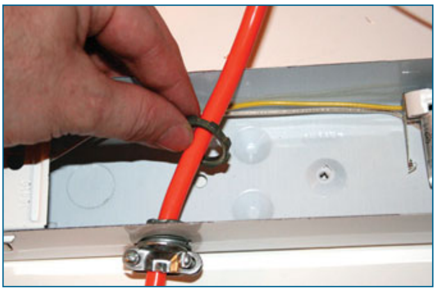
Step 15

Now you're ready to return to the fixture itself.

On the side of the fluorescent fixture, you'll find a punch-out—this is a small circular indentation that is connected to the fixture housing by a single weak weld. Using the tip of your screwdriver, poke into the fixture housing. This will bend it away from the fixture on the weld and expose a round hole. Bend the small piece of circular metal back and forth until it breaks off, leaving a ½-inch circular hole. You can discard the small round piece of metal.

Step 16

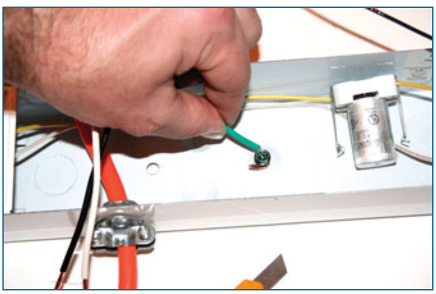
Using the third ½-inch wire retainer, unscrew the retaining ring, and slip the threaded end into the fixture through the ½-inch hole you just opened and secure it in place with the retaining ring. Feed the remaining stripped end of the 5-foot (load) cable (which is now connected to the switch box) through the retainer into the fixture. You'll want about 6 to 8 inches of cable inside the fixture. Secure the cord into the retainer by screwing down the pressure-plate until it has a firm grasp on the orange cord.



About 6 to 8 inches of cable from the stripped 5-foot length are inserted into the fixture and secured in place with the lock-down.

Step 17

Inside the fixture you'll find another green grounding screw, just like you found inside the gang box. Connect the green (ground) wire from the 5-foot (load) cord to the ground screw, just as you did in the gang box. Again, be careful to place the hook toward the right so when the screw tightens, it tightens the hook.

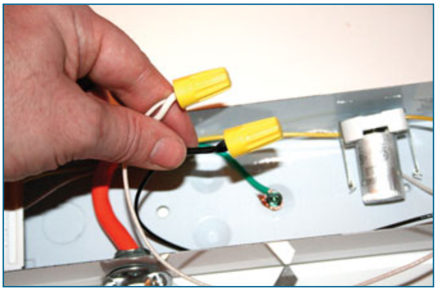


Attaching the grounding wire inside the fluorescent fixture.

Step 18

Inside the fluorescent fixture is a small ballast that you attached to the fixture according to the manufacturer's instructions in Step 1. Coming out of this ballast are two wires, one white (neutral) and one black (hot).

Twist the white wire from the 5-foot orange cord together with the white (neutral) wire coming from the fluorescent fixture's ballast.



The neutrals from the cord and fixture and the hots from the cord and fixture should now be connected.

Secure them with a wire nut.

Do this same thing with the black (hot) wire from the cord and the black (hot) wire from the ballast. Give each of them a little tug to ensure a good connection with the wire nut.

Step 19

Now attach the cover of the fluorescent fixture and you're good to go!

Once you put a lamp in the fixture, you can plug this fixture into any standard wall outlet, and the switch will turn the lamp on or off. Do not use a dimmer on a fixture like this; the ballast is not designed for it and it will burn the ballast out.

This same procedure applies to larger fixtures.

I typically use gaff tape to secure a baby plate to the back of the fixture so I can mount it in a C-Stand, but you can attach whatever favorite connector you like.

Caution

A word of caution: fluorescent tubes contain mercury, which can be a deadly poison. Handling these fixtures without protection over the bulbs can result in the fragile bulbs breaking. Use caution when handling bare bulbs and fixtures with exposed bulbs at all times.

You can use this same concept of adding a switch and a plug to pretty much any size fluorescent fixture. As I mentioned earlier, I have several sizes of these fixtures in my kit, and they definitely come in handy.

With a collection of fluorescent tubes in your kit, you'll be ready to add some light to a number of situations.

Now that you've read about tungsten and fluorescent fixtures, you'll take a look at some other lighting tools that may come in handy.

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10

A Light by Any Other Name: LEDs and More

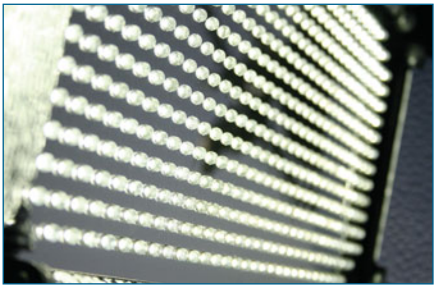
Thus far, you've learned about tungsten light and fluorescent light but, of course, that's not all the choices available, by far. If you look around you, there are myriad luminaries creating light in our world.

At the dawn of the motion picture industry, there were very few choices of light sources for the 6 ASA film. The slow emulsion required 3,250 footcandles of light to achieve a proper exposure at an *f/4*. That's the equivalent of 190 60W light bulbs at a distance of about 3 feet (or what you might also call a wall of heat!). At the beginning of the 20th century, there was no artificial means of generating that kind of lighting intensity, short of starting a major forest fire, so film stages were built with open ceilings to allow natural sunlight to expose their scenes.

Today, digital cinematographers have a complex range of lighting technologies available to them. Advances in electronic imaging have made extraordinary leaps in light sensitivity, making exposures possible in as little as a single footcandle of light. Today's digital cameras, with their typical sensitivities ranging from 320 to 640 IE, require only 30 to 60 footcandles of light to reach an *f/4*, the equivalent of about two to four 60W light bulbs, which is less than 1% the amount of light originally required for the first film emulsions. Further, the new HDSLR cameras have sensitivities as high as 25,600 ISO and require less than a single footcandle for an *f/4* exposure.

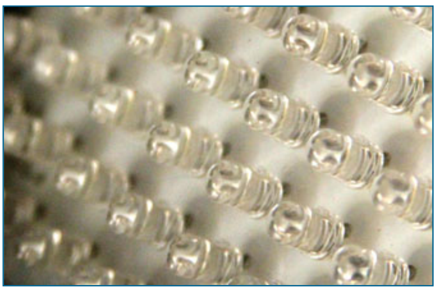
It's not a bad idea to keep a mental (or written) inventory of different types of lights that you come across in everyday life; you'll never know when that'll come in handy. This chapter covers some additional lighting sources to consider for your needs.

Light Emitting Diodes (LEDs)


Light emitting diodes have surfaced as the new wave of lighting technology.

LEDs are quickly becoming ubiquitous in our modern society. Previously relegated to mere indicator lights, LEDs have advanced to the point where they can be utilized as primary lighting sources for a number of applications.

Bulb 101: The Science Behind LEDs


A close-up of an array of LEDs in a fixture.

The modern light emitting diode (LED) was originally invented in the early 1960s, based on technological discoveries made at the turn of the 20th century. Early LEDs were only capable of emitting a red light and at very low intensity, but further advancements paved the way to brighter red LEDs, then orange, green and, finally, in the mid 1990s, blue LEDs. As technology improved and brighter LEDs were created, techniques were employed to coat the inside of the plastic lens with phosphors to turn the bright blue light into "white" light, or rather light with a CCT of 5,600°K to 6,500°K.

LEDs require very low power, produce no heat, and have extraordinarily long lamp lives; typically in the 50,000- to 100,000-hour range. As a result of this efficiency, many long-term installations have already switched over to nearly exclusive LED technology. In the United States and Canada, traffic signals have been switching over to LED lamps since the mid 1990s. Now there is a movement to replace gas-arc street lamps with LEDs as well.

The advancements in LED technology have moved them into the viability range for film and video applications. Companies such as Litepanels, Kino Flo, Nila, Element Labs, Zylight, and more are manufacturing LED fixtures specifically for film and video production use.

The LEDs themselves are a fixed color, generally in a very narrow bandwidth, and they are not capable of changing color. Film and video LED fixtures are just like their incandescent, gas-discharge, or fluorescent cousins, available in a specific color temperature. However, the small size of individual LEDs allows for many varying color diodes to be clustered together and activated at various intensities to create nearly any color in the visible spectrum with the possibility of dimming from one color to the next. Fixtures like Kino Flo's Kelvin Tile incorporate clusters of red, green, and blue LEDs that, mixed together, create any color of the rainbow.

Note

It is important to note that although LEDs are now available nearly everywhere, the consumer-grade LEDs are *not* made the same as the professional-grade photographic devices. At the time of this publication, consumer-grade LEDs are not specifically color balanced for use in photography. For those consumer-grade LEDs that I could find CRI ratings for, I saw numbers like 60, 65, and 66 CRI—extremely low and worse than industrial fluorescent lamps. For all intents and purposes, LEDs are, now, where fluorescent lamps were 30 years ago: used for industrial or utility applications, but not suitable for sensitive photographic lighting—unless manufactured specifically by a company focused on doing so.

That being said, consumer-grade LEDs do provide light. This means you *can* use them to light your shots, or elements of your shots, but be aware that you may have color issues with them. Depending on the manufacturing, you can see a lot of green or cyan cast from consumer-grade LEDs (and even some inexpensive "professional" film/video fixtures). If you're combining LEDs with any other light sources, be aware of this difference and that it might not be easily correctable later.

Putting LEDs to Good Use

Where can LEDs work? Well, one of the great things about them being low power and small is that you can sneak a small LED fixture nearly anywhere. One of the best uses is lighting car interiors at night. These small fixtures can easily be tucked into the corners, hidden from view, and provide sufficient glow to light your talent. Since driving in a practical car will mean you'll be encountering all kinds of color temperatures (sodium vapor street lamps, mercury vapor lamps, LED lamps, neon, fluorescent, tungsten, and more), the off-color LED will most likely fit right in. Also, since many LED fixtures can be powered by standard batteries, they don't require cabling or additional power sources, which make them fantastic for moving shots.

The Road Ahead: Using Headlamps as Fixtures

Many years ago when I was working as a gaffer for my good friend Chris Probst on his first feature as a cinematographer, we had the challenge of shooting a shark attack off a yacht at night. On a no-budget production, with minimal gear and no power generator, we had to figure out how to light the man and the rubber shark in the water. Chris suggested the idea of using car headlamps, a true stroke of brilliance. Not only will car headlamps work off a boat's 12V DC power supply, but they're also sealed and water proof. We wired the headlamps directly to the ship's 12V battery, attached them to the ends of C-Stands, and plunged them into the water. After a length of time, the salt water finally got the best of the lamps and started to seep in and burn out the filament. We simply replaced the blown-out bulbs and kept shooting.

A standard 12V car headlamp.

Some time later, we were working on a pair of short films for HBO and had to shoot a nighttime car interior, again, on a low budget. I reached back into my bag of tricks and remembered the headlamps. I picked up a few headlamps at the auto supply store, built Croney Cones (see Chapter 7, "Soft Lights") for them, and attached them to the hood of the car. We connected zip cord to the headlamps and ran them straight to the car's battery—they worked perfectly.

"Converting" a 12V car headlamp to work for your needs isn't difficult, but it does require a 12V DC power source. You can't hook them into AC power—especially not 120V; you'll instantly blow out the lamp.

I use small "alligator" connectors and attach them to the end of a piece of zip cord.

Alligator clips help to make viable connection points at the end of a piece of zip cord and easily attach to the terminals on the back of a headlamp.

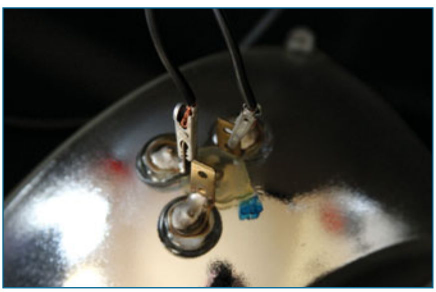
These clips connect very simply to the terminals on the back of a headlamp. Then you can run the other end of the zip cord to your battery source. I usually leave these as just stripped wire, and a fairly generous amount of stripping, perhaps as much as 3 inches. If I'm connecting to a car battery, with the longer strip I can merely wrap the wire around the terminal and tape it into place. For a more portable source, I've used 12V batteries from out of cordless power tools and merely taped the zip cord to the terminals on the battery.

Note

Remember, with a DC circuit, it is necessary to have a connection to both positive and negative terminals in order to complete the circuit. Although you're working with bare wire or metal alligator clips, there is no danger of electrocution—especially not with the low voltage you'll be dealing with. Be cautious, however, when the cord is connected to your battery. If you touch the alligator clips together, they will short and spark.

There are three terminals on the back of a headlamp. Any two connections will turn on the lamp.

One pair will turn on the "high beams," and one pair will turn on the low beams. It's an either-or situation; you can't have both at once. The high beam is positioned, most often, at the focal point of the lamp's reflector and will give you the most directional and efficient light. Low beams



Attaching the zip cord to two of the three terminals on the back of the headlamp.

are actually positioned off-axis to the reflector and designed to focus the light down and to the right (in the US and other right-side driving countries). There isn't necessarily a significant intensity difference between the high-beam and low-beam functions and if you have the lamp in a Croney Cone, you won't discern much of a difference at all.

If you're working with headlamps, make sure you are using standard tungsten filament lamps, not high-intensity discharge lamps, which are often mercury vapor lamps or xenon short-arc lamps. These are not only more complicated lamps, requiring a ballast, but they have very low CRIs (in the low to mid 70s) and, because of their mercury content, aren't safe to handle.

'Tis the Season: Lighting with Christmas Lights

Not just for decorating trees, Christmas lights are small, require very little power, and create a very pleasing soft, warm glow.

One tool that I always carry with me is good ol' fashioned Christmas tree lights. These strands of small, white lights are handy for dozens of applications from detail lighting in the background to use as key lights. They consume very little electricity but provide a warm soft glow. Even though they're 50- to 150-point sources, clumping the strand together creates a single source that produces a fairly soft result.

Los Angeles cinematographer Garrett Shannon suggested a Christmas light rig to me that was composed of a 4'×4' cut of bead board onto which he taped two strands of Christmas lights in a grid pattern and then covered it with a sheet of diffusion. This creates a very low-profile soft light that consumes very little power. It can easily be placed against a ceiling or tucked away in a corner.

I've used Christmas lights dozens and dozens of times, quite often as background elements, but also—at times—as key lights.

Model Heather "Sparrow" Carr gives the camera a sultry look against a background of Christmas lights. Also at work here were streak filters to spread the highlights into a horizontal flare across the image.

They're very handy to have around. Be aware, however, that current movements toward LED lighting are making traditional tungsten filament Christmas lights more and more difficult to find. LED Christmas strands are often closer to the daylight color temp and lack the warmth of the tungsten variety. They also have a high green content.

Get a Rope: Using Rope Lights

Rope light is an interesting tool. Although I've never used rope light as a primary source of illumination, I've certainly used it as background detail and for additional glows. Rope lights consist of long tubes of small bulbs encased in plastic. It can be bent and twisted and formed around objects or walls. It can be cut to size, requires very little electricity, and—like Christmas lights—provides a nice warm glow. It's inexpensive and easy enough to carry around with you.

Bendable, low-energy rope light can be used in a lot of nooks and crannies that are otherwise difficult to light. Generally best for detail and background lighting.

Caution

If you use tape to secure the rope light, be aware that as it does tend to heat up a little bit, it can melt the tape or the adhesive right off the tape. At best, the rope light will simply fall down and you have to re-attach it, but the worst-case scenario is the melted tape or adhesive harms the surface you're attaching the light to.

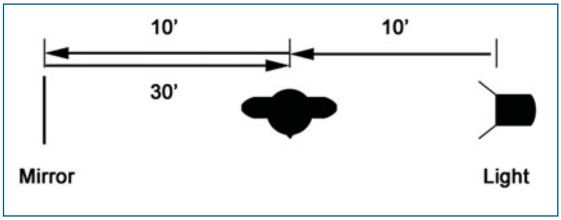
Using Stick-Ups and Hide-Aways

Small, compact, lightweight, these little architectural detail lights are great for little kicks and background details.

It's fun to scour the aisles of your local hardware and home improvement stores for little fixtures. I have a couple of sets of small halogen lights that are intended to be used under kitchen counters or in entertainment units. By separating the fixtures and converting them to work as individual lights, I can put them anywhere I want as a little accent light in the background. A lot of these fixtures come with their own "Edison" plugs, but some have their own custom connectors. When they have their own connectors, I'll usually clip those off, wire-nut on some zip cord, and attach a Quick-On to turn it into an individual pluggable fixture that I can put anywhere I want. Often I'll string out a long run of zip cord, snap on a few Add-a-Taps, and then place these stick-up fixtures along a wall or behind furniture—anywhere to give some lighting detail quickly and inexpensively.

Being Reflective: Using Mirrors as a Light Source

Very early on in my lighting career I became a big fan of mirrors. I always had a package of 1'×1' mirror tiles in my kit and often carried two to four 4'×4' mirrors on the lighting truck with me.



The distance between the object and the subject, in a reflective situation, is the distance from the object to the mirror added to the distance from the mirror to the subject.

Mirrors are truly wonderful tools. They can turn one light source into two. If I have only one light and I position it to my talent's left, I can use a mirror on my talent's right to bounce the light passing them right back onto them and turn that single source into two sources. Anytime you put light into a mirror, you get back a harder source. This is because you're increasing the distance to that source. If your light source is 10 feet from your talent's left and your mirror is 10 feet from your talent's right, the light coming off the mirror is, effectively, 30 feet away from your talent, and the greater distance creates a harder source of light.

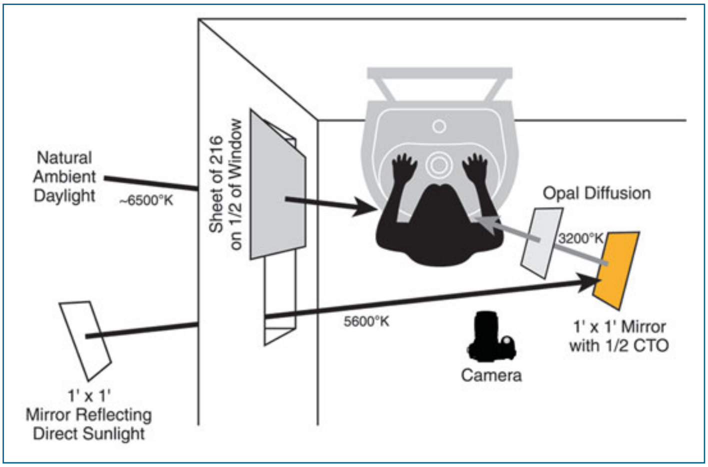
In Chapter 6, "Lighting Techniques," I discussed a music video that I lit with only mirrors and natural sunlight. In that situation, mirrors provided me the equivalent of about $5,000 worth of rented lighting equipment for less than $50.

In this shot, actress Lauren Solomon is lit purely by natural sunlight coming through a window and reflecting off mirror surfaces.

The image of actress Lauren Solomon is an example of a shot that was lit totally with natural daylight and mirrors. I was able to achieve two color temperatures with one source: the sun. The following diagram shows my lighting setup.

I used a 1'×1' square mirror tile on a C-Stand outside the window, which bounced direct sunlight into the bathroom, behind the position where Lauren, the actress, was standing. I didn't want this hard light directly on her; I just wanted to get the beam of sunlight into the bathroom set.

Inside, I used another 1'×1'mirror, on another C-Stand, on Lauren's right side. This bounced the direct sunlight from outside onto the right side of Lauren's face. I set the camera's white balance to "tungsten" 3,200°K, which turned the natural daylight into a blue-ish "moonlight."



A diagram of the lighting setup for the natural light shot of Lauren Solomon, showing the placements of the mirrors, diffusion, and color correction.

Then, in order to achieve "white" light on the right side of Lauren's face, I placed a sheet of Lee 1/2 CTO on the surface of the inside mirror to color-correct the bounced direct sunlight to tungsten. In this case, I only used 1/2 CTO because the light would be filtered twice through the same gel. The light coming from the mirror outside would pass through the gel receiving one layer of correction, and then it would reflect off the mirror and pass back through the same gel again. The light would be filtered twice through one sheet of gel, hence turning 1/2 CTO into full CTO by the nature of its being placed on the surface of the mirror.

The bounced sunlight from the mirror on Lauren's face was way too harsh for my taste, so I hung a piece of Rosco Opal diffusion in the space between the inside mirror and Lauren's face to soften the light quite a bit.

In addition, to reduce the intensity of the natural daylight through the window, I placed a sheet of Rosco Tough White Diffusion (216) on half of the window, nearest Lauren to diffuse and reduce the intensity of the light there, but to avoid diffusing the direct beam of sunlight that was bouncing off the outside mirror onto the inside mirror.

That did the trick and the result, considerably underexposed to achieve the feeling of night, was accomplished by using only natural daylight, but resulting in two different color temperatures from the same light source through the use of mirrors and a little CTO.

Mirrors are fantastic for creating hot kicks of light in the background, or for bouncing sunlight into the floor and creating a soft, natural warm glow. If you simply tape a baby plate to the back of the mirror, you can easily attach it to a C-Stand and position it where you need. Remember, as covered in Chapter 2, "The Fundamentals," the angle of incidence is equal to the angle of reflectance and mirrors will be easy!

TIP

As long as you're not superstitious, here's a tip for creating a very interesting background light with a 1'×1' mirror tile.

1. Cover the entire mirror face with heavy-duty clear packing tape.
2. Cover the entire back of the mirror tile with packing, duct, or gaff tape.
3. Drop the mirror flat on the ground! (Yup! You read that right!)

The result is a broken mirror that is still held safely in one piece by the tape. Bouncing light into this mirror creates an amorphous and naturally scattered pattern of light; beautiful stuff!

Innovation at Work

One of the fantastic benefits to having been a technical journalist on the side for many years is the opportunity to talk with so many great cinematographers and learn about their tricks and techniques. While writing a story for *American Cinematographer* magazine about a film called *The Black Tulip*, I had a chance to interview cinematographer David McFarland about his work. *Black Tulip* was shot in Afghanistan in 2009—at the height of the US war in that country. He had very little gear, all of which had to be lightweight, versatile, and highly portable (much of which he had to pack in his suitcases and bring from the United States). He told me of a soft light that he created using a collapsible laundry hamper made of white material that he purchased at a discount home décor store. By attaching a socket to one end of the hamper and putting a lamp inside, he created a portable, inexpensive "space light" that created a wonderful soft glow. The following image, courtesy of David, shows the "hamper light" in use on a nighttime exterior shot in Afghanistan.

A shot from the set of *Black Tulip* featuring David McFarland's "hamper light" in action in the streets of Afghanistan. Photo by David McFarland.

This is a perfect example of working with readily available materials and creating an extremely viable tool for very little money.

What Else?

What else is there? Anything that creates light… Matches, torches, flashlights, glow-in-the-dark paper, glow sticks… All of these things create light. Understanding the fundamentals of exposure and color temperature will help you understand how any particular light source will react in a given situation. There's a fantastic iPhone application called Catchlight, created by Ben Syverson (www.bensyverson.com/software/catchlight/), that allows you to dial in any solid color or simulated color temperature on your iPod touch or iPhone screen to use as a light source; yup, even your iPhone can be a light…

In the past I've used road flares, battery-operated lanterns, the light from a computer monitor, the light from a single match.... You're limited by the constraints of your technology and your imagination. It all comes down to context. Obviously, I wouldn't recommend lighting a corporate interview with road flares, but a dramatic nighttime chase scene? All the hero has is one remaining flare from his trunk as he enters the dark cave... that flare and maybe a Mylar emergency blanket taped to a piece of foamcore as a bounce to help fill in the shadows?

And that covers the world of inexpensive lighting tools! Experiment! Explore! Always keep mood, story, and context in mind when you're lighting your scenes. The right light for one scene might not work for another scene. Don't be afraid to be bold and experiment—especially on your own time! Remember: read, shoot, read, shoot, read some more, and get back out and shoot more!

In the final chapter, I cover some miscellaneous tools that you can build to help shape and refine your skills yet a little more.

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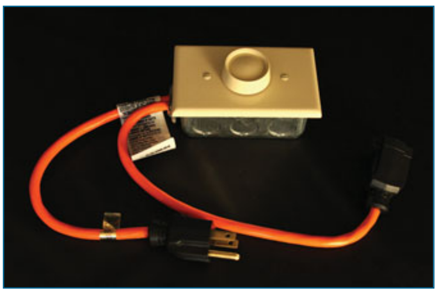
11

Accessories and Miscellaneous Tools

Aside from luminaries and bounce materials, there are a number of tools that help shape and manipulate light. In this chapter, you'll learn how to create a few of them to round out your new do-it-yourself lighting arsenal.

Making a "Hand Squeezer" Dimmer

These little dimmers are great for any lights, 600W (6A) or less. They're great for household lamps and especially great for practicals in your scene.



The finished "hand squeezer" rheostat dimmer.

You'll need these supplies:

- Single-pole standard household rheostat dimmer: $5
- ½-inch deep single-gang EMT box: $2
- Single-gang faceplate: $1
- 6-foot 16-gauge extension cord: $4
- ½-inch wire retainer: $1
- Four wire nuts: $1
- Grounding screw: $1
- Pair of wire strippers
- Flat-head screwdriver
- Razor knife

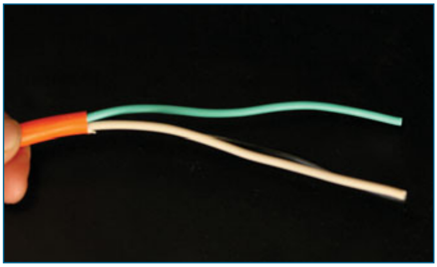
Total project cost: $15

The elements necessary for the "hand squeezer" project.

Cutting the extension cord to create a plug, a socket, and extra wire elements.

Step 2

Next, you want to cut away the main orange outer insulation about 4 inches from the cut end on each side of the cord. This exposes the three wires inside. Be sure to cut only the orange insulation, not the individual wire insulations inside. Do this on both orange cords.

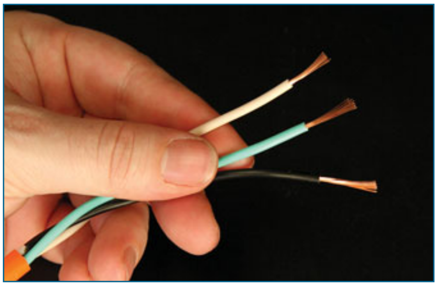


Stripping the orange insulation off the plug and socket ends.

Step 3

Now, using the wire strippers, you'll strip away the insulation on each of the three wires about 1 inch to expose bare wire. Do this on all three wires (black, white, and green) on both cords.

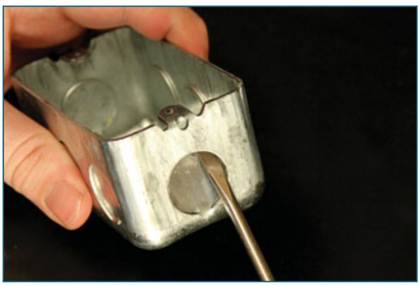
When you're done with all that, you'll have three wires, each stripped 1 inch on both pieces of cord.



Stripping the individual wires in the plug and socket ends.

Step 4

Next up, take the ½-inch deep single-gang EMT box and pop out one of the punch-outs. You'll need to tap it loose with a screwdriver (pushing in like a soda can top) and then wiggle it until it breaks off. Some are much harder than others, but they'll break off eventually.



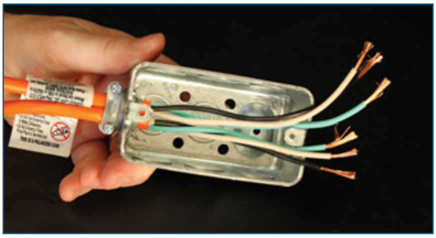
Breaking out the retainer ring in the gang box.

Attaching the wire retainer to the gang box.

Step 5

Insert the wire retainer into the open hole in the gang box and secure it to the gang box with the provided retaining nut. To tighten the nut down, use the tip of your screwdriver against the nibs on the outside of the retaining ring and tap to tighten it as far as you can.

Step 6



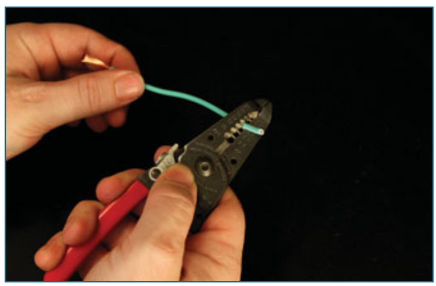
Slip the wires into the wire retainer and secure them in place. Make sure you have about 4 inches of stripped individual wires in the box.

Feed both stripped ends of the wires through the wire retainer into the box and secure them safely in the retainer clamp.

Step 7

Returning to the length of cord you set aside, cut off 4 inches of cord and strip off the orange insulation completely. You'll have one black, one white, and one green 4-inch wire. You can discard the black and white; you'll need only the green.

From the remaining extension cord, cut off 4 inches of orange cord and strip off the orange insulation completely to create a 4-inch ground wire.



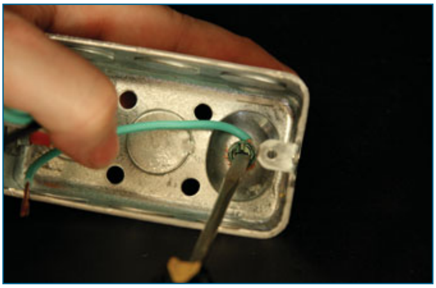
Stripping the ground wire.

Step 8

Strip off 1 inch of insulation from both sides of the 4-inch green wire.

Step 9

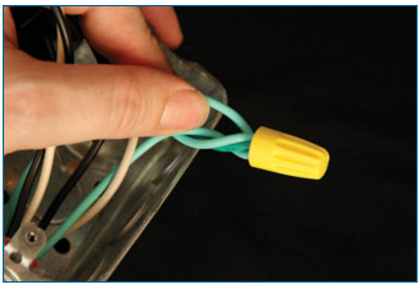
Using your green ground screw, screw it into the gang box. You'll find a threaded hole in the gang box, typically on a raised portion of the metal, that perfectly fits the grounding screw. Bend a hook into one end of the 4-inch green wire and slip it under the screw with the open end facing clockwise so that when you tighten the screw down, it closes the hook.

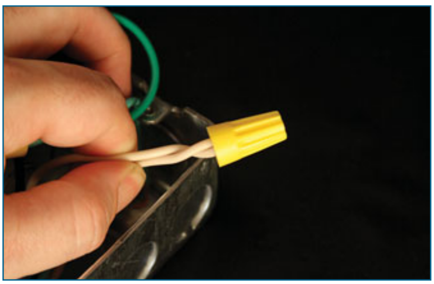

Attaching the ground wire to the gang box.

Step 10

Open the dimmer package, being careful not to lose the two loose screws inside the package. You'll need those.

Using a wire nut, twist the grounding wire you just connected to the gang box together with the ground wires from each end of the extension cord and the green ground wire from the dimmer. Twist all four wires together and then attach the wire nut. Give the nut a little tug to make sure it's secure.


Securing all the grounds together.

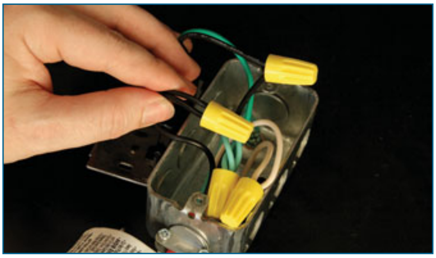

Securing the neutrals.

Step 11

Next, attach the two white wires together under one wire nut. Again, give the nut a little tug to ensure it's secure.

Step 12

Next up you'll be attaching your hot lines. Connect one of the black wires from the dimmer to the black wire from the plug end of the extension cord under one wire nut. It doesn't matter which black wire from the dimmer that you choose.



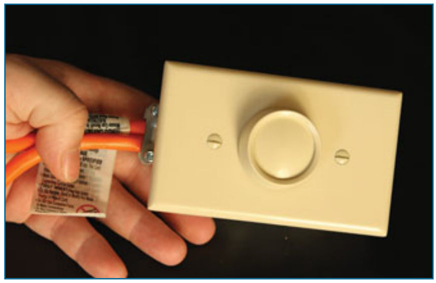
Securing the hots.

Under another wire nut, connect the *other* black wire from the dimmer to the black wire from the socket end of the extension cord. As always, give those wire nuts a little tug to make sure they're firmly in place.

Step 13

Now carefully fold all of the wires and wire nuts into the gang box and, using the two screws that came with the dimmer, secure the dimmer into the gang box.

Securing the dimmer in the gang box.



Attaching the faceplate and button.

Step 14

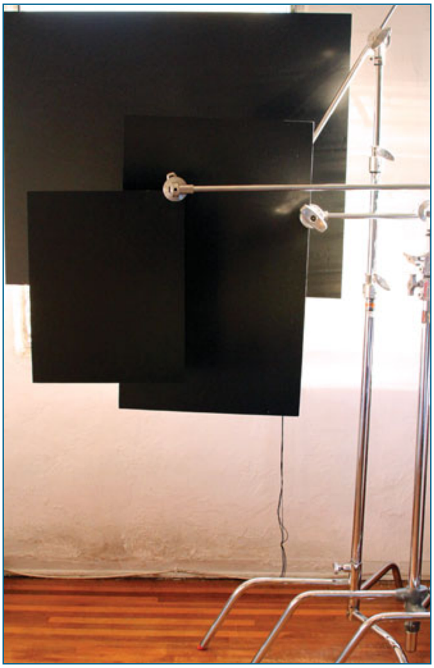
Attach the faceplate to the dimmer in the box and then slip on the button to finalize the hand squeezer.

And you’re done!

Now you have a hand squeezer dimmer you can hook up to incandescent lights to dim them. This is great for practical lights on a real location. Cheap and handy!

Making Your Own Flags

Flags are an essential part of any lighting kit. In the professional world, a flag is a metal wire frame that is covered in black duvetyn to block light.



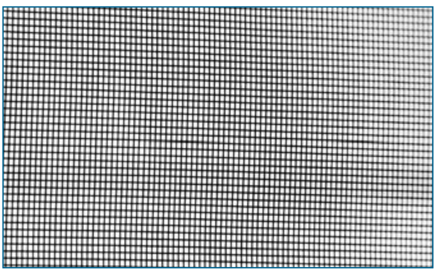
An assortment of foamcore "flags."

Making your own is incredibly simple and cheap. However, to keep costs down and simplify, you'll make rigid flags, not fabric ones. Simply procure large panels of black-on-black foamcore and cut them to size. Typical flag sizes are 4'×4', 2'×3', 18"×24", and 12"×18".

Making your own, however, you can cut any shapes and sizes that you need. The smaller sizes, 18"×24" and under, are easily clamped into the head of a C-Stand and simply supported that way. The 2'×3' flags can start to get flimsy after a few uses and may require a second stand. If you're making a 4'×4' flag, your best bet is to create two of them and use spray glue to mount them together (back-to-back) to make them stiffer.

You may also try using thicker foamcore, or using ⅝-inch wooden dowel rods inserted into the foam in the center of the board to stiffen them.

Making Your Own Nets



Screen door material to use as nets.

A net, in cinematography, is a piece of material that is intended to reduce the intensity of a light source without altering its color or quality. In the professional world, nets are identified by a color coding system: a purple is a ¼ stop; a green is a "single," which reduces the light by ½ stop; and a red is a “double,” which reduces light by a full stop. Nets, like most professional gear, are expensive. However, I have found that simple window screen material can be a suitable alternative. Look for screen material that is not glossy and has a tight weave. You’ll have to measure for yourself to see how much light loss each type of screen cuts, and then you can double up the screen material for twice as much light reduction to create your own “double.” If you look back at Chapter 7, “Soft Lights,” you’ll see that I used a custom window screen replacement kit to create a large diffusion screen. You can use these same kits with—whoa—actual window screen material (go figure) and create nets of your own.

CAUTION

Once again, keep in mind that screen door material is *not* flame retardant. Keep this material away from hot lights to avoid melting or danger of fire.

One of the handy aspects of professional nets is that you can get open-ended nets. These are nets that have a metal frame on three sides and a thin wire on the fourth side. This way, you can put the net into only part of a light path and not cast a harsh discernable shadow from the net’s frame itself.

If you utilize the custom window screen kit and omit one side, you can use the stiff wire from a coat hanger to bridge the gap. Use needle and thread to attach the window screen material to the wire. Remember that the closer to the light source you place the net (keeping far enough away to not start a fire or melt the screen), the softer the shadow potentially created by the wire will be.

Parting Thoughts

As this book comes to a close, there are a few ideas I’d like to leave you with; read on!

Think Outside the Box

If there’s one thing I can advocate above everything else, it’s to never get stuck thinking of the “right” way to light a scene. There is not necessarily a right or wrong when it comes to lighting. As you work more and more with lighting, you’ll learn to trust your instincts. Learn to “see” light, as I talked about in the introduction, and apply these memories to your lighting situations.

In every situation, you need to ask yourself the following questions:

- What is most important for the audience to see?
- How do I best represent the mood and emotion I want to convey?
- How do I achieve these objectives within the limitations I have?

The answers to these questions will show you the way to light any particular scenario.

Whose Creative Vision Is This Anyway?

There are times as a cinematographer that you'll be answering to someone else; someone else will have the final say on the look of the project you're shooting (if you're not a director-cinematographer or producer-cinematographer hyphenate, then it's always this way). That person might be a director, producer, or a client. Always keep this in mind—if you're not the head honcho on the show, you're working for someone else. It's your job to deliver the images according to others' wishes. Although you might have grand creative ideas about how to best light the scene, you have to play nice with the other kids. One of the key elements of a cinematographer's job is to craft the lighting *within the director's vision*. That is to say that the director (or producer or client, depending on the situation) has the bigger picture in mind, and it's your job to interpret that picture and deliver that vision. Sometimes this vision might go against what *you* want.… Unfortunately, that's the nature of the beast. If you simply cannot live with their decisions and simply cannot alter your own visions to suit their needs, perhaps this is not the right job or director for you.

Try, Try, and Try Again…

Don't be afraid to experiment, especially when you're *not* working on a specific project. One of the most advantageous aspects of digital technology is the fact that you can own your own equipment for a fairly low price, and now you can have your own lighting tools, too! Owning your own gear means that you can work with it and experiment anytime. Don't let it sit and gather dust! Shoot! Shoot more! Read as much as you can; then shoot, read, and shoot some more!

In the introduction to this book, I talked about when Chris Probst and I used to shoot scenes (single shots, even) to build our cinematographer's demo reels. These were experiments. They were learning tools; our hands-on workshops. They ranged from something as simple as shooting a clock face and experimenting with light direction and movement across the face of the clock to elaborate *spec commercial* shoots. In my experiments with lighting, I shot models, wine bottles, fruit, watches, toys, glassware, lamps… anything I could to experiment. I tried to get a picture of how something might look in my head and then execute that picture as best as I could. Did I succeed? Did I fail? Where could I do better?

Both of the following images—of model Ilaria Giansanti-Borden and of the couple in front of the fountain—were single-shot projects. They were tests or experiments purely to execute a single lighting or photographic concept.

A shot of model Ilaria Giansanti-Borden from 1992; one of the very first test shoots I did to experiment with lighting and film stocks. This was all artificial light from two sources: one on Ilaria's right side, a 500W Fresnel through a wooden shutter to create the Venetian blind effect; and a 100W reading lamp above and behind the chair. I also used a small 2'×2' foamcore bounce board low and to the left of Ilaria to help fill the shadows just a little bit.

A stolen shot testing emulsion speed of a Fuji film stock utilizing two actor friends and the available light of a fountain outside a Los Angeles hotel. This was an exercise in optimizing available light to create a mood.

Refine Your Eye

I also recommend picking up magazines. Not just photography magazines, but fashion magazines—especially ones with lots of ads in them. These are shot by the top photographers and, often, feature unique applications of light. Take a look at the ads and try to dissect how the photograph was lit. How many sources did they use? Where were they placed? How big were those sources?

Then, put in your favorite movies on DVD (or whatever) and watch them! Except—watch them with the sound turned *off*. Watch them in silence and just look at the picture. How does that cinematographer illustrate the story in light? Hit that Pause button and break down the lighting for that shot. Where are the sources coming from? How many do you think were used? Were they big? Small? Soft? Hard? How does the scene use color? Does it combine color temperatures? How is the light being shaped on the actors' faces?

In addition, magazines such as *American Cinematographer* (www.theasc.com/magazine) often run lighting plots with stories. These can be invaluable tools in helping understand how lighting is used in the professional world.

Optimize the Real World

So many times, when working on a limited budget, you simply don't have the resources and tools available to do what you want to do. Working with the real world lighting that exists in any given location is your best bet. This doesn't mean just walking in and shooting; it means you walk in, evaluate what is there, and then augment and change what you can. Position your talent in a way to optimize the existing lighting and make it work for you. Keep that old adage in mind: "If you can't beat 'em, light 'em with what you've got...."

Be Creative and Build Your Lighting Arsenal

I've said it a hundred times before: you can light with anything that creates light. In the right circumstance, the glow from the screen of a cell phone can be enough to light a shot. There are advantages and limitations to each and every type of light, from a single candle to the immense power of the sun. Always be looking around you; constantly *see* the light around you and keep a mental inventory of lighting resources, techniques, and looks. Remember that lighting isn't just about getting enough light to photograph an image. It's about mood and story. Even if you're shooting a corporate interview, finesse in your lighting will elevate your work.

Be creative; be inventive. Use the projects in this book to jump-start your toolkit, and invent from here. Be safe. Shoot well.

Appendix A

Bibliography and Suggested Further Reading

Adams, Ansel. *The Negative*. Boston: Little, Brown and Company, 1981.

Ascher, Steven, Pincus, Edward. *The Filmmaker's Handbook: A Comprehensive Guide for the Digital Age*. New York: Plume, 1994.

Box, Harry C. *Set Lighting Technician's Handbook: Film Lighting Equipment, Practice and Electrical Distribution.* Boston: Focal Press, 1993.

Boyle, Geoff. *Cinematography Mailing List: CML—the First 5 Years*. Devon: Boyle, 2005.

Boyle, Geoff. *Cinematography Mailing List: Lighting—January 2001 to January 2005.* Devon: Boyle, 2005.

Brown, Blain. *The Filmmaker's Pocket Reference*. Boston: Focal Press, 1994.

Burum, Stephen H., ed. *The American Cinematographer Manual,* 9ed. Hollywood: ASC Press, 2004.

Carlson, Verne, Carlson, Sylvia E. *Professional Lighting Handbook*, 2ed. Boston: Focal Press, 1991.

Carter, Paul. *Backstage Handbook: An Illustrated Almanac of Technical Information*, 3ed. Louisville: Broadway Press, 1994.

Konigsberg, Ira. *The Complete Film Dictionary*. New York: Signet, 1987.

Long, Ben, Schenk, Sonja. *The Digital Filmmaking Handbook*, 3ed. Boston: Cengage Learning, 2006.

Malkiewicz, Kris, Mullen, M. David. *Cinematography: The Classic Guide to Filmmaking, Revised and Updated for the 21st Century*. New York: Simon & Schuster, 2005.

Millerson, Gerald. *The Technique of Lighting for Television and Film,* 3ed. Boston: Focal Press, 1991.

Monaco, James, et al. *The Encyclopedia of Film: The Most Up-to-Date Reference Book Available.* New York: Perigee Books, 1991.

Parker, W. Oren, Wolf, R. Craig. *Scene Design and Stage Lighting,* 6ed. Fort Worth: Holt, Rinehart and Winston, Inc., 1990

Richter, Herbert P., Schwan, W. Creighton. *Practical Electrical Wiring*, 16ed. New York: McGraw Hill, 1993.

Upton, Barbara London, Upton, John. *Photography*, 4ed. Glenview: Scott, Foresman and Company, 1989.

Viera, Dave. *Lighting for Film & Electronic Cinematography*. Belmont: Wadsworth Publishing Company, 1993.

Williams, T. Jeff. *Basic Wiring Techniques*. San Ramon: Ortho Books, 1982.

American Cinematographer Magazine. Pizzello, Stephen, ed. Hollywood: ASC Press.

DV Magazine. Williams, David, ed. New York: New Bay Media.

Appendix B

Glossary

18% Gray—A standard of reference for "middle gray" or the middle of an 11-step exposure scale from black to white. Used to color-balance and achieve proper exposure. A base reference for light meters (although some experts state that 12% is more accurate). See also *gray card*.

3,200°K—Kelvin color temperature representing "indoor" or "tungsten" artificial light. See also *color temperature*.

5,600°K—Kelvin color temperature representing "outdoor" or "daylight" natural light. See also *color temperature*.

Absolute zero—The temperature at which all molecular movement ceases, –273° Celsius. Also zero on the Kelvin scale. See also *color temperature*.

Absorbance—All objects absorb a certain amount of the light that strikes the surface of the object. The darker the color, the more light is absorbed. See also *reflectance.*

Additive color mixing—Mixing various colors of light. Red, green, and blue are lighting primary colors, and a mixture of variations of the three creates any color of the visible spectrum. The more light colors that are added, the brighter the result. A combination of all colors creates white light.

Alternating current—The primary system of electrical delivery to commercial and residential locations within the United States and many other countries. Current in one conductor alternates between positive and negative at a given frequency—in the United States, 60 times a second (60 Hz).

Ambient light—Also referred to as *available light*; the lighting pre-existing at a given location, be it architectural or natural light. Generally, any light not specifically added for the purposes of photography. Also describes an overall general level of illumination (available or added) that appears to be directionless and has no particular discernible source.

American Standards Association (ASA)—Former name for the American National Standards Institute. The ASA scale was created to identify the sensitivity of a film emulsion. Now an obsolete scale, replaced by ISO and EI. See also *International Standards Organization*.

American Wire Gauge (AWG)—Used since the mid-1800s, a system for identifying the diameter of electrically conducting wire.

Ampacity—The measurement of the total number of amps that can be conducted through a component of a circuit.

Ampere (amps, amperage)—A measurement of the number of electrons passing a given point in a given period of time, represented mathematically by the abbreviation *I* (intensity).

Angle of incidence—A descriptor for the angle of light striking a given subject. The angle of incidence is equal to the angle of reflectance.

Aperture—The iris of a camera, most often within the lens, that restricts the amount of light passing through the lens to the sensor. See also *f-stop*, *T-stop*.

ASA—See *American Standards Association.*

AWG—See *American Wire Gauge.*

Backlight—Any light positioned on a subject that is behind the plane perpendicular to the lens; from the 10:00 to the 2:00 position on the clock dial is considered back light; light that comes from behind the subject.

Ballast—In electricity, a component responsible for regulating current flow to a device.

Barn doors—An accessory for lighting fixtures that attach to the front of the light, generally featuring two or four adjustable blades that help to shape and cut the light emitting from the fixture.

Bead board—A generic name for Expanded Polystyrene (EPS) sheets, commonly known by the trade name of Styrofoam.

Best boy—A position in the electrical department on a motion picture set. The best boy is the immediate assistant to the gaffer, and the manager of the electrical crew. The best boy is often responsible for hiring electricians, ordering and maintaining the electrical equipment and truck, and managing the electrical distribution on set. The primary liaison between the production team and the gaffer. See also *gaffer*.

Borosilicate—A robust, high-heat-resistant type of glass made from silica and boron oxide. First introduced in the early 1890s as Corning Glass Works and later sold in the early 1900s as Pyrex. An alternative to quartz glass. See also *tungsten-halogen.*

Bouncing—A technique for reflecting light off a given surface to change the overall quality and *effective size* of the light source.

Bus bars—A thick strip of conductive metal, generally copper or aluminum, that provides electricity to a number of components, most often individual circuit breakers in a distribution box.

C-47—Colloquialism for wooden clothespin.

Cable tie—A thin strip of heavy-duty plastic molded with ridges that folds onto itself through a case at one tip with a ratchet device that, once the tie passes through the ratchet, prevents it from being pulled back. Also called zip-ties, used to secure cables or other objects in place.

CCD (charge coupled device)—An electronic light sensor used in digital cameras. Invented in the late 1960s, CCDs were the primary image capture medium in digital video cameras until the 2000s when advances in less expensive, easier to manufacture CMOS chips started to tip the balance. Generally more robust with less image artifacting, but extremely difficult to manufacture. In the mid 2000s there were only three manufacturers of CCDs, and all cameras used chips from one of the three manufacturers.

CCT—See *Correlated Color Temperature.*

CFL—See *compact fluorescent lamp.*

China ball—See *paper lantern.*

Cinematographer—Also *director of photography*. The head of the camera department in charge of the visual interpretation of the production according to the director's wishes. Responsible for camera placement, lens choice, shot size, composition, camera movement and lighting, in addition to managing the grip, electric, and camera crews.

Circuit—The complete path of electrical current from the generating point to the delivery point, including all components therein.

CMOS (complementary metal-oxide semiconductor)—An electronic light sensor used in digital cameras. Patented in the late 1960s, CMOS sensor chips are an alternative to CCD image sensors and, generally, are less expensive to manufacture. Advances in CMOS technology in the 2000s made it a popular choice for a new breed of HD cameras. Simplified manufacturing meant that companies weren't locked into using one of the three CCD manufacturers but could create their own CMOS chips to suit their own designs.

Color Rendering Index (CRI)—A scale from 0 to 100 representing the accuracy by which a luminary will represent colors. A rating of 100 is natural daylight, representing colors with 100% accuracy. A rating of 0 would not represent colors at all.

Color temperature—A scale, defined by Kelvin temperatures, that describes a relationship between Celsius temperature of a theoretical black body radiator incandescent source and the general color spectrum combination that is emitted from that temperature.

Compact Fluorescent Lamp (CFL)—A category of fluorescent fixtures wherein the glass tube is bent or twisted in very tight formations to increase the overall surface area in a smaller physical space. Also features a built-in ballast to be a stand-alone unit that can be integrated easily into fixtures designed for incandescent bulbs.

Composition—Defining the placement and arrangement of elements within the frame of a photograph. The photographer *composes* the image to frame the subject in the way that best conveys a specific message to the viewer.

Conductor—An element, typically a metal, with a free orbiting electron that can easily allow for the process of *electromotive force* and conduct electricity.

Contrast ratios—A relative number referring to brightness values of shadow and key sides of a subject. The ratio refers to the highlight brightness compared to the shadow darkness. A ratio of 1:1 means that both sides are equally lit. A ratio of 2:1 means that the bright side is twice as bright as the shadow side.

Correlated Color Temperature (CCT)—A modified Kelvin scale for non full-spectrum light sources to identify the simulated color temperature.

CRI—See *Color Rendering Index.*

Croney Cone—Industry term for a softbox, named for the late cinematographer Jordan Chronenweth, who would often build softboxes to alter the light quality of his lighting fixtures. See also *softbox*.

CTB (color temperature blue or correct to blue)—A dyed piece of translucent plastic with a blue tint intended to raise the physical color temperature of a light source. Most commonly used to match a 3,200°K tungsten source to a 5,600°K daylight source.

CTO (color temperature orange or correct to orange)—A dyed piece of translucent plastic with an orange tint intended to lower the physical color temperature of a light source. Most commonly used to match a 5,600°K daylight source to a 3,200°K tungsten source.

CTS (color temperature straw)—A dyed piece of translucent plastic with an orange-ish/yellow-ish tint intended to lower the physical color temperature of a light source and add a slight warm hue. Most commonly used to match a 5,600°K daylight source to a 3,200°K tungsten source.

Cucaloris ("cookie")—A piece of wood or wire mesh cut out or coated with an amorphous pattern intended to be placed into the path of a light beam. Used to break up the single source into a random pattern of light, as if light were passing through leaves of a tree.

Dichroic—A specially coated glass filter that cuts red wavelengths and allows through more blue. Most commonly used to match a 3,200°K tungsten source to a 5,600°K daylight source.

Diffusion—A medium, generally white and semi-translucent, that is intended to scatter the light passing through it.

Direct current—A method of delivering electrical current to a component composed of a closed circuit of one negative and one positive lead. Both must be connected in order for the circuit to be complete. Common use is in batteries.

DSLR (digital single lens reflex)—A term referring to a type of digital sensor camera wherein the viewfinder is of a reflex type utilizing mirrors or prism optics to view directly out of the camera's lens.

Duct tape—Typical plastic-coated cloth-structure adhesive tape intended for securing components of air conditioning and heating ducts, but can be used in a number of applications. High-tensile strength. Generally comes in a metallic silver color.

Duvetyn—A soft, short-napped fabric typically in black, made of wool or cotton.

Dynamic range—See *latitude*.

Edison plug/socket—Named for inventor Thomas Edison, trade name for a standard 15A 120V plug with two parallel blades (one for hot, one for neutral) and, in some devices, a longer, rounded pin for connection to ground.

Effective light source—After light passes through *diffusion* media or *bounces* off a surface, the secondary surface becomes the new source of light.

Electrode—A conductor of electricity that connects with non-metallic parts of a device. In a fluorescent tube, for example, the electrode provides electrons that collide with mercury atoms in the tube and, in turn, creates ultraviolet radiation to excite the phosphor coating inside the glass, thus creating light.

Electromagnetic spectrum—The range of all possible frequencies of electromagnetic radiation. The spectrum extends from low frequencies (long wavelengths) used for modern radio to ultra high frequencies such as gamma radiation (short wavelengths). Also represents the wavelengths of light.

Electromotive force—The difference in potential between two points of a circuit akin to how many free electrons are available to move from one point to another. Also called *voltage*.

Ellipsoidal reflector spotlight (ERS)—A lighting fixture composed of an ellipsoidal-shaped reflector and a series of lenses to focus the light beam into a very tight circle of projected light. Various metal or glass patterns can be placed inside the spotlight and projected on a surface. Also called a *leko*.

Emulsion—The basis of a film stock. Light-sensitive silver halide crystals are suspended in a gelatin coating on the base plastic film stock.

Envelope—The glass enclosure of a light bulb.

ERS—See *ellipsoidal reflector spotlight.*

Exposure—Subjecting a digital sensor or film emulsion to light for a given period of time to create an image.

Exposure index (EI)—A system wherein the sensitivity of an emulsion or sensor is measured. Replaced ASA, DIN, and ISO as an industry standard. See also *American Standards Association* and *International Standards Organization*.

Fall-off—A description of diminishing intensity of light as it travels farther away from the source. Defined loosely by the *inverse square law*, some types of light diminish and disperse more rapidly than others.

Filament—The tungsten element inside a bulb that glows when electricity is supplied to it. See also *incandescence* and *tungsten*.

Fill—An additional source of light added to a composition to increase the brightness of the shadow areas of a subject. Traditionally used to lower the contrast ratio.

Fireproof—A material that will not sustain an open flame. It will self-extinguish and not permit an open flame to grow.

Flags—Solid, opaque objects placed in the path of a light to eliminate, or cut, the light off an object or area.

Flame retardant—Refers to a chemical treatment of materials to make them more resistant to heat and open flame. Not to be confused with "fireproof," flame-retardant materials are merely more resistant to heat and open flame than untreated materials, but will burn with prolonged or intense exposure.

Fluorescence—The process of creating light by utilizing ultraviolet radiation within a vacuum *envelope* to excite a phosphor coating.

Foamcore—A lightweight, rigid material composed of two sheets of clay-coated paper and an inner layer of polystyrene foam.

Focal length—The distance between the optical center of a lens and the focusing plane at the target (film or sensor). Generally represented in millimeters, focal lengths identify the scale of photographic lenses; the smaller the focal length number, the wider the visual perspective captured by that lens.

Footcandle—Basic English unit of measurement of incident lighting intensity. Based on the theoretical light from one candle on a 1-foot square area 1 foot away from the flame. See also *lux*.

Footlambert—Basic English unit of measurement of reflected lighting intensity off a subject. Whereas a footcandle describes the incident light falling onto an object, a footlambert describes the reflected light coming off the object and reaching our eyes or the camera.

Frame rate (FPS, frames per second)—The measurement of the number of individual frames a motion picture camera photographs in one second of time. Not to be confused with shutter speed, but a component of it.

Fresnel—A type of lens with a series of concentric circles. Created by planing down the convex side of a simple plano-convex lens, the Fresnel is lightweight and creates an even, circular, field of light.

***f*-stop**—Scale system for describing the size of a camera's aperture. A geometrical relationship between the focal length of the lens and diameter of the iris opening. See also *T-stop* and *aperture*.

Gaffer—Also *chief lighting technician.* The head chief lighting technician; the head of the lighting crew immediately under the director of photography or cinematographer. Responsible for managing all of the electrical crew and executing the lighting needs under the direction of the cinematographer.

Gaffer's tape—A cloth-based adhesive tape with a dull finish, most often in black. A high-tensile strength, but easily torn. Also called gaff tape.

Gamma—Representation of photographic contrast in the middle of the exposure scale between blacks and whites.

Gang box—A plastic or metal box, most typically intended to be recessed in a wall, designed to hold an electrical device such as a switch or outlet and the connecting wires.

Gauges—See *American Wire Gauge.*

Gels—Flexible lighting filters impregnated or coated with specific color dyes. Most often with a polyester base. Can be trimmed or cut to size.

Globe—Industry slang for light bulb, specifically the glass of the bulb. See also *envelope*.

Gobo—Any object placed in the path of a light to shape the light by way of creating shadow. Can be a flag, net, cookie, or even a cut metal template in a spotlight used to project a pattern.

Gray card—A calibration device in a portable form that is coated with a specific shade of neutral gray with an 18% reflectivity. See also *18% gray*.

Gridcloth—A specific type of white nylon cloth diffusion with a square grid-like pattern. Can be sewn to create larger diffusion pieces.

Ground—Element of an electrical circuit that provides a connection from the Earth to all the non-electrical metal components within a device.

Halogen—See *tungsten-halogen.*

Hard light—Defining quality of light wherein the light creates hard, sharp shadows on a subject. Created by point sources.

HDSLR (high-definition single lens reflex)—A term coined for a new brand of digital *SLR* camera that also shoots high-definition video.

HMI (Mercury medium-arc iodide)—Periodic element Hg (atomic weight 80), also known in Latin as *hydrargyrum*. A short-arc gas-discharge light source that generates a light source in the "daylight" Kelvin temperature range.

Hot—The current-carrying element of an electrical circuit. Typically identified by the colors of black, red, or blue.

Hubbell—Trade name for a type of 15A 120V "Edison" style plug or socket.

Incandescence—The physical process of creating light as a by-product of intense heat.

Incident light—The light falling onto an object.

Incident meter—A light-sensitive measuring device that calculates the light falling onto an object. Typically with the tell-tale ½ "ping pong ball" collector dome.

Infrared radiation—Electromagnetic wavelengths just beyond the light spectrum that are outside the visible range of human vision, but still possible to generate exposure in film and digital sensors. Discerned by humans as heat.

Insulator—An element that is highly resistant to the flow of electricity.

Intensity—Mathematical term for *amperage*, measuring the number of electrons flowing past a given point in a given period of time. See also *ampere*.

International Standards Organization (ISO)—A standards-setting body composed of global representatives to form worldwide industrial and commercial standards. Current standard ISO 5800:1987 replaced the American Standards Association (ASA) and German Institute for Standardization (DIN) scales to define film sensitivities. See also *American Standards Association* and *Exposure Index*.

Inverse square law—Property of the physics of light, when emitted by a point source, that states the intensity of the light will diminish proportionally by the square of the distance traveled.

IRE (Institute of Radio Engineers)—Scale on a waveform monitor to define values of electrical current representing areas between black and white in the visual image.

Ishihara chart—A method for identifying symptoms of color vision deficiency in people utilizing specific color dots and visible numbers "hidden" in the dots.

ISO—See *International Standards Organization.*

Japanese lanterns—See *paper lantern.*

Kelvin—See *color temperature.*

Key—The primary component of a lighting setup, the principal light for the subject. Or, the value of lighting intensity equal to Zone V as determined by the camera's *aperture*.

Kicker—Identification of a common lighting position wherein the light is set behind subjects to "kick" light onto their backs. See also *backlight*.

Kodachrome—Trade name for a family of film stocks, created by the Eastman Kodak company, primarily color reversal film. Kodachrome *emulsions* were manufactured through 2009 before being discontinued.

Latitude—Definition of an emulsion or sensor's ability to represent various levels of luminance between black and white to create a pleasing photographic image.

LCD—Liquid crystal display.

LED—See *Light Emitting Diode.*

Leko—Trade name for an *ellipsoidal reflector spotlight*.

Light—The portion of the electromagnetic spectrum from, roughly, 400 to 700 nanometers that produces wavelengths visible to the human eye.

Light Emitting Diode (LED)—A semiconductor light source.

Logarithmic—A mathematical scale by which a number to a given base is the exponent to which the base must be raised in order to produce that number. For example, the logarithm of 100 to base 10 is 2, because 10 to the power of 2 is 100. Sensitometry is defined on a logarithmic scale.

Luminary—Anything that creates light.

Lux—Metric system of measuring lighting intensity. A secondary measurement based on lumens, one lux is equal to one lumen over a square meter area. One footcandle is 10.76 lux. See also *footcandle*.

Masking tape—A low-tac adhesive, paper-based tape.

Medium-base—General standard size of screw-type light bulb base for general consumer use in the United States and other countries.

Mercury vapor—A category of short-arc light sources that create light from two electrons arching through a combination of gas containing mercury. Typically utilized in industrial applications: street lamps, warehouses, sports arenas, and so on. Produces a blue-cyan light.

Minus Green—Color correction filter or gel, in varying strengths, of a magenta hue intended to eliminate green color wavelengths from a light source. See also *Plus Green*.

Mired (micro reciprocal degrees)—A mathematical scale by which Kelvin color temperatures can be added, subtracted, and compared. Mireds are equal to 1,000,000 divided by the specific Kelvin temperature.

Muslin—A type of loosely woven cotton fabric created from carded cotton yarn. Used for diffusion or to bounce media in film and video applications.

Nanometer—One billionth of a meter.

NEC (National Electric Code)—Published and governed by the National Fire Prevention Association, publication number 70 is known as the National Electric Code and sets a minimum standard of electrical practices to maintain safety from fire and accident.

Neodymium—A chemical element (periodic table abbreviation Nd, atomic number 60). A soft silvery metal, generally used as a glass dye to create a bluish coating to change the emitted color output of a source.

Net—Screen-like material placed in the path of a light beam to reduce the intensity of the light without altering its color or quality.

Neutral—Element of an alternating current electrical circuit with a neutral polarity, the connection to Earth to complete an AC circuit.

NTSC (National Television System Committee)—The analog television system in use in the United States for standard-definition color images.

Off-camera key—A technique of lighting faces wherein the primary source of light is on the opposite side of the face as the camera. This technique ensures that the defined shape of a person's face is closest to the camera, adding more definition, modeling, and interest to the image. Also called *shadow-side to camera*.

Ohms—Element of electricity that represents a conductor's resistance to the flow of electrons.

OSHA (Occupational Safety and Health Administration)—Legal governing body responsible for setting minimum standards for life safety in professional work environments.

Paper lantern—Generally spherical in shape, a thin wire or wooden skeleton frame wrapped in a light translucent paper. When a light source is placed inside the lantern, it emits a soft glow.

Parabolic Aluminized Reflector (PAR)—A type of lighting fixture featuring a reflector in the shape of a parabola (conic) that serves to focus beams of light into parallel rays. Most often a closed unit wherein the reflector is built into the bulb itself.

Persistence of vision—Phenomenon of human vision whereby the brain retains an image for a brief moment so that a series of still images presented sequentially in rapid succession gives the appearance of movement.

Phospor—A substance composed of transition metal or rare Earth compounds that exhibit the phenomenon of luminescence.

Photometrics—Mathematical specifications on the measurement of a lighting fixture and its brightness over given distances.

PIE—The mathematical equation Power = Intensity × Electromotive force. An alternative form of Ohm's law that states the relationship between Power (watts), Intensity (amps), and electromotive force (voltage).

Plano-convex—A basic lens with one flat (plano) side and one curved (convex) side. Intended to focus or collimate light rays into parallel beams.

PLUGE (picture line up generating equipment)—The three black rectangles in SMPTE color bars that represent blacker than black, black, and just above black.

Plus Green—A color-correction media, or gel, that comes in varying strengths with a green-ish hue intended to add green wavelengths to luminaries. Generally used to correct non-fluorescent fixtures to match the green content of standard commercial fluorescent lights. See also *Minus Green*.

Point source—A luminary composed of a single, small light-emitting element.

Power—Mathematical representation for *wattage*.

Pure black—The point at which there is no longer any discernible picture detail in the shadow, or black, region of an image. No detail is recorded and no detail can be extracted from this area in a post-production process. See also *pure white.*

Pure white—The point at which there is no longer any discernible picture detail in the highlights or white region of an image. No detail is recorded and no detail can be extracted from this area in a post-production process. See also *pure black.*

Quartz-halogen—See *tungsten-halogen.*

Quartz-iodine—See *tungsten-halogen.*

Rake—A technique of lighting by which light is angled to side-light a subject or object and just "skip" across the surface. Generally used with hard light to accentuate the surface texture of the lit object.

Reflection—The change of direction of a wave of light after striking an object.

Refraction—The altering of a direction of a wavelength of light as it passes through a translucent material such as glass or water.

Rembrandt—Referring to the work of Dutch painter Rembrandt Harmenszoon van Rijn, but more specifically to the specific technique of lighting utilized in some of his paintings wherein the "key" light source is placed slightly above and to the side of the subject, thus creating a triangle of light on the shadow side of the face under the eye and alongside the nose.

Resistance—Mathematical representation of ohmic resistance in a conductor. All elements have some natural resistance to the flow of electrons; insulators have higher resistance than conductors.

RGB (red, green, blue)—The three primary colors. Variable combinations of these three are capable of creating any color in the visible spectrum. See also *additive color mixing*.

Rocky Mountain Leg—The leg of a lighting or C-Stand that is adjustable in height to accommodate for uneven terrain and allow the stand to be leveled.

Room tone—A term coined by the late cinematographer Conrad Hall, ASC, to refer to a base level of exposure in an environment, underexposed below the key, to provide a minimum level of detail in the shadow regions.

Shutter angle—The degree of opening of the circular shutter in a motion picture camera. 180-degree shutter is a $\frac{1}{2}$ circle. 90 degrees is $\frac{1}{4}$ of a circle, and 45 degrees is $\frac{1}{8}$ of a circle. Most digital cameras have a simulated shutter—not a physical spinning shutter; this function is achieved electronically.

Shutter speed—The speed, represented in fractions of a second, at which the shutter inside a camera opens to reveal the light-sensitive emulsion or sensor to light. In digital cameras, mostly this is an electronic function. Shutter speed is also the representation of frames per second divided by the shutter angle as a fraction of a circle. 24 frames per second with a 180-degree shutter angle ($\frac{1}{2}$ of a circle) is a $\frac{1}{48}$ of a second shutter speed.

Single-phase—A method of electrical distribution of alternating current in which all hot, current-carrying elements alternate between positive and negative polarity in synchronization with each other. As opposed to three-phase, which features three hot conductors that alternate cycles to reach electrical neutrality at three different points in a given second-long cycle.

SLR (single lens reflex)—A category of camera whereby a mirror or prism allows the viewfinder to see directly through the camera's lens.

SMPTE (Society of Motion Picture and Television Engineers)—An international professional association created for the purpose of generating internationally recognized standards for the motion picture and television industries.

Soft light—A quality of light that is defined by long, gradual shadow transitions or no shadows at all. Created by large light sources in close relative distance to the subject.

Softbox—A diffusing accessory, generally trapezoidal in shape, that affixes to the front of a lighting fixture to increase the effective size of the light source and soften the resulting light. See also *Croney Cone*.

Sourceless—Term used to describe a very soft light that does not have a discernible directionality. See also *room tone* and *ambient light*.

Space light—A category of lighting fixture, generally suspended overhead with the light source pointing down, surrounded by a cylindrical shape of diffusion and, generally, a spherical diffusion base. Creates a very soft, even field of general light.

Spec commercial—Short for speculation commercial. A full ad spot that isn't commissioned by a company for any particular product. It's done on "speculation." Basically a fake commercial for a real or imagined product that demonstrates the skills and abilities of the filmmaker.

Spectrum—Also *color spectrum*, *light spectrum*, *continuous spectrum*. Defines a range of values, specifically the range of colors that make up natural "white" light.

Specular—A mirror-like reflection of a light source that creates a highlight on a shiny surface.

Spot meter—A category of light-measuring tool that calculates the reflected light off objects.

Spreader—Small wire insert in a paper lantern that keeps the lantern expanded to its intended shape.

Stinger—Colloquialism for flexible extension cord.

Subtractive color mixing—Combining of secondary colors (cyan, magenta, yellow) that creates a darker color with each new combination. Also the process of filtering, or subtracting, various color wavelengths from light to create a new color of light after the filtration. Mixing all colors creates black or the absence of light.

Three-point lighting—A traditional approach to lighting people including a *key*, *fill*, and *backlight* or *kicker*.

T-stop—Calibrated scale of defining aperture sizes based on the *f*-stop with consideration to the actual measured transmission of light through the specific lens. A more highly calibrated form of the geometric *f*-stop.

Tungsten—A natural element (periodic table abbreviation W, atomic number 74) having the highest melting point of all non-alloy metals. Used in the creation of incandescent lamp filaments.

Tungsten-halogen—Category of incandescent light bulb that features a halogen gas—most commonly iodine—inside the vacuum envelope to assist in tungsten particle regeneration and higher color efficiency fidelity. Requires a thicker, higher melting point glass, most typically quartz. See also *quartz-iodine*, *quartz-halogen*, and *halogen*.

Ultraviolet radiation—Electromagnetic waves just below the light range. Invisible to the human eye. Reaction to UV can cause substances to glow or fluoresce. UV radiation is a component of sunlight (and gas-discharge arc lamps) and can cause damage to human skin, commonly referred to as sunburn.

Volts—Measurement of electrical potential between two points in a conductor. See also *electromotive force*.

Watts—Element of electricity that defines the energy created by a specific device. See also *power*.

Waveform—A technical evaluation tool that represents, in electronic signals, the values of a photographic image between black and white. See also *IRE*.

West Virginia rule—(Acrostic) Mathematical formula representing a secondary expression of Ohm's law, based on the abbreviation of the State of West Virginia: WVA, W=Watts, V=Volts, and A=Amps. The formula is W=VA. See also *PIE*.

White balance—Electronic technique by which a digital sensor defines the white, or color-neutral, portions of an image to render the rest of the image in natural color tones. Intended to remove *color temperature* bias from lighting and electronically filter the image to create the most naturally accurate reproduction of the photograph.

Xenon—A chemical element (periodic table abbreviation Xe, atomic weight 54). A colorless, heavy, odorless gas, used as an additive in arc light bulbs to generate very bright, "daylight" colored, light.

Zebras—An attribute of many electronic viewfinders that allows the operator to superimpose diagonal hash marks on the portions of an image that exceed a given luminance value (are overexposed). The lines are not recorded in the image, just presented in the viewfinder to aid the operator in making exposure judgments.

Zip cord—Industry slang term for 18/2 cord, also called a *lamp cord*.

Zip-tie—See *cable tie.*

Zone System—Photographic evaluation technique for determining exposure created by Ansel Adams and Fred Archer in the late 1930s. A systematic method of determining exposure values based on an 11-step grayscale from black to white, with each step representing one photographic *f*-stop or a factor of two times the previous or successive step.

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